KEER2014. Proceedings of the 5th Kanesi Engineering & Emotion Research, International Conference

Linköping, Sweden, June 11-13

Editors

Simon Schütte and Pierre Levy

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Linköping Electronic Conference Proceedings, No. 100
ISBN: 978-91-7519-276-5
ISSN: 1650-3686
eISSN: 1650-3740
URL: http://www.ep.liu.se/ecp_home/index.en.aspx?issue=100
Linköping University Electronic Press
Linköping, Sweden, 2014

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1A - Kansei Information Design 1

KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Item Response Theory Approach to Kansei Design：

Basic Concept

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Abstract: This paper points out that Kansei Design needs a good match between the customer and the producer. Recently, in the field of educational testing, Item Response Theory is drawing attention. In classical test theory, tests were given to examinees without considering any individual characteristics. The same tests were given to all examinees. But everybody knows that we have strong points and weak points. Some are good at sports. Others are good at arts. If a test is about sports, then those who are good or who like sports make a good score. And the score will be better, if the examiner likes sports. Now, it is found out that if an examiner and an examinee have more in common, then the examinee makes a better score. This is considered to be because an examinee understands the question better. And the examinees are more motivated and their scores keep going up question after question.

Many people emphasize the importance of considering personalities of customers in Kansei Design. But very few discuss how it is important to find a good match of Kansei between the customer and the designer. If their intersection is small, the product would not appeal to the customer. A designer should know who will be his or her customer and should make efforts to increase the size of intersection. It would not work if they do not share intersection at all or would not work effectively if the intersection is small.

Keywords: Kansei Design, Intersection, Matching, Item Response Theory, Lifetime Value.

1. LEVELS AND TRAITS

1.1. European Kansei and Japanese Kansei

Kansei Engineering is very different between Japan and Europe. In Japan, when they talk about Kansei, it is about the levels in most discussions. They believe that if the level of Kansei is high, then a product is very personalized and appealing. And customers are thought to be not so much

creative and active. Most of them seem to regard customers as passive consumers. Japanese designers seem to think that If he or she can provide their customers with a product with a high level of Kansei, it will satisfy customers.

In other words, Japanese regard Kansei more in a framework of extrinsic motivation. Europeans, on the other hand, regard Kansei, more in a framework of intrinsic motivation. They seem to be more interested in how they can motive their customers from within.

1.2. Item Response Theory (IRT) and Classical Test Theory (CTT)

In this sense, the difference between European Kansei and Japanese Kansei may be compared to Item Response Theory (IRT) and Classical Test Theory (CTT) [Wikipedia, November 22, 2013]. What differentiates IRT from CTT is best explained if we know another name for IRT is Latent Trait Theory. IRT assumes there are latent traits in every examinee so that there should be a test best fit to measure abilities, attitudes and/or other variables of an examinee.

If an examinee is good at sports, he or she would respond very well to the questions about sports. And if an examiner is good at sports so that a examinee and examiner share common interests, then the examinee's latent traits would show up more clearly.

1.3. Static Kansei and Dynamic Kansei

In other words, Japanese Kansei researches focus more on Kansei at present and how they can measure with higher accuracy the levels of preferences or what Kansei pattern a customer has. In short, Japanese discuss more in the static sense. European Kansei researches, however, focus more on how customer's Kansei can be developed. In short, they are more interested in dynamic Kansei. This may be understood better if we recall the word Emotion has strong relation with the French word "emouvoir" or to stir up, although Emotion and Kansei are not identical. But they have a lot in common.

This is author's very personal impression about Japanese Kansei and European Kansei researches. There may be Japanese researchers who are pursuing dynamic Kansei or European researches pursuing static Kansei. What the author would like to insist here is not the difference between two areas, but we should distinguish these two approaches and we should move more toward dynamic Kansei, since our world is changing very frequently and extensively.

1.4. Kansei and Emotion

Japanese developed many excellent approaches to measure static Kansei. So if it comes to static Kansei, we can utilize them in many applications. But our environments and situations change very often and very extensively, so our preferences change accordingly. This will be best described if we use Emotion instead of Kansei. As described above, the word "Emotion" has a strong relation with the French word "emouvoir" or "stir up", but if we know it comes originally from the Latin word "e=ex=out" and "movere=move", it literally means "to move out" and in addition, the words motivation and motive come from the same Latin word. Thus, making decisions on which direction to go or whether to go further is crucial in emotional engineering (Fukuda, 2011, 2013). Motivation-Action-Emotion constitutes a cycle as shown in Figure 1.

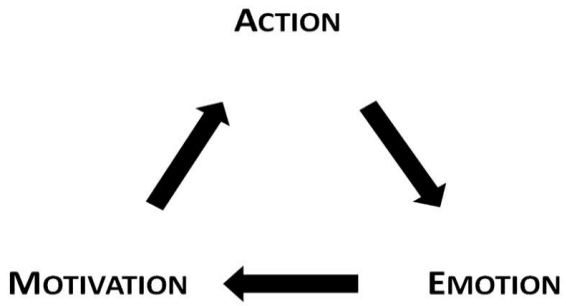

Figure 1: Motivation-Action-Emotion

1.5. Importance of Process

IRT is also called “Computerized Adaptive Testing”. The word “adaptive” means how a test can adapt to the change of an examinee because his or her abilities, attitudes and/or other variables change in response to the changing environments and situations. So IRT may be interpreted as a testing approach focused not on the outcomes or the final results but on the processes. If an examinee has a very good adaptability or large room for growth, he or she would develop his or her abilities to a great extent, no matter how the situations may change. But if his or her adaptability or room for growth is low, then even if his or her scores are good in the present situation, he or she cannot show that high level when the environments or situations change.

1.6. Adaptability of a Product and Marketing

The evaluation of customer adaptability is very important in marketing. If a customer is very much adaptive, we can develop many different products and a customer would accept them as a good product, because he or she maintains high level of Kansei feeling, no matter what new or unexpected products come up.

But if a customer’s adaptability is low, a new or unexpected product would not appeal to him or her. It would be better to develop his or her attachment more and turn them into a lifetime customer. To describe this in other words, we can employ a disruptive innovation approach to adaptive customers, but we have to apply a sustaining innovation approach to not-adaptive ones.

In the latter case, Japanese approach will be very much effective. They focus on fixed traits and makes efforts to bring these dimensions to the higher level. To achieve this goal, an open loop system will work. But to achieve dynamically adaptive Kansei, we have to change our system into a closed loop system so that we can keep track of how our customer’s Kansei is changing (Figure 2)

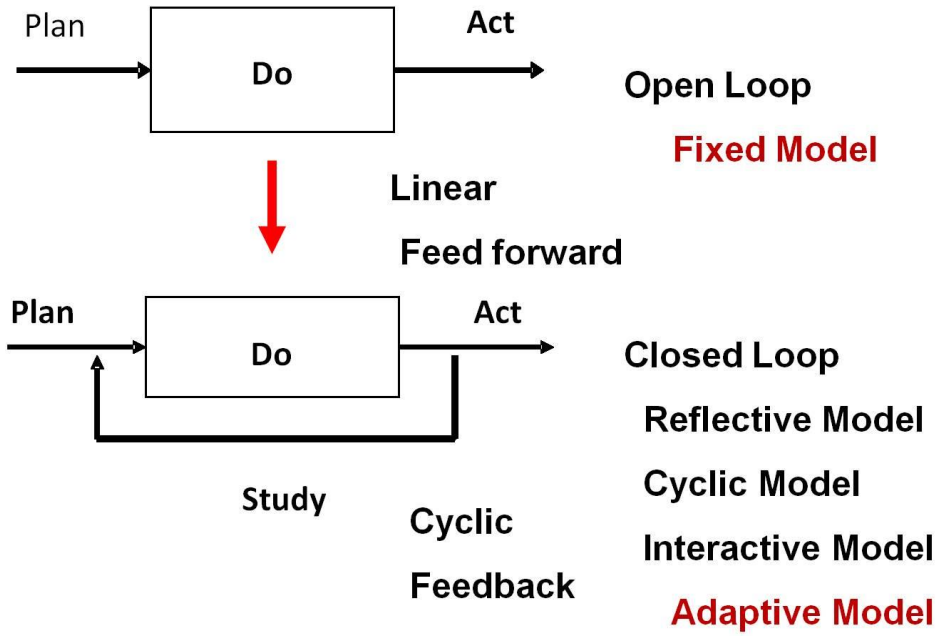

Figure 2: Open Loop and Closed Loop System

2. DYNAMIC KANSEI AND PRODUCT DEVELOPMENT

2.1. How We Can Make Adaptive Kansei Design Easier

Although it sounds very appealing that if we can prepare very adaptive Kansei products and if we carry out a very excellent design, the problem is if we change our product design very often, it will bring about many issues in production. Manufacturing equipments must also be changed every time in response to a new design. Then, how can we solve this problem?

2.2. Trucks

A design and production in truck industry gives us a solution. In the case of trucks, they have to carry many different kinds of loads so their load carrying bodies vary from truck to truck, although their chassis are common. So in fact, truck manufacturing companies are separated into two groups. One group produces just load carrying bodies. The other group produces common chassis. And they assemble them together. Thus, they can produce different kinds of trucks to respond to many different needs (Figure 3)

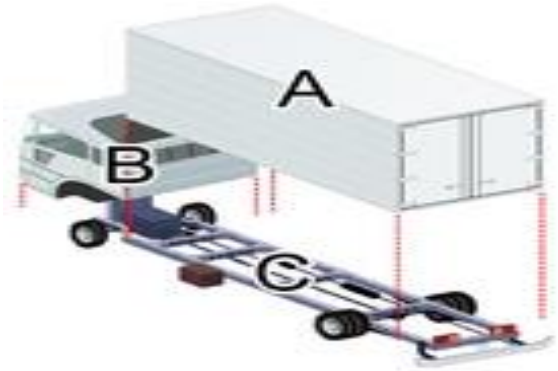

Figure 3: Truck design

2.3. Wedding Dresses

Interestingly enough, same idea can be observed in wedding dress design. Ladies would like to wear a wedding dress just for her alone. But not every lady is so rich that she can order a wedding dress just for her. Most of them have no other choice than to rent a wedding dress. But they insist that the dress should be just for her.

So wedding dress designer for rental companies observe where ladies are focusing their attention during the show, etc by using such technologies as eye tracking, etc. And they change only these eye-catching or Kansei-intensive parts and let the other parts be common. Thus, they can mass customize and personalize their wedding dresses. Thus such modularization brings happiness to ladies and to wedding dress companies.

2.4. One Time Based Modularization

Such strategy of modularization based on where we focus our Kansei attention can make products adaptable to many different Kansei needs and what is better is that we can easily update such parts to accommodate the changing expectations. Of course, our customers' preferences may change over time and their focus part of Kansei attention might change. But these changes are slow and do not change so quickly.

It may be understood better if we recall ladies change such small ornaments as earrings, etc very often to adapt to the daily needs or preferences, but they do not change their dresses so often. So if we separate parts whose Kansei attractions change very slowly from those which change quickly, we could make our Kansei design more flexible and make production much easier.

3. ATTACHMENT AND PRODUCT DEVELOPMENT

3.1. One Time Value and Lifetime Value

Although this is also time-related issue, attachment is another problem. The issue discussed above is how we can flexibly adapt to the change of Kansei expectations from our customers. This is a one time value. How we can design and produce a product which will appeal to customers whose Kansei requirements change frequently was the issue. Modularization is one of the

solutions to how we can make our products flexible and adaptive enough to accommodate such changes. The basic idea here is how we can make our product most appealing at the time of sale.

3.2. Feeling of Best Fit

Another time-related issue is attachment. It is the problem of how we can extend the duration of Kansei appeal.

Let us take shoes for example. We feel happy and enjoy walking, when we feel they come to fit us best. We would like to wear these best fitting shoes as long as possible. But these best fit conditions are not designed at first. The initial functions does not necessarily realize the best fit. But after using some time, they come to fit us better and better or in other words, they adapt to our needs and preferences. Then we are more and more attached to them.

But the current Kansei design is focused more on a one time value and it does not consider too much about this problem of attachment. How we can keep the condition of best fit as long as possible and keep the feeling of attachment growing?

3.3. Lifetime Based Modularization

Modularization again will give a solution to this problem. The part which gives such a feeling of best fit can be identified by using rapidly progressing sensor technology. ASICS (Moriyasu. 2013), for example, is one of the companies which demonstrate the usefulness of this approach. They developed many shoes for sports, jogging and walking.

What should be stressed is that this problem of attachment is not so well discussed, but from the standpoint of marketing, we can secure a lifetime customer and we do not have to worry too much about diversification and frequent or short term changes. As attachment is a long term issue, we can pay attention to selected parts and make efforts to keep them in their best fit conditions as long as possible.

3.4. IRT Approach

IRT approach is effective in this point. Such an approach will ferret out how their expectations or attachment will develop. Unlike CTT, IRT pays attention to how a test adapt to the changes of an examinee with respect to noticed dimensions. Although IRT techniques may not be directly applicable to this issue, because IRT was developed originally for educational testing, the basic idea of IRT is very much useful and effective in dealing with the problem of keeping the best fit conditions. This problem is very much associated with room for growth.

4. Matching between Designer and Customer

The above discussion does not touch upon the issue of matching between a designer and a customer. IRT is unique in that although CTT does not consider matching between an examiner and an examinee, IRT does. CTT assumes that the level of examinee can be evaluated by tests and these tests can be prepared by any examiner, if he or she has knowledge. It only considers the level of knowledge of an examiner and does not question what pattern or dimensions an examiner has.

But Some examiners may know mathematics well. Some others may know literature well. If an examinee likes or excels in mathematics, he might get better scores from the tests given by mathematics loving examiner. Thus, a mathematics loving examiner would stimulate a mathematics loving examinee's room for growth so that he or she accelerates the examinee's growth or brings about larger growth.

Why IRT is also called "Computerized Adaptive Testing" is because a computer adapts to the traits of an examinee and gives him or her the questions best fitted to him or her, which would bring out the latent traits to evaluate how much rooms of growth there are in his or her abilities and in which dimensions. Thus a computer adapts to an examinee so that it and an examinee have most in common.

There is very few, if any, discussion about the matching of a designer and a customer. This IRT approach teaches us that we should consider more about their matching. We should try to find out not only what Kansei dimensions a customer has, but also what Kansei dimensions a designer has and what dimensions he or she can develop.

It is the problem of increasing the intersection of Kansei between a customer and a designer as shown in Figure 4.

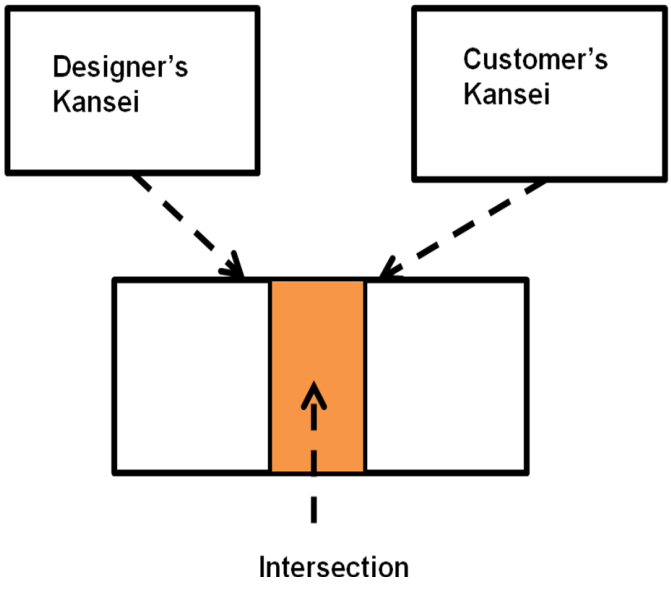

Figure 4: Kansei interaction between designer and customer

5. CONCLUDING SUMMARY

This paper describes how important it is to pay attention to dynamic aspects of Kansei and to try to establish a better match between a designer and a customer in their Kansei dimensions.

In this connection, IRT (Item Response Theory) in testing provides us with a very useful concept and it is expected that it will be a good tool for Kansei design, too. As it is originally developed for educational testing, small alterations may be needed.

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Kansei-related design information exchange during early concept creation phases

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Abstract: In this paper the authors will investigate early experience-centred design activities. Twenty-seven past industrial design projects were analysed. Information was gathered from interviews with former project team members and from an analysis of the projects' final reports. All of the projects involved the Toyota Motor Europe – Kansei Design (TME-KD) division. Three types of projects were identified: "exploratory concept," "product lining strategy," and "pre-development direction." The analysis will show that these project groups not only each have a specific context (purpose, design team members, audience) but that their outputs are also different regarding the type of design information they convey. This will lead to a comparison of the different typologies of projects and a discussion about the kansei-related design information exchange in early design stages. A model of kansei-related design information based on these discussions will be presented.

Keywords: kansei design, design information, early design stage, industrial context.

1. INTRODUCTION

In the consumer goods industry, design teams include members with diverse profiles, such as marketing product planners, engineers, and styling designers. Initially, the design team usually identifies problems and defines challenges in a document often designated as the "brief." Before any concrete aspects (e.g., shape, technology specification) of the product to be designed are fixed, other representations appear in the process. These representations (e.g., mood-boards, target customer description, technology demonstrators, etc.) convey intentions and possible directions. They can be seen as communication tool to increase mutual understanding of the concept and facilitate discussions about specific topics between the diversely skilled members of a design team.

These representations all touch on aspects of user experience, but they never communicate any clear intention related to it. Nevertheless, user experience is at the boundary between the three main functions involved in design teams (marketing, engineering, styling) as it relies on an affective link between a user (i.e., market) and the environment (including the product, the interaction, the context). Users' experience with products recently became a major differentiation factor between competitors and can greatly influence the success of a product. Karapanos and Martens (2009) stated that decisions made at the conceptual design stage have the highest impact on the final user experience (UX) and eventually on UX failures. From this statement, we postulate that taking experience into account and discussing it early in the design process increases the chances that the final product will have a positive impact on its users' kansei.

In this paper, different uses of kansei representations in the industrial process will be investigated. In order to do so, 27 early-design projects leading to the creation of kansei representations were analysed. These projects, which took place between 2008 and 2013 and were coordinated by the TME-KD division, can be characterised as experience design-driven NCD projects.

2. LITERATURE REVIEW

The first section of the literature review will create a link between the complementary notions of user experience and kansei process. The second section will detail the early phase of the industrial design process, and the final section will investigate the literature related to the design information exchanged within a design team during this phase.

2.1. User experience and the kansei process

Ortíz Nicólas and Aurisicchio (2011) analysed 11 user experience frameworks from the literature in an attempt to bring together in a consistent overview the rapidly growing and disjointed literature on the subject. The conclusion of this research suggested that even if the perspectives and focus points of the 11 researchers were different, common constituent elements (user, interaction, artefact, context) and aggregates (subjective, conscious, emotional, interconnected, dynamic) of user experience were acknowledged by the majority of the perspectives reviewed.

The situation described with the term *user experience* can be understood in relation to the definition of the *kansei process*. Lévy, Lee, and Yamanaka (2007) described the latter as the function of the brain related to "emotions, sensitivity, feelings, experience and intuition, including interactions between them" (p. 9). It is further described as originating in one's sensory perception and personal characteristics (*kansei means*) and providing as output a qualitative meaning and value of the environment (*kansei result*). Notably, Lévy et al. indicated that the flow between kansei *means*, *process*, and *results* is not strictly linear and that these different aspects influence each other.

Figure 1 represents a framework that combines the notions of user experience and kansei process. It represents the main entities of an experience during the interaction between a user and a product. The *personal characteristics* and *attributes of the environment (product, interaction, context)* cover what has been previously defined as *kansei means*, whereas the *perceived kansei qualities* are direct consequences of *kansei results*. Notably, the framework also retains the four constituent elements of an experience identified by Ortíz Nicólas and Aurisicchio (2011). More details about the creation of this framework can be found in another publication (Gentner, 2014).

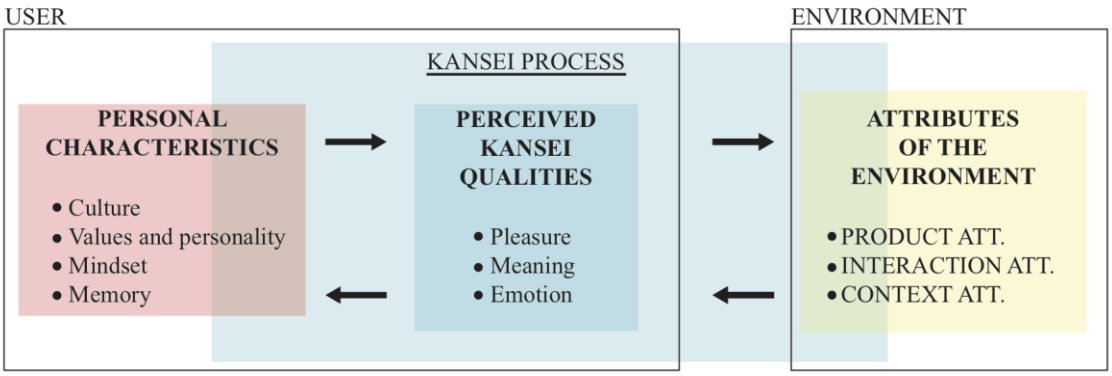


Figure 1: Kansei-experience framework

2.2. The new concept creation phase of the industrial design process

Scholars usually divide the industrial design process into two major phases: the new concept development (NCD) phase and the new product development (NPD) phase (Cooper, 2008; Buijs, 2012). The NPD phase then leads to the commercialisation of the new product. Gero (2010) described an *innovation* as the introduction or uptake of intellectual property (created during the NCD phase) into NPD projects (during which the consumable artefacts are designed). This means that both phases (NCD and NPD) are necessary for the innovation process. This definition of innovation also corresponds to that of Van de Ven (1986): “new ideas that have been developed and implemented” (p. 590). Depending on the changes they involve, innovations can be range from incremental innovation to radical innovation. Their nature also impacts the typology of products to which they are related (Wheelwright & Clark, 1992). In that sense, the nature of the intellectual property created determines the product development strategy that will be adopted by the project managers (Verworn & Herstatt, 1999).

Wheelwright and Clark (1992) distinguished between three main typologies of new products: *breakthrough products*, *platform products*, and *incremental products*. These typologies characterise products based on the extent of product and process change induced by their development.

- *Breakthrough products* involve the most product and process changes. In the automotive industry, the introduction of the first hybrid vehicle in the 1990s and electrical vehicle in the 2000s are good examples of *breakthrough products* (in these cases, the breakthrough innovation came from the engine).
- At the other extreme, *incremental product* developments involve only few process and product changes. In the automotive industry, such developments correspond to small vehicle updates that occur usually three years after the launch of a new vehicle. They involve minor styling and performance changes (but not deep architecture changes).
- In between these two extreme typologies are *platform product* developments. These developments establish a basic architecture for a next generation of product or process and are substantially larger in scope than *incremental products* (Meyer & Lehnerd, 1997). The introduction of a new vehicle and the addition of new body styles (e.g., coupe, convertible, station wagon) are the result of *platform product* developments.

Verganti (2009) identified three types of innovations: market pull, technology push, and design driven innovations (Figure 2). Market pull innovations correspond mostly to *incremental products* and are based on needs expressed by customers. Criticisms from scholars regarding this type of innovation are that customers (the market) have a short-term view and that their requirements are neither fully explicit nor stable (Sandmeier et al., 2004; Norman, 2010). This is why market pull innovations alone cannot induce the changes and intellectual property necessary for the

development of new *platform products* and *breakthrough products*. In recent years, new *platform* as well as *breakthrough products* (and services) providing new and well-achieved experiences gained in importance (e.g., Nintendo Wii, Apple music and app ecosystems) (Verganti, 2009). When dealing with NCD activities, organisations are shifting from a technology-only focus (the two examples given previously do not necessarily have the most advanced technical specifications) to a combination of technology- and design-driven approaches. The latter approach enables organisations to better deal with user experience and concepts that radically influence the meaning of the product. Scholars indeed highlighted both the nonsense of NCD processes focused only on users and their needs, and the importance of considering the UX at the conceptual stage (Norman, 2010; McCullagh, 2010; Karapanos & Martens, 2009).

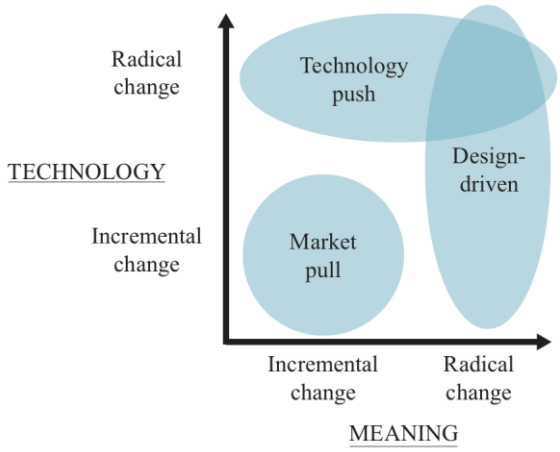


Figure 2: Types of projects at the origin of different innovations (Verganti, 2009)

2.3. Design information

Bouchard, Kim, and Aoussat (2009) studied the design information expressed by design team members when discussing and brainstorming about design intentions during early NCD design-driven activities. The authors gathered design information from empirical studies. They organised it into different design information categories, which were structured into three different groups depending on their abstraction level. The three groups identified corresponded to low, middle, and high levels of abstraction.

- *Low-level design information* corresponds to concrete and sensory attributes mainly related to the artefact to be designed (colour, shape, texture).
- *Middle-level design information* puts in relation abstract and concrete design information. It links abstract design information (i.e., high-level) with information describing a design solution (i.e., low-level). Middle-level design information corresponds to intended functionalities, as well as to the context and sectors or objects used as references.
- *High-level design information* corresponds to abstract information that corresponds to the user's personal characteristics, the user's perceived kansei qualities, and the attributes of the product (users' personal value, semantic words describing the experience, and style inspirations related to the future product).

Each category of design information has been defined and exemplified by Kim et al. (2009). This contribution has been used as a major input for this experimentation and is further detailed in Table 1. Notably, the categories identified by Bouchard et al. (2009) and described by Kim et al. (2009) all relate to the different entities of the intended experience (user's personal characteristics, perceived kansei qualities, product attributes, context attributes) (see also Table 1).

3. RESEARCH QUESTION AND HYPOTHESIS

The research question combines the notions of “kansei,” “new concept creation,” and “design information” described in the state of the art. The research question can be formulated as follows: *What are the design information categories that kansei-focused activities can cover in the early concept creation phase?*

One hypothesis was identified in order to discuss the research question:

> H - The design information exchanged during early design activities depends on the typology of the project in which these activities take place.

4. PRESENTATION OF THE EXPERIMENTATION

4.1. Data gathering

The projects were selected because their outputs described a user experience intention. For each of them, the projects’ material (including a description of the design process and final reports) was analysed and used as an input. Interviews related to each project were also conducted with at least one member of the original project team. The interviews were semi-directed. Approximately 30 minutes were spent for each project. Similar questions were asked each time to clarify the context of the projects. Discussions focusing on the output material (early representation) were then initiated. This part of the interview permitted the gathering of additional information related to the category of design information on which the resulting early representations were focusing.

4.2. Context of the projects

The projects were structured according to their position on the overall operation procedure of the company. Three typologies were identified from the 27 design-driven NCD projects analysed. These typologies are related to the creation of “exploratory concept”, “product lining strategy”, and “pre-development direction.” During the interviews, the context of the project (in regards to one of the three below types) was discussed and specific attention was paid to the project’s purpose, the composition of the design team (culture and affiliation of the members), and the audience addressed by the project.

- The “exploratory concept” group is composed of design-driven NCD projects that intend to explore innovative possibilities able to provide new pleasurable experiences, including new meanings (Verganti, 2009). These projects intend to influence the development of *breakthrough products* as defined by Wheelwright and Clark (1992).
- “Product lining strategy” projects are NCD projects meant to impact upcoming *platform product* development projects (e.g., hybrid vehicle NPD projects). Their outputs highlight kansei directions and related design strategies. They provide material related to user experience that enriches downstream NPD information activities.
- The purpose of “pre-development direction” projects is to prepare an upcoming *incremental product* NPD projects. Similar to “product lining strategy” projects, they intend to communicate kansei directions and related design strategies. As the focus here is on user experience and not on style, these strategies are centred on the kansei qualities that can be expressed by different variations (or grades) of a vehicle update.

4.3. Design information conveyed

In order to classify the design information conveyed by the kansei representations created in the projects, categories were created based on those proposed by Kim et al. (2009). In order to better fit to the experience design focus of the projects, some of the original categories have been adjusted (i.e., extended, divided, or combined). New categories have also been added. Table 1 presents the

19 categories of UX-related design information used for the analysis.

The *action enabled*, *product characteristics*, *interface characteristics*, *engagement required*, *gesture*, and *feedback* categories have been extracted from the original *functionality* category. This was done in order to better identify the nuances of the latter category in terms of design information in regards to related UX entity and level of abstraction. Notably, Kim (2011) identified that this category of design information was the most used during design activities. The new categories should therefore permit refined observations. The original *context* category was extended into *physical* and *temporal context* and the *texture* category was extended to *tactile attribute*. The extensions permitted to cover more accurately these two attributes of the environment of an experience. Some original categories were also grouped. This reduced the unnecessary complexity and eliminated notions that were not the focus of this research. *Form* and *colour* were combined into *visual attribute*, and *analogy* and semantic word were combined into *semantic descriptor*. Finally, several categories were also added that correspond to the design information that was observed during the data gathering and the previous experimentation but was not originally described. The categories were created in order the fit to the user experience framework introduced in the state of the art and used in the previous experimentations detailed in this dissertation. The new categories are *emotion*, *lifestyle*, *culture*, *morphology*, *auditory attribute*, and *olfactory attribute*.

Table 1: Categories of design information used

Category name	**Description**	**Example**	**Related UX entity**
Value [O] (H)	These words represent final or behavioural values.	Ambitious, open-minded	User's personal characteristics
Semantic descriptor [C] (H)	Adjectives related to the meaning and characteristics.	Playful, romantic, traditional	User's perceived kansei quality
Emotion [N] (H)	Targeted emotion to be felt by the user	Joy, surprise, interest	User's perceived kansei quality
Style [O] (H)	Characterization of all levels together through a specific style.	Edge design	Product attributes
Lifestyle [N] (M)	Combination of values of the user	Work hard and play hard	User's personal characteristics
Interface characteristic [E] (M)	Underlying logics, engagement required	Mental engagement, physical and direct interface	Interaction attributes
Action enabled [E] (M)	Function, usage	Create, relax, communicate	Interaction attributes
Product characteristic [E] (M)	Components, ways of functioning, spatial organisation	Mechanical handle, roominess	Product attributes
Sector/object [O] (M)	Object or sector being representative for expressing a particular trend	Tennis, wearable computing	Product attributes
Physical context [X] (M)	Physical elements surrounding the product	In a modern living room	Context attributes
Temporal context [X] (M)	Notion of time in the interaction	Narrative description on an interaction	Context attributes
Culture [N] (L)	The culture of a user covers his/her age, gender, nationality, function, and organisational affiliation.	Young (20-29) Europeans	User's personal characteristics
Morphology [N] (L)	Related to the outward appearance of the user	Body shape, structure, handicap	User's personal characteristics
Gesture [E] (L)	Movement of a part of the user's body used as input	Hand and body movements	Interaction attributes

Feedback [E] (L)	Communication to the users that is influenced by prior inputs	Blinking light and sound	Interaction attributes
Visual attribute [C] (L)	Overall shape or component, shape size, and chromatic properties	Square, long and thin, Light blue, Pantone 17-5641 Emerald	Product attributes
Tactile attribute [X] (L)	Material, temperature, texture	Plastic, stripped surface, rough	Product attributes
Auditory attribute [N] (L)	Rhythm, timber, etc.	Irregular, high pitch	Product attributes
Olfactory attribute [N] (L)	Scent families and facets	Citrus, woody, floral	Product attributes

(H): High level of abstraction

(M): Middle level of abstraction

(L): Low level of abstraction

[O]: Category originally presented by Kim et al. (2009)

[E]: Extracted from an original category

[C]: Combination of original categories

[X]: Extension of an original category

[N]: New category

5. ANALYSIS

In this section, the results of the analysis of each typology of design-driven NCD projects will be presented one by one. The results focus on the context of the projects (purpose, design team, audience), and on the design information conveyed by their output representations. The results will then be discussed together in section 6.

5.1. Exploratory concept (EC) projects

Eleven of the 27 projects analysed were described as “exploratory concept” projects. These include, for instance, the “Window to the world” project, which proposed to tackle the interaction between car occupants and their environment in a poetic and seamless way. An output of this project can be found on Figure 3. More information, such as a video and prototype pictures, can also be found on the Internet (http://bit.ly/15sb6A3 and http://bit.ly/114Gwhq).

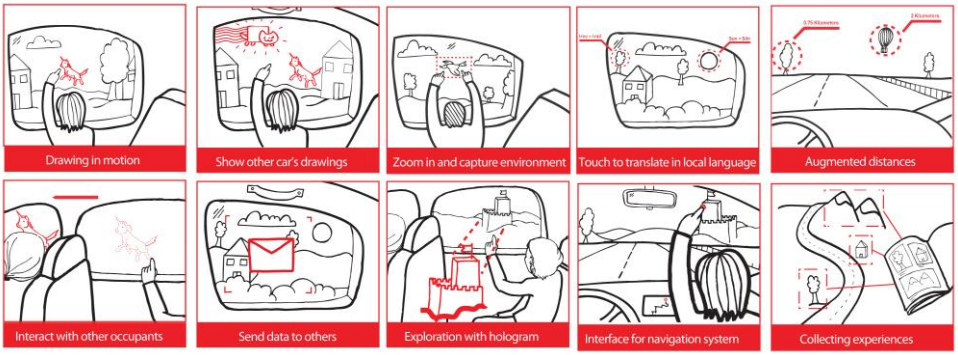


Figure 3: Window to the world project – a TME-KD & CIID collaboration

5.1.1. Context of the projects

The outputs of EC projects were concepts offering new experiences of mobility. Their focus was on mobility itself or on the interactions between a human and the environment (including other humans) supported by a mobility device. They can be regarded as NCD projects providing experience design-driven outputs for future *breakthrough products*. For all of these projects, the design team involved were rather small (around 5 persons) and varied a lot from one project to

another. They were always multi-cultural (multi-nationality, multi-gender, multi-function). The functions covered included design, business, and engineering, as well as complementary functions such as social sciences and computing. Most of the projects (73%) involved design team members external to TME. These external members were affiliated with organisation such as consultancy firms or universities. For every project analysed, part of the final audience was unknown at the start. The audience finally reached was nevertheless much wider than that of the other types of projects. It depended on the topic tackled but also on the advice and recommendations received during the communication process. The audience was generally high up in the organisational scale.

5.1.2. Design information conveyed

The main design information categories conveyed by final outputs of "exploratory concept" projects are presented in Table 2. The table organises categories according to their abstraction level (vertically) and the experience entity to which they refer (horizontally). As shown in this table, it appears that the kansei representations created mostly cover abstract design information. Most of the categories corresponding to high and middle levels of abstraction are covered (all except *style* and *product characteristics*). Notably, no concrete design information categories related to the product to be designed are covered. The narrative and interactive outputs relied on concrete elements in order to communicate the experience intention, but these characteristics did not belong to the main design information that were intended to be communicated.

Table 2: Categories of design information conveyed by EC project outputs

Abstraction level	User's personal characteristics	User's perceived kansei qualities	Interaction attributes	Product and context attributes
High	- Value	- Semantic word - Emotion		
Middle	- Lifestyle		- Interface characteristic - Action enabled	- Sector/object - Physical context - Temporal context
Low	- Culture		- Gesture [EM] - Feedback [EM]	

[EM]: Emerging category

5.2. Product lining strategy (PLS) projects

Ten of the 27 projects analysed fit in the "product lining strategy" project type. These projects include, for instance, the methodologies and outputs such as those presented by the authors in other publications (Gentner, Bouchard, Esquivel, & Favart, 2013).

5.2.1. Context of the projects

"Product lining strategy" projects are meant to impact specific upcoming *platform product* development projects (e.g., hybrid vehicle NPD projects). Their outputs were meant to be used by upcoming NPD teams (internal or supplier R&D teams). The audience was composed of both managerial (for EC projects) and working-level Toyota employees. Therefore, the interviewees expressed the importance of having the experience directions and strategies conveying information that could be used directly by engineering, business, and design departments. Compared to EC projects, the profiles of the multi-cultural design teams were much more structured. Only product planners, designers, and engineers were involved in PLS projects. They also involved fewer members affiliated with external organisations (30% and only as support).

5.2.2. Design information conveyed

The main design information categories conveyed by the kansei representations resulting from PLS projects are presented in Table 3. The scope of information covered is wide. All experience entities except the context are covered with low to high abstraction categories (when a category exists). The kansei representations contained information to guide and inspire styling (e.g., *semantic word, emotion, style, visual attribute, tactile attribute,* and *other sensory attributes*) and interaction design activities (e.g., *semantic word, emotion, gesture, feedback*). They could also be used by product planners interested in information about markets (e.g., *value, culture*) and product package (e.g., *sector/objec*t), as well as by engineers working on topics such as material developments (e.g., *emotion, semantic, style, visual,* and *tactile*). Notably, many categories of design information are currently emerging in PLS projects (noted as EM in Table 3).

Table 3: Categories of design information conveyed by PLS project outputs

Abstraction level	User's personal characteristics	User's perceived kansei qualities	Interaction attributes	Product and context attributes
High	- Value [EM]	- Semantic word - Emotion		- Style
Middle			- Action enabled [EM]	- Sector/object - Product characteristic [EM]
Low	- Culture - Morphology [EM]		- Gesture [EM] - Feedback [EM]	- Visual attribute - Tactile attribute - Auditory attribute - Olfactory attribute [EM]

[EM]: Emerging category

5.3. Pre-development direction (PDD) projects

Six projects could be described as PDD projects. They will be described in terms of context and design information conveyed.

5.3.1. Context of the projects

The UX-related design information that these projects provide was preparing upcoming NPD projects (short-term). The kansei representations were aimed at a very specific audience, such as styling designers (e.g., for wheel development) or material engineers (e.g., for material development). The audience covered both managerial and working-level employees. These representations expressed directions and strategies focused on the kansei qualities that could be expressed by different grade variations of a future vehicle updates. Fifty percent of the projects used kansei cards, a visual tool facilitating kansei-related discussions (Gentner, Bouchard, Badoil, & Favart, 2014).

The particularity of "pre-development direction" projects is that they were directly related to a new *incremental product* development project (NPD). Similar to the other typologies of projects, the design teams involved were multi-cultural. In the teams' composition, a stronger accent was usually put on the function that would later be the most involved in the NPD projects (e.g., more styling designers were involved when preparing styling oriented projects). Notably, this typology of projects only involved members working at TME.

5.3.2. Design information conveyed

The main design information categories conveyed by the kansei representations resulting from PDD projects are presented in Table 4. It can be observed that whereas all product attributes are covered, no design information categories related to interaction attributes are tackled. This can be

put in perspective with the fact that the original role of TME-KD was related to sensory quality perception. The experience resulting from static perception appears to remain the domain of activity of the division the most established for the projects that are the closest to the NPD phase.

Table 4: Categories of design information conveyed by PDD project outputs

Abstraction level	User's personal characteristics	User's perceived kansei qualities	Interaction attributes	Product and context attributes
High	- Value	- Semantic word - Emotion		- Style
Middle	- Lifestyle [EM]			- Sector/object - Product characteristic
Low	- Culture			- Visual - Tactile attribute

[EM]: Emerging category

6. DISCUSSION

The three typologies of projects will now be discussed together. Table 5 summarises this discussion.

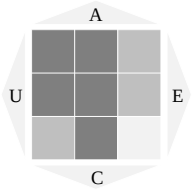
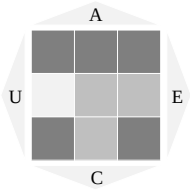
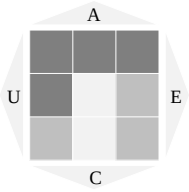
6.1. Context of the projects

By construction, the purposes of the three types of projects are different (this is the definition of EC, PLS, and PDD projects). Similarities could nevertheless be observed regarding the nature of the design teams involved. It appeared that they were all composed of a similar number of members. Five seemed to be the average number, regardless of the project type. The different design teams also had in common the fact that they were multi-cultural. Functions traditionally less related to the industrial context (e.g., human sciences, computing) could only be found in EC projects. The involvement of people outside the company in the design team was the highest for projects related to long-term innovations (EC projects). Their involvement decreased progressively for PLS and PDD projects (when the commercialisation date becomes more and more clear). Differences could also be observed regarding the audience of the projects. Whereas EC projects mainly targeted managers dealing with vision and strategies, PLS and PDD projects' audiences covered both managerial and working-level employees. These two typologies of projects were indeed meant to increase reciprocal understandings of UX topics among upcoming NPD projects teams and their stakeholders.

6.2. Design information conveyed

The kansei representations resulting from the different types of projects had in common the fact that they effectively covered abstract design information categories and that they related these categories to design information categories with a lower level of abstraction. All the types of projects expressed an intention regarding kansei qualities (emotion, semantic descriptor). They also referred the abstract design information related to the potential user (*value*) and to the product to be designed (*style*). Outputs from EC projects were nevertheless the only ones to convey design information related to all five UX entities and sub-entities. PLS and PDD projects lacked information about intentional contexts of use (temporal, physical), and PLS projects did not covey any intention related to interaction attributes.

Table 5: Summary of the experimentation

		Exploratory concept	**Product lining strategy**	**Pre-development direction**
Context of the projects	*Purpose*	Propose new experience concepts for future *breakthrough products*	Identify user experience logics and directions for future *platform products*	Prepare grade and character strategies of future *incremental products*
	Design team	- Multi-cultural - Members from inside and outside the company	- Multi-cultural - Mostly members from inside the company	- Multi-cultural - Only members from inside the company
	Audience	- Wide but fuzzy - Mostly management level	- Specific - Management and working levels	- Very specific (development team) - Management and working levels
Design information conveyed	*High level*	PC: Value KQ: Semantic descriptor, emotion	PC: Value KQ: Semantic descriptor, emotion PA: Style	PC: Value KQ: Semantic descriptor, emotion PA: Style
	Middle level	PC: Lifestyle IA: Interface characteristic, action enabled PA: Sector/object CA: Physical context, temporal context	IA: Action enabled PA: Sector/object, product characteristic	PC: Lifestyle PA: Sector/object, product characteristic
	Low level	PC: Culture IA: Gesture, feedback	PC: Culture, morphology IA: Gesture, feedback PA: Visual, tactile, auditory, olfactory att.	PC: Culture PA: Visual, tactile att.
	Summary			

Design information conveyed
PC: Personal characteristics
KQ: Kansei qualities
IA: Interaction attributes
PA: Product attributes
CA: Context attributes

A: Abstract
C: Concrete
U: User
E: Environment

For EC projects, the design information related to the product to be designed remained abstract. On the contrary, this type of design information was very present for PLS and PDD projects. This is indeed the experience entity that appeared to be most directly impacted by the NPD projects that followed. This might be because it is where new meanings and experiences are traditionally created in the automotive industry (e.g., interior layout, materials, features).

EC projects and, increasingly, PLS projects conveyed design information related to interaction attributes. They covered categories such as *gesture*, *feedback, interface characteristic,* and *action enabled* (*action enabled* only for EC). The reasons for this were nevertheless different. On the one hand, EC projects proposed concepts with radically new UX (in the sense of Verganti, 2009) that included new interaction propositions, and on the other hand PLS projects increasingly sought to investigate the influence that different interfaces (e.g., button vs. touchscreen) have on the

perceived kansei qualities in conventional vehicle environments. In the latter case, the interaction-related design information enriched the recommendations provided by the resulting kansei representations.

As highlighted previously, the outputs of PLS and PDD projects did not express any specific intentions related to the contexts of the intended experiences. One reason for this is that the temporal and physical contexts of new *platform* and *incremental products* resemble that of current vehicles. This aspect is therefore not the centre of attention of these project typologies.

In Table 5, the summary figures related to the design information section give an overview of the typical categories covered by each typology of project. The darkness of the box is proportional to the precision with which the area is covered. The vertical axis corresponds to the abstraction level (low, middle, high). The anchors of the horizontal axis are labelled “user” and “environment.” The left column corresponds therefore to design information describing the targeted user (i.e., personal characteristics) and the right column to design information describing static aspects of the environment (i.e., intentional product attributes, physical context). Finally, the centre column corresponds to the information related to the intended user-product interaction (i.e., kansei qualities, interaction attributes, temporal context). The related categories neither describe to the targeted user, nor the intended product and environment of use.

7. CONCLUSION

It this experimentation, 27 industrial NCD projects conveying an intention in terms of user experience were analysed. Their outputs can be referred to as kansei representations as they link intended kansei qualities with personal characteristics of targeted users and attributes of the environment of design. The three types of projects identified (“exploratory concept,” “product lining strategy,” “pre-development direction”) were described and compared in terms of context and design information categories conveyed by their outputs.

This experimentation enabled us to validate our hypothesis (H - The design information exchanged during early design activities depends on the typology of the project in which these activities take place). Indeed, it appeared that the design information exchanged during early concept creation phases is very dependent on the type of project in which the concept creation phase occurs. Although this experimentation covered 27 industrial design projects, one limitation that can be identified is that these projects were all related to the same organisation (TME-KD). Additionally, further activities should also be conducted in order to better relate the design information conveyed with the design methodologies and with the nature of the early representations used as a means of communication (e.g., visual, multi-sensory, narrative).

A model of kansei-related design information has been created in order to better picture the contributions of this experimentation and to facilitate future researches of the subject. The model, which is presented in Figure 4, keeps the structure of the figures used in Table 5 in order to summarise the design information conveyed by the three identified typologies of design-driven projects. The design information categories in Table 1 are presented according to two dimensions (two axes) representative of their level of abstraction (vertical axis) and of the experience entity to which they are referring (horizontal axis). In that sense, the model shows a representation of the experience originating from a human-product interaction (see “kansei-experience framework” in Figure 1) from the perspective of the design information exchanged during concept creation activities.

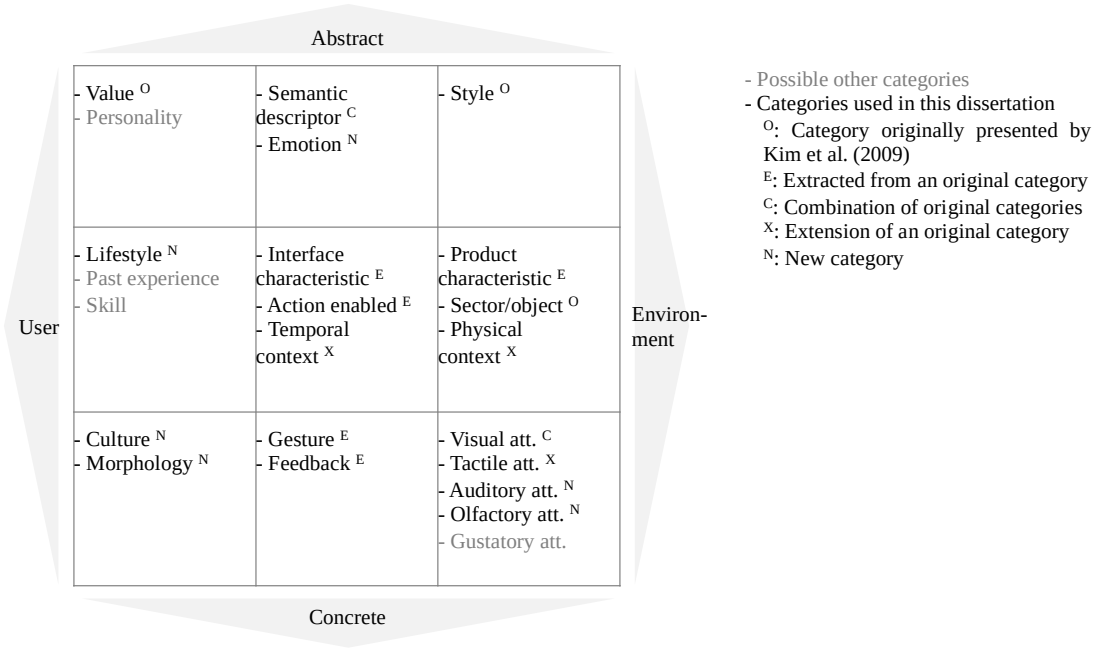


Figure 4: Model of kansei-related design information

Besides describing the design information exchanged within a design team, the model also facilitates comparisons and discussions related to our research question (*What are the design information categories that kansei-focused activities can cover in the early concept creation phase?*). The summary figures displayed in Table 4 are a good example of this additional function of the model.

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BIOGRAPHY

Alexandre Gentner recently defended his PhD research focusing on the definition and representation of user experience intentions in the early phases of the industrial design process. This action research was made possible because of a long-lasting collaboration between Arts&Métiers ParisTech (university) and Toyota Motor Europe (industrial partner). In this research, he explored the bridges existing between user experience and kansei research and the way these aspects can be addressed in early design activities. Some of the industrial contributions of this research were the creation of tools and methodologies supporting the reciprocal understanding of design information-rich representations of user experience directions.

Carole Bouchard is professor at Arts&Métiers, ParisTech (France). She teaches and guides research in The Product Design and Innovation Laboratory. She obtained her PhD in 1997 in the field of automotive design and is professor since 2012. Her research focus lies on Kansei Design, as well as creativity and innovation in early design stages. She pilots various research projects that seek to develop innovative design tools to efficiently integrate the Kansei in the design process and was one of the organizers of KEER 2010.

Carole Favart is leading the Kansei Design Division based in Toyota's European R&D centre (Belgium). She initiated this design-oriented cross-functional division at Toyota Motor Europe (TME) in order to optimize synergies between R&D, Product Planning and Design. This division, created in 2004, was recently promoted as one of TME R&D's "Competency Centre", and is unique in the Toyota organisation. It plays an active role for advanced models and vehicle development, creating also new methodologies and tools supporting strategic design as well as mid- and long-term visions. Since 1990, Carole Favart is also involved in design education (teacher and jury). She is also part of as well as in professional design think tank and committees.

Kansei cards

A visual tool supporting the investigation, discussion, and representation of the kansei-related intentions of a product to be designed

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Abstract: In order to strengthen communication efficiency between different functional teams and discuss the experience potential users could have with products, a tool composed of various sets of cards was created: the *kansei cards*. The pictures and keywords represented allow, according to the situation, for an investigation, discussion, and representation of intentional kansei qualities. Over the last three years, this tool has been used in various industrial design projects.

In this paper, we will first detail the state of the art that will set the frame for our research and introduce the key notions related to the creation of the tool and related methodologies. After having detailed our research question and hypothesis, we will present the creation of the *kansei cards* and two experimentations making use of them. The first methodology involves “users” in participatory design sessions to test if the cards permit an identification and communication of the directions of kansei-related design information. The second explores the impact that the cards have on discussions related to intentional experiences occurring within design team prior to idea-generation activities. To conclude, we will discuss the added value and limits of the tool and, more generally, the representation of kansei-related design information.

Keywords: collaborative design tool, kansei design, kansei-related design information, new concept development, picture-based early representation

1. INTRODUCTION

In design practice, the early design phase can be described as the “new concept development” (NCD) stage, which is characterised by the creation of new intellectual property (Gero, 2010). This newly acquired knowledge might have the opportunity, later in the design process, to be transformed into innovation when transferred into the development of future products or services (new product development phase). At the NCD stage, research teams (marketing people, styling designers, engineers) investigate style and rational qualities related to the product to be designed as well as in terms of trends in customer preference. At this moment of the design process, it often happens that the teams involved in these different types of consideration are disconnected one from another (Koen et al., 2002).

Products characterized as experience-driven innovations have their roots in projects at the new concept development (NCD) stage (Verganti, 2009). The design of experience is critical in these projects because decisions made at the conceptual design stage have the highest impact on the final user experience (UX) and eventually on UX failures (Karapanos & Martens, 2009). This article will explore if and how a visual tool (*kansei cards*) can support the investigation, discussion, and representation of kansei-related intentions of a product to be designed at this early stage of the design process.

2. STATE OF THE ART

2.1. User experience and the kansei process

Ortíz Nicólas and Aurisicchio (2011) analysed 11 user experience frameworks from the literature in an attempt to bring together in a consistent overview the rapidly growing and disjointed literature on the subject. The conclusion of this research suggested that even if the perspectives and focus points of the 11 researchers were different, common constituent elements (user, interaction, artefact, context) and aggregates (subjective, conscious, emotional, interconnected, dynamic) of user experience were acknowledged by the majority of the perspectives reviewed.

The situation described with the term *user experience* can be understood in relation to the definition of the *kansei process*. Lévy, Lee, and Yamanaka (2007) described the latter as the function of the brain related to “emotions, sensitivity, feelings, experience and intuition, including interactions between them” (p. 9). It is further described as originating in one’s sensory perception and personal characteristics (*kansei means*) and providing as output a qualitative meaning and value of the environment (*kansei result*). Notably, Lévy et al. indicated that the flow between kansei *means*, *process*, and *results* is not strictly linear and that these different aspects influence each other.

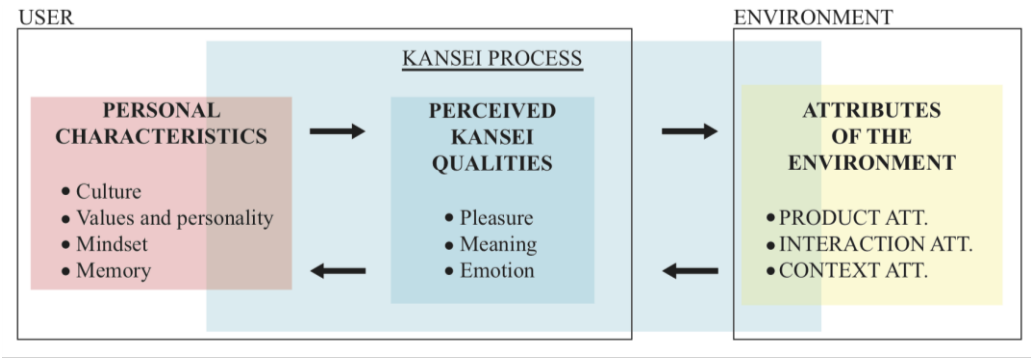


Figure 1: Kansei-experience framework

Figure 1 represents a framework that combines the notions of user experience and kansei process. It represents the main entities of an experience during the interaction between a user and a product. The *personal characteristics* and *attributes of the environment (product, interaction, context)* cover what has been previously defined as *kansei means*, whereas the perceived kansei qualities are direct consequences of *kansei results*. Notably, the framework also retains the four constituent elements of an experience identified by Ortíz Nicólas and Aurisicchio (2011). More details about the creation of this framework can be found in another publication (Gentner, 2014).

2.2. Multi-cultural design teams

A common culture exists among people who share the same nationality, organisational affiliation, function, age or gender. Yet, nowadays most design teams working in industrial design processes are multi-functional (Dahlin Weingart, & Hinds, 2005). This means that the team members have different functional backgrounds, including that of designers (styling), engineers (technology), and business managers (product planning, marketing). Related to the phenomenon of globalisation, contemporary design teams are often composed of people of different nationalities and even different organisational affiliations. This is especially true in the automotive industry, which is organised internationally in networks composed of OEMs, suppliers, and contractor companies (Miller, 1993). For all these reasons, many current design teams can be described as multi-cultural. The function of team members is determined by both their education and work experience. According to Bunderson and Sutcliffe (2002), a person's dominant function is that in which he has worked most of his life. Dominant functions give team members a functional perspective that influences the way they think, act, and behave. Differences in terms of functional perspectives between team members create "functional walls" that surround individuals and hinder interaction between team members (Bunderson & Sutcliffe, 2002).

Graff, Koria, & Karjalainen (2011) discussed these "functional walls" in conjunction with the "jointness" principle developed by Douglas and Strutton (2009). This principle was at first aiming to be used within the general organisation context. It relies on four factors: *functional competences*, *reciprocal understanding*, *cross-functional communication*, and *trust*. *Functional competences* are presented as indispensable preconditions enabling other factors to emerge (Douglas & Strutton, 2009). According to Graff, Koria & Karjalainen *reciprocal understanding* and *cross-functional communication* can be acquired through education, training, and cross-functional team experience. *Trust* is then finally built on top of reciprocal knowledge, the result of the three other factors. Cantalone, Droge, & Vickery (2002) also showed that while *trust* does not guarantee success, its absence increases the probability of failure. The presence of these factors (especially *reciprocal understanding* and *cross-functional communication*) in a cross-functional design team opens the "functional wall" and increases team effectiveness (Graff et al., 2011).

In addition to the notion of the "functional wall," authors observed other opportunities and challenges related to multi-cultural design teams. Gibson (2004) and Graff, Mikko, and Karjalainen (2009) also highlighted the importance of having multi-cultural teams at the NCD stage. It appears that even if such teams are more chaotic, they are also more likely to come up with ideas leading to breakthrough innovations (improved decision quality, greater innovation, higher adaptability).

2.3. Informational design activities and picture-based early representation

2.3.1. Design information

Bouchard, Kim, and Aoussat (2009) studied the design information expressed by design team members when discussing and brainstorming about design intentions during early design phase activities. The authors gathered design information from empirical studies. They organised it into

different design information categories, which were structured into three different groups depending on their abstraction level. The three groups identified corresponded to low, middle, and high levels of abstraction.

- *Low-level design information* corresponds to concrete and sensory attributes mainly related to the artefact to be designed (colour, shape, texture).
- *Middle-level design information* puts in relation abstract and concrete design information. It links abstract design information (i.e., high level) with information describing a design solution (i.e., low level). Middle-level design information corresponds to intended functionalities, as well as to the context and sectors or objects used as references.
- *High-level design information* corresponds to abstract information that corresponds to the user's personal characteristics, the user's perceived kansei qualities, and to attributes of the product (user's personal value, semantic words describing the experience, and styles inspirations related to the future product).

Notably, the different categories of design information identified by Bouchard et al. (2009) relate to different entities of the intended experience (user's personal characteristics, perceived kansei qualities, product attributes, interaction attributes, context attributes).

2.3.2. Informational design activity

Together with *generation*, *evaluation & decision*, and *communication*, *information* is one of the four main design activity (Bouchard & Aoussat, 2003; Cross, 2008). This model has the particularity of being fractal, as it can describe design activities occurring at different levels (e.g., at a micro-level it corresponds to designers' continuous "Seeing-Drawing-Seeing" cycle (Schön & Wiggins, 1992)). In this paper, the model will be used at a macro level in order to describe design tasks. In this case, the time span of an activity is typically counted in days.

The purpose of informational activities is to gather information and to find inspiration in order to prepare the subsequent activities (Sanders, 2005). Informational activities are usually, although not always, followed by generation activities. Several categories of tools and methodologies exist in order to support these activities (desk research (Wormald, 2010), field research (Vredenburg, Mao, Smith, & Carey, 2002), interviews (Lee Harada, & Stappers, 2002), questionnaires (Karapanos, 2010), involvement of users (Sanders, 2006)). After discussing picture-based representation in section 2.3.3, information activities involving these representations will be presented in section 2.3.4.

2.3.3. Picture-based early representation

Baxter (1995) identified several types of image-based representations created by designers and used by design teams during research and development activities. These representations focus either on targeted users and represent abstract (high-level) design information related to these users ("lifestyle boards") or on the product itself ("mood boards" and "visual theme boards"). In the case of product representations, Baxter differentiated boards that "try to identify a single expression of values for the product" (p. 222) ("mood boards") and boards that represent a style direction that is more focused on visual aesthetics ("visual theme boards"). Therefore, these two types of representations convey different categories of design information. Whereas "mood boards" are focused on high-level design information such as *analogy*, *semantic word*, and *style*, "visual theme boards" convey both low- and high-level design information related to the attributes of the product to be designed (*style*, *sector/object*, *form*, *colour*).

An ethnography study undertaken in an industrial context has shown that these compositions of images play an important role in design communication (Eckert & Stacey, 2000). The boards

described correspond to the “mood boards” defined by Baxter (1995), as they were composed of images describing an aesthetic impression direction and a specific semantic. The researchers identified that the image boards were used from the early design phase to the end of the styling design process, where they are used to illustrate sources of inspiration together with design propositions. They also highlighted the fact that “mood boards” have the property to define and communicate a design space (i.e., design direction). Another research conducted by McDonagh and Denton (2005) highlighted the importance of picture-based representations as a tool supporting both information and communication activities occurring during the NCD phase.

2.3.4. Involvement of “users” in picture-based early representation

Potential future users are often involved in user-centred design activities. They can either be treated as subjects or as partners (Sanders & Stappers, 2008). In both cases, picture-based early representations are considered simple and efficient ways to engage with users. We will now introduce two inspiring methodologies that treat potential users as partners of the design team.

- In the *mutual design approach with image-icons*, “users” are asked to select images that fit their impression of a given design brief (Lee et al., 2002). A computer-aided process permits them to construct image-icons from the selected inspirational pictures. These image-icons are used as inspiration for concept generation activities.
- *Collages* also make use of the engaging quality of images. In this methodology, “users” are asked to create picture-based representations similar to “mood-boards” or “visual theme boards” (Sanders, 2006). These collages are then used both as material to trigger discussions with “users” and as inspiration for the design team.

3. RESEARCH QUESTION AND HYPOTHESIS

The notions of “user experience,” “multi-cultural design team,” and “early representation” described in the state of the art are all underlying the research question. The research question can be formulated as follows: *How can design activities enabling the definition and representation of user experience intentions be improved?*

One hypothesis was identified in order to discuss the research question:

> H – The exchange of kansei-related design information during informational design activities can be supported by visual tools.

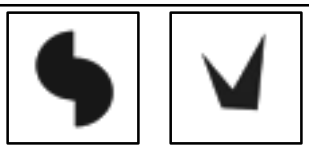
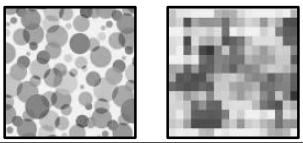
4. EXPERIMENTATIONS

In this section, we will first present the visual tool and then go through two experimentations making use of it and testing its added value. The first experimentation involves a participatory design sessions with potential users, whereas the second tests the tool with multi-cultural design teams.

4.1. Kansei cards

The intention of *kansei cards* is to enable participants of collaborative design sessions to identify and communicate their experience-related expectations or impressions regarding a context. In the state of the art, it could be seen that pictures have the ability to convey a wide range of design information. It was therefore decided that different families of pictures should be created. Each family should focus on particular categories of design information and the pictures from each family should cover the widest possible spectrum of variations within these categories.

Table 1: Example of 11 families of *kansei cards*

Family topic	Amount of cards	Main category of design information	Example of pictures
Simple shapes	59	- Semantic descriptor - Visual attribute (shape)	
Patterns	95	- Semantic descriptor - Style - Visual attribute (shape)	
Animals	47	- Value - Semantic descriptor - Emotion - Product characteristic - Gesture	
Natural landscapes	30	- Value - Semantic descriptor - Emotion	
Chairs	30	- Style - Semantic descriptor - Product characteristic	
Sports	37	- Value - Semantic descriptor - Emotion - Interface characteristic - Temporal context	
Flowers	31	- Semantic descriptor - Style - Visual attribute (shape+colour)	
Arm gestures	29	- Semantic descriptor - Emotion - Interface characteristic - Gesture	
Semantic keywords	16	- Semantic descriptor	
Emotions	17	- Emotion	
Instrumental values	18	- Value	

Through a pilot study, it was validated that participants easily extracted key design information

from the pictures and used these pictures to illustrate one of their ideas (Gentner, 2010). Another learning point from the pilot study was that it was easier to analyse and compare the association made with families of items commonly known across age groups and cultures (music instrument or animals vs. cities or cartoon heroes).

Fourteen families of *kansei cards* were then created: eleven families of pictures and three families of keywords. The families of pictures display simple shapes (59 samples), patterns (95 samples), landscapes (30 samples), products and ambiances (90 samples), chairs (30 samples), animals (47 samples), flowers (82 samples), music instruments (31 samples), localised gestures (35 samples), arm gestures (29 samples), and body gestures (28 samples). Each family of cards was created to focus on specific categories of design information (see examples in Table 1). For example, all the cards (except for those in the "flowers" family) were printed in black and white in order to remove the influence of colour. The three keyword-families correspond to semantic keywords (34 samples), emotions (33 samples), and instrumental values (18 samples). English and Japanese translations of each keyword were displayed together on the *kansei cards*. The dimensions of cards are 9x9cm for the pictures and 11x4cm for the keywords cards. Both sets of cards were made out of rigid cardboard.

4.2. Use in participatory design sessions

4.2.1. Protocol

The first experimentation was divided into three main activities. Participants followed the step-by-step protocol detailed in Figure 2. Before going through the three activities, participants were greeted and introduced to the context and the overall content and purpose of the experimentation. The context of this experimentation is the definition of UX directions for the next generation of hybrid car (NGH) and for European customers. Thirty-three participants attended the sessions. They each took about an hour to individually complete the protocol. The participants were all hybrid car drivers and were considering such cars as a possible future purchase. The participant pool covered nine different European nationalities. Belgian nationality was by far the most represented, with 11 participants (the experimentation took place in Belgium).

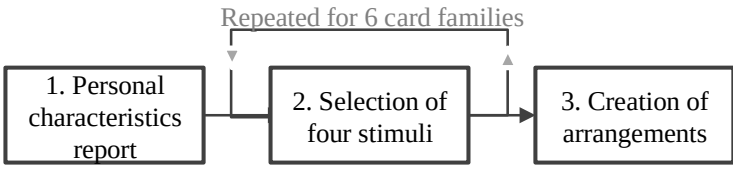


Figure 2: Protocol of the participatory design session

1. When starting the experimentation, the participants were asked to report information about their age, gender, and nationality.
2. The second section of the experimentation involved five families of *kansei cards*: "animals," "simple shapes," "patterns," "flowers," and "products and ambiances." Magnets were attached to the cards and they were organised by family on five whiteboards. The five families were selected because of their complementarity. Together they covered abstract design information related to the perceived kansei qualities, as well as to attributes of the product to be designed (e.g., emotions, semantic keywords, as well as style) and concrete design information related to the product to be designed (e.g., shape, colour, etc.). In order to even better cover concrete design information, colour samples (15x11cm) from the "Color-aid" colour model were also displayed on a table (314 samples). At this stage, the participants were introduced to the different families of samples and asked to select four samples that they considered as being the closest to their idea of NGH from each family. This selection was followed by a brief interview during which they explained their choices.

3. In this section, participants were asked to investigate possible kansei-related directions for NGH. In order to do so, they were asked to create different representations by putting together samples they had previously selected. The directions created were composed of arrangements of three to six samples and always included one colour sample. Using that colour sample, the participants were then asked to create a colour harmony using additional samples from the colour model. Once the arrangements were created, a semi-structured interview was conducted with the participant. They were asked to comment on their compositions and the ideas they wanted to convey. To conclude this section of the experimentation, the participants were asked to assess all their arrangements on 5-point semantic differential scales. A selection of six semantic keywords was used (e.g., *dynamic*, *premium*, *leading-edge*, etc.). The anchors were labelled “not at all” and “extremely,” whereas the central point was labelled “moderately.”

4.2.2. Analysis and results

For each participant, the selected of *kansei cards* and related comments were reported into a digital database. For the sake of comparison, the comments were progressively clustered (after multiple iterations) into “comment categories” corresponding to kansei qualities (e.g., *elegant*, *minimalistic*, *freedom*, *technology*, *joy*). As a result, the kansei qualities that were most often referred to could be identified. The structured database of the five kansei card families were then used as input for principal component analyses (PCA), which display on 2-axes graphs all the variables and permit to observe the main correlations occurring between them.

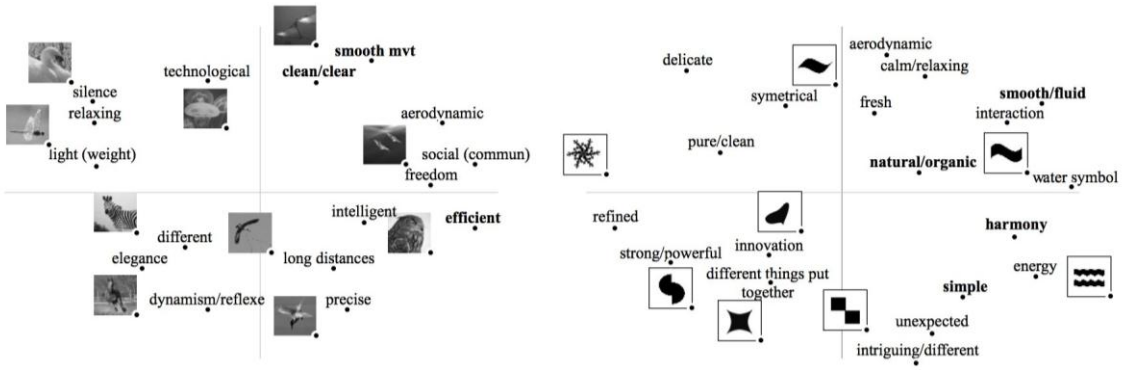


Figure 3: PCA of the “animals” and “simple shapes” families

The PCA permitted the creation of statistically robust (depending of the variability in the data represented by the principal components) kansei mappings related to each family of *kansei cards*. The ones related to the “animals” and “simple shapes” families are represented in Figure 3 (only the cards that were selected most often are displayed). Several kansei-related directions combining keywords and images can clearly be identified on both graphs. The kansei qualities to which participants referred to the most are represented in bold.

The 33 participants created a total of 89 arrangements. Using the arrangements created and described as input, another database was constructed. For each arrangement, the selected samples (*kansei cards* and colour samples) were first reported. “Comment categories” were created in similar ways as described previously. The rating of the arrangements relative to the six semantic keywords was also integrated to the database. These variables were particularly interesting because they had the particularity of being common to every arrangement (5-point SD scale rating). In this case, in addition to a PCA, a hierarchical cluster analysis (HCA) was made using the first five principal components. This enabled an identification of the seven main clusters of correlated variables. Each of the 89 arrangements can be related to one of the clusters on the PCA mapping (depending of their position relative to the area covered by each cluster). Figure 4 details two of the seven clusters identified. In addition to the expressed and rated kansei qualities, the *kansei cards*

that appeared the most in each cluster are also shown. For each cluster, the most selected kansei quality is represented in bold. A specific activity was also conducted regarding colours and colour contrasts. Parts of the results are displayed at the bottom of each cluster. Each cluster also contains an example of colour harmony, description of the typical hue and of the typical intensity of contrast of hue and light-dark contrast (as described by Itten (1967)). This activity combined statistical analysis (colour and type of contrast related to each cluster) as well as interpretation of the arrangements made (description of the hue and contrast using pictures of the 89 arrangements).

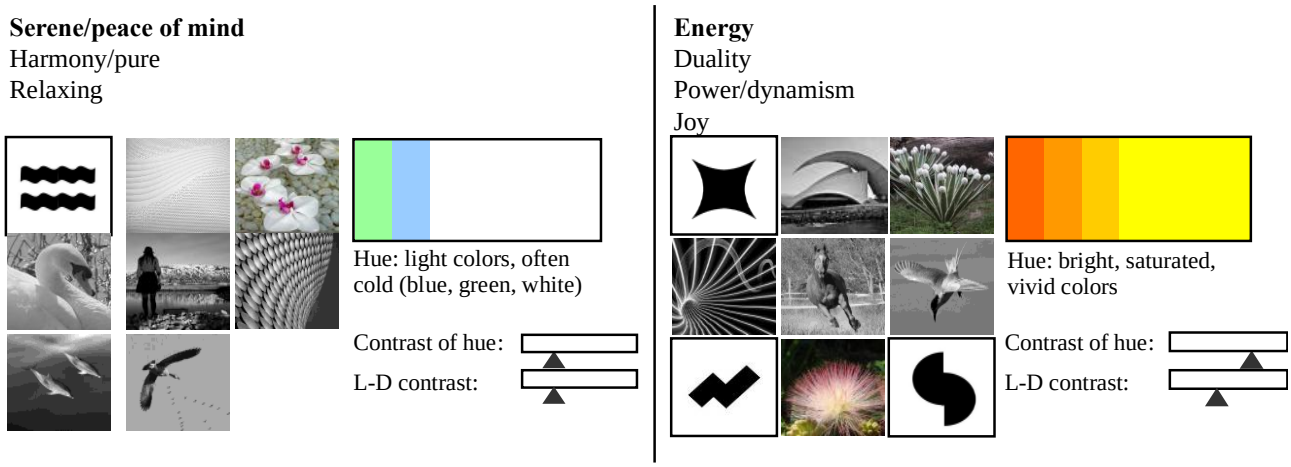


Figure 4: Example of 2 clusters

4.3. Use as a co-design tool within a design team

4.3.1. Protocol

For the second experimentation, two protocols were created: one for the *control group* and one for the *test group* (Figure 5). The groups both represented multi-cultural design teams. Only section B of the protocol was different for the two groups, whereby the *test group* participated in a co-design activity involving the *kansei cards* whereas the *control group* did not.

Two design challenges were tested in this experimentation. For each of them, a *control group* (CG) and a *test group* (TG) followed the protocols detailed in Figure 5 (four groups in total). The groups representing the design teams were multi-cultural. They were always composed of two professional engineers and two professional styling designers. For each of them the gender and nationality distribution of the participants was the same: two males and two females, and two Europeans and two Japanese. All of them were Toyota Motor Europe (TME) employees, and the moderator was always the first author of this paper. The groups were nevertheless not real design team as the participants were selected on a voluntary basis. Some of the participants knew each other but none of them were used to working together. It took approximately 1 hour for the *control groups* and 1 hour and 30 minutes for the *test groups* to complete all the tasks.

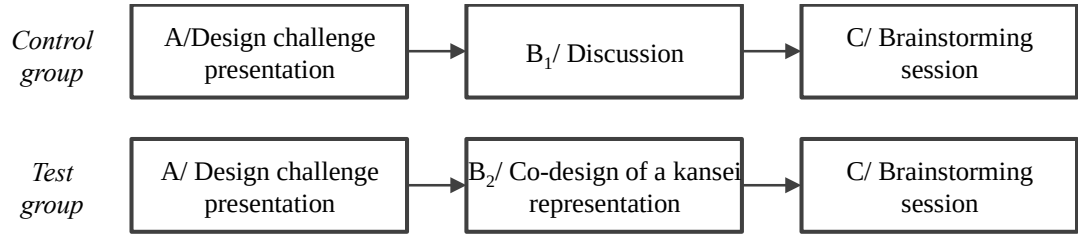


Figure 5: Protocol of the co-design activity

1. Both groups started with the “design challenge presentation” section. This consisted of a presentation on the project’s background and the findings of researches previously undertaken

(technology, context). It took a total of approximately 15 minutes. A design challenge related to the urban mobility topic was then presented to the design team. The two design challenges used in this experimentation were “Give more flexibility to people using their car as a working tool (e.g., nurses, salespeople)” (DC1) and “Give elderly people easier access to their favourite places” (DC2). Note that the design challenges were created for the purpose of this experimentation and are not related to any project currently investigated by TME.

2a. For the *control group*, section B consisted of a free discussion about the topic and the design challenge among the members of the group. This section lasted about 15 minutes for both control groups.

2b. For the *test group*, the presentation of the design challenge was followed by a “kansei representation co-design” activity. During this activity, the participants were asked to position cards from different families on a table. Two axes representative of the context of study and prepared before the experimentation structured the space. In both cases, the anchors of the axes used were labelled “city centre” and ”suburbs,” and “efficient” and “comfortable.” The participants selected cards they believed to be relevant and discussed the positioning of the cards among themselves. This allowed them to co-create a common kansei representation of the field studied (Figure 6). This activity was moderated in order to last 45 minutes. For both design challenges, five families of *kansei cards* were used: “animals,” “sports,” “music instruments,” “semantic words,” and “emotions.” Examples of cards are visible in Table 1. These families were selected because they appeared to be complementary and relevant to the topic of the experimentation.



Figure 6: Result of the co-design activity before rating the cards

3. For both *control groups* and *test groups*, the final section was a brainstorming session. The participants were given 25 minutes to generate ideas and represent them on A5 pieces of papers. Before that, the activity was presented to them (including rules such as “Encourage wild ideas," "Build on the ideas of others," "Stay focused on the topic," "Respect everyone and let everyone speak") and examples of ideas were given by the moderator.

4.3.2. Analysis and results

The “kansei representation co-design” activity was new to all the participants of the *test groups*. The tasks (including discussing, positioning, and rating the cards) seemed rather easy for them to accomplish. They all reacted positively and contributed with interest. This activity enabled the groups involved in both design challenges to define together the kansei states (user’s values, emotions felt, possible semantic-related needs, etc.) that a potential user would have in several situations. The cards also facilitated discussions related to the artefact to be designed (e.g., style intention, sensory characteristics) and its context (e.g., road infrastructure, issues related to period of the day and transportation behaviours).

In total, the participants created 66 concept ideas (33 for both design challenges). These ideas were given to three user experience experts (professional or academic), who were asked to assess them according to two criteria: their kansei qualities and rational qualities. Using predefined guidelines, the experts individually assigned a number of stars to each concept idea (from 1 to 3). If a consensus was not reached for specific concepts at this stage, it was reached after discussion between the three experts. Figure 7 presents two concept ideas related to the first design challenge (both created by test group participants). The idea on the left has been rated 1 star by the expert panel, whereas the one of the right has been rated 3 stars.

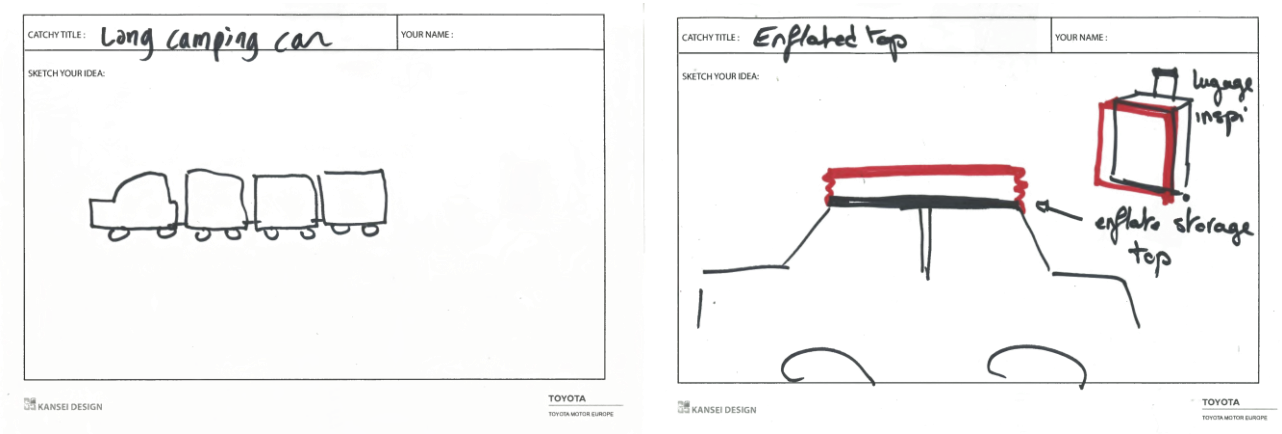


Figure 7: Concept generation for DC1 and rated with 1 star (left) and 3 stars (right)

When comparing the results of both groups, it appeared that the concept created by the participants involved in *test groups* surpasses the ones from *control groups* in terms of both quality and quantity (Table 2). On average, the brainstorming following a co-design activity produced 66% more concepts and had a higher ratio of valuable concepts: 80% of them were rated 2 or 3 stars for the *test group* instead of 68% for the *control group*. Even though the amount of brainstorming organised is not significant enough to draw conclusions about the exact added value of the co-design of kansei representation activity, it appeared to have a significant impact on the brainstorming performance of multi-cultural design teams.

Table 2: Rating of the concepts created by the four different groups

Groups	Design challenge	1 star concepts	2 stars concepts	3 stars concepts	Total
Control group	DC1	3	3	5	11
Test group	DC1	5	8	9	22
Control group	DC2	5	4	5	14
Test group	DC2	3	7	9	19

5. DISCUSSIONS

In the previous section, the *kansei cards* were presented and two ways of using them during early phase design activities were investigated with two distinctive experimentations.

In the first experimentation, the cards were used in participatory design sessions involving potential future users. The methodology presented is situated between the *mutual design approach with image-icons* (Lee et al., 2002) based on logical and structured reasoning, and *collage* methodology (Sanders, 2006) based on an intuitive and abductive way of thinking. Guided with predefined samples and a protocol including association sessions and semi-directed interviews, the participants were able to construct their own images of intended user experiences including pictures

and words. Statistical analysis permitted then to construct seven main experience directions for future hybrid cars from the input of the 33 participants. The directions cover design information with low to high levels of abstraction and include explicit keywords as well as inspirational pictures and colour harmonies.

The second experimentation exemplified in a structured setting the way the *kansei cards* are used to trigger discussions among multi-cultural design teams. It first showed that the design teams members are able to discuss user experience-related topics with design information with both high and low levels of abstraction. The comparison with discussions not involving these picture-based early representations showed that when using the cards the outcomes following concept generation activities were better in terms and quality and quantity. This led us to think that the use of the cards tends to break down walls between design team members of different genders, functions, and nationalities. In that sense, the cards probably positively influence factors such as *reciprocal understanding*, *cross-cultural communication*, and *trust* within design teams (Graff et al., 2011). Visually representing design intentions also permits for a communication of the sources of inspiration together with design propositions in later stages of the design process. Eckert and Stacey (2000) have highlighted the positive effect of this combination on communication activities. This aspect could nevertheless not be examined in the experimentation developed in this paper.

Both experimentations validated our hypothesis (H – The exchange of kansei-related design information during informational design activities can be supported by visual tools). Indeed, in both cases the *kansei cards* were used to gather or exchange a wide range of design information, with low to high abstraction levels. This information has the particularity of covering intentions related to kansei means (personal characteristics, attributes of the environment) and to direct consequences of the kansei results (perceived kansei qualities). In that sense, the two design methodologies presented correspond to valid answers to our research question (*How can design activities enabling the definition and representation of user experience intentions be improved?*). Limitations can nevertheless be identified. For instance, the families of *kansei cards* fail to describe the complete scope of possibilities for any given design information category and some categories are rarely covered (tactile attributes only included to some extent in “animals,” “music instruments,” and “products and environments”). Also, the families of cards only contribute rather vaguely to discussions related to intentional interactions attributes. Picture-based early representations are therefore complementary to other types of early representations such as multisensory representations or narrative (often scenario-based) representations.

6. CONCLUSION AND PERSPECTIVES

From a general perspective, the *kansei cards* presented in this article can be seen as an attempt to emphasize the importance of exchanging kansei-related design information in early phases of the design process. This paper showed that it is possible to represent a complex combination of design information before styling design activities (e.g., initial sketches). Moreover, it showed that it is possible to do this with only limited material and resources. Finally, it also allowed us to identify that these early kansei-related design information exchanges appear to have a positive influence on the subsequent generation activities.

Notably, the tool and experimentations presented in this paper point towards greater prospects. Several other experimentations that have been either planned or conducted following those presented here will enable better understandings of the design information exchanged in the early design phases and create methodologies and early representations that fit more situations.

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BIOGRAPHY

Alexandre Gentner recently defended his PhD research focusing on the definition and representation of user experience intentions in the early phases of the industrial design process. This action research was made possible because of a long-lasting collaboration between Arts&Métiers ParisTech (university) and Toyota Motor Europe (industrial partner). In this research, he explored the bridges existing between user experience and kansei research and the way these aspects can be addressed in early design activities. Some of the industrial contributions of this research were the creation of tools and methodologies supporting the reciprocal understanding of design information-rich representations of user experience directions.

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An Approach for Emotion Recognition using Purely Segment-Level Acoustic Features

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Abstract: A purely segment-level approach is proposed in this paper that entirely abandons the utterance-level features. We focus on better extracting the emotional information from a number of selected segments within utterances. We designed two segment selection approaches (miSATIR and crSATIR) for selecting utterance segments for use in extracting features that are based on information theory and correlation coefficients to create the purely segment-level concept of the model. We established a model using these selected segment-level speech frames after clarifying the time interval for the segments. Testing has been carried out on a 50-person emotional speech database that was specifically designed for this research, and we found that there were significant improvements in the average level of accuracy (more than 20%) compared to that using the existing approaches for all the utterances' information. The test results that were based on the speech signals stimulated by the International Affective Picture System (IAPS) database showed that the proposed method could be used in emotion strength analyses.

Keywords: Emotion recognition, Human-computer interface (HCI), Segment-level features, Probabilistic neural network (PNN), Emotion strength analysis.

1. INTRODUCTION

Interest in using speech for emotion recognition has recently increased because of the significant developments made in human-computer-interface (HCI) technology (Picard, 2000). Speech is the most natural and efficient type of human communication and this has inspired researchers to consider speech as an approach to human and machine interaction. However, simply adding

emotional intelligence to computers is a challenge, although it could lead to a meaningful evolution of the relationships between humans and automated systems, although these systems would largely benefit from knowing and adapting their operations according to the users' emotional states. Recognizing human emotion from speech also introduces some promising applications, such as in the emotion analysis of commercial conversations, virtual humans, emotion-based indexing, and in information retrieval, (Morrison, Wang, & De Silva, 2007) and (Gratch & Marsella, 2005).

The utterances (phrases, short sentences, etc.) referred to in current research papers are often considered the fundamental unit and are recognized based on the global utterance-wise statistics of the derived segment low-level descriptors (LLD), so the segment features are transformed into a single feature vector for each emotional utterance (Ververidis & Kotropoulos, 2006), (Kim, Hyun, Kim, & Kwak, 2009), (Qi-Rong & Zhan, 2010). However, many researchers have recently been focusing on an issue that questions whether or not the utterance level is the right choice for modeling emotions (Schuller & Rigoll, 2006). They are concerned with this because of the difficulties in using the utterance-wise statistics in avoiding the influence from spoken content, which requires accurate partitioning of an utterance for segmentation. Moreover, valuable but neglected information could be used in the segment-level feature extraction approach rather than calculating only the utterance-wise statistics. Many researchers also support this hypothesis (Schuller & Rigoll, 2006), (Yeh, Pao, Lin, Tsai, & Chen, 2011), based on the fact that improvements can be made by adding segment-level features to the common utterance-level features.

Motivated by these findings, we focus on developing a novel scheme for improving speech emotion recognition using segment-level features instead of using a strategy that includes ensemble learning from different classifiers using the same utterance-wise features (Morrison et al., 2007), (Schuller, Lang, & Rigoll, 2005). We took into consideration a purely segment-level strategy for speech emotion recognition and abandoned the utterance-wise features in order to reduce the noises from spoken content and use the neglected information in the calculation of the utterance-wise statistics in this study. The aim of this paper is to properly design an approach for utterance-level emotion recognition that is based on aggregating the segment-level labels without introducing more computational complexity.

Our experimental design is introduced in Section 2. In Section 3, the analytical method for emotion recognition using segment-level speech frames is described. The results are discussed in Sections 4 and 5. In Section 6, an application example for the proposed approach is introduced, and finally, in Section 7, our conclusion is drawn on the proposed research.

2. EXPERIMENTAL DESIGN

A well-annotated database is needed to construct a robust model for recognizing emotions using speech signals. Our experiment emphasizes "natural speech". The participants are prevented from becoming aware that they are in an experimental environment during the experiments, which is much more realistic than experiments that were conducted using scripted speech. Natural speech is difficult to analyze, but more suitable than scripted speech for validating the robustness of an emotion analysis method.

2.1. Experimental protocols

The experimental setup is composed of one instructor, one coordinator, and two participants. The coordinator cooperates with the participants in order to help better stimulate their emotions. However, the coordinator pretends to be one of the participants in the experiment to avoid being an

extra obstruction for the real participants. The stimulation process unfolds through conversations with the aid of videos. The steps are demonstrated as follows.

- The instructor sets up the experiment's environment, such as a projector for the videos and microphones for collecting the speech signals, and gives instructions to the participants.
- The instructor also explains the steps to the participants, including the coordinator, for freely providing their impressions related to the videos.
- Self-introductions are made to create an easy speaking atmosphere.
- After watching each emotion evoking video, which lasts several minutes, the speech signals are recorded from the impressions.

The emotion corresponding to each utterance from the recorded speech signals is not only self-assessed by the participants but also by ten other people after the experiment. Therefore, it is possible to evaluate the degree of reliability of the utterances emotion labeling.

2.2. Data information

Ninety six people participated in the experiments, which included 53 males and 43 females ranging from their early teens to their 40s. We provided the sample selections for obtaining reliable data in two steps. First, only the samples with the same label (pleasure or displeasure) based on the self-assessment and others-assessment were taken into consideration. Second, for maintaining a balance between the sample numbers for each label, we selected 300 utterances with higher rankings using the others-assessment, which consisted of 150 utterances as pleasure data and 150 utterances as displeasure data from the 50 participants. Ten specialists put a label on every utterance in the others-assessment, and the rank for each utterance was calculated based on the ratio of the numbers from the specialists who gave labels that were consistent with the label set from the self-assessment.

3. METHODOLOGY

The proposed methodology for emotion recognition is based purely on the segment-level speech frames, and the important issues for consideration here are the increased decline in the number of samples in the generalization ability of the classifier. In our work, we address the quantitative analysis of various analytical schemes related to segment-level speech emotion recognition, and we propose an automatic approach for decreasing the number of samples in order to reduce the computational complexity and improve the classifier generalization ability.

3.1. Feature extraction

We focused on a set of 162 acoustic features from speech signals, including 50 Mel-Frequency Spectral Coefficients (MFCC) (Davis & Mermelstein, 1980), 50 Linear Predictive Coefficients (LPC) (Atal & Hanauer, 1971), and 10 statistical features (mode, median, mean, range, interquartile range, standard deviation, variation, absolute deviation, skewness, and Kurtosis) calculated from each of the five levels of the detailed wavelet coefficients by using the Discrete Wavelet Decomposition (DWT) (Grossmann & Morlet, 1984), pitch, energy, zero-crossing rate (ZCR), the first seven formants, centroid, and 95%-roll-off-point from FFT-spectrum.

3.2. Segmentation approach

3.2.1. Existing segmentation schemes

Several segmentation strategies (Figure 1) were proposed in a previous study (Schuller & Rigoll, 2006), their concepts are introduced in the following.

- *GTI segmentation (Utterance-level segmentation).* The speech signals are segmented by pauses during the speech without word or syllable boundary detection.
- *ATI segmentation.* Different from utterance-level segmentation, the speech utterances are segmented at the same fixed time interval.
- *RTI segmentation.* Speech utterances are segmented at the fixed relative positions.
- *ATIR segmentation.* ATIR segmentation combines the ideas of ATI and RTI segmentation. Fixed-length segments are constructed at fixed relative positions, and this overcomes the drawback of different segment lengths and numbers obtained from different utterance lengths.

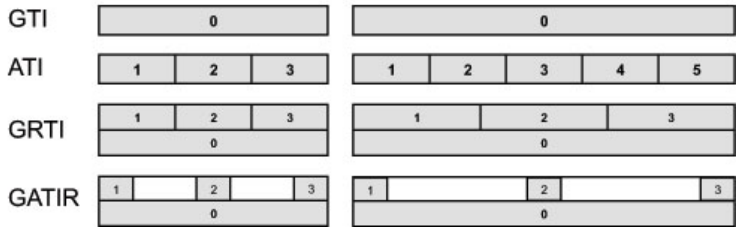

Figure 1: Illustrations of segmentation schemes. GTI: global time intervals (Utterance-level segmentation); ATI: absolute time intervals; RTI: relative time intervals; ATIR: absolute time intervals at relative positions; GRTI: combination of utterance-level and segmental features extracted using RTI segmentation; GATIR: combination of utterance-level and segmental features extracted using ATIR segmentation.

3.2.2. Proposed segmentation approaches

The following difficulty must be overcome in order to carry out segment-level based speech emotion recognition, which concerns defining the labels of the segments representing the classifiers. We propose the novel segmentation strategies, entropy-based ATIR (eATIR), mutual information-based ATIR (miATIR), and correlation coefficients based ATIR (crATIR) inspired from the ATIR segmentation method because of its advantages of getting a smaller and fixed number of segments from an utterance. We adopt a more efficient way for finding more informative segments by minimizing the amount of mutual information between feature vectors. Fixed-length segments are constructed in this study at selected positions based on the designed indexes. So, not all the segments of an utterance are used in the analysis. Framing is used to deal with the utterance signal after dividing the utterance into several sections. A 10-ms window with no overlap is used for calculating the ranking of the fixed-length segment. The proposed segmentation methods are illustrated in Figure 2.

We use several measuring indexes on the extracted features to get the most representative ones from among all the segments, and the average of the index values within each segment is used for the selection. The indexes are introduced in the following paragraphs.

Entropy index: Entropy is a measure of the information content, which is introduced as "a measure of how much 'choice' is involved in the selection of an event" (Shannon, 2001). We have to determine how to obtain the best approximation for creating the model in order to model an emotion with segments that are represented by an unknown probability distribution. One approach is to have the distribution with the maximum entropy ensure that the approximation satisfies and subjects to any constraints on the unknown distribution (Jaynes, 1957). A number of top-ranked segments are selected in our study after calculating the entropy of the segment features.

Mutual information index: The mutual information (Shannon, 2001) measures the "lumpiness" of the joint distribution, and several of the most informative segments can be selected by minimizing the redundant information.

Correlation coefficient index: The correlation coefficient (Pearson, 1895), which is also known as the Pearson product-moment correlation coefficient, is a measure of the linear dependence between two feature vectors. This index shares the same concept with the mutual information for reducing the redundancy.

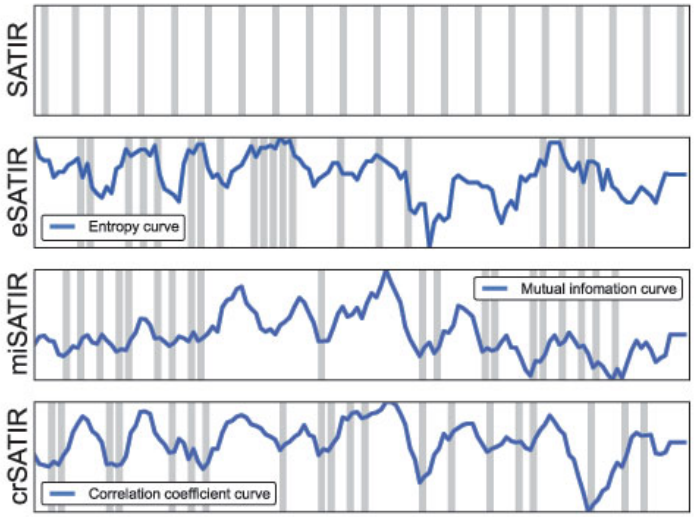

Figure 2: Fixed-length segment positions illustration using proposed segmentation approaches (20-segment selecting situation is shown and the positions are represented using grey lines). 'S' is included in the abbreviation to represent the purely segment-level concept

3.3. Decision model

The decision for determining the emotion of an utterance is based on the prediction of its segments from a classifier. We simply use the efficiency approach called the majority vote, which determines the label of the utterance from the label in majority so that we can pay more attention to examining the effectiveness of the proposed segment-level approaches for speech emotion recognition. The decision model is shown in Figure 3. Our decision model is based on a classifier called the probabilistic neural network (PNN) (Specht, 1990).

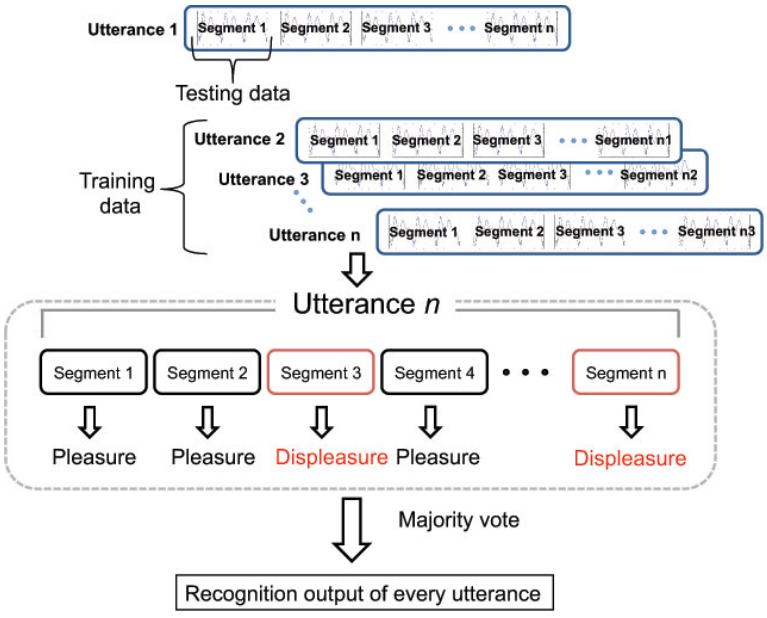

Figure 3: Illustration of segment-level classification concept for decision model.

4. RESULTS

A 10-fold cross validation is used to evaluate and test our proposed approaches as well as make comparisons with previous researches because it is used in many other emotion recognition researches for validating general models (Schuller & Rigoll, 2006), (Yeh et al., 2011), (Yu & Xu, 2007). We reviewed all the most recent research on the aspect of classifiers for creating a solid illustration and found that the support vector machine (SVM) is one of the most robust and popular classifiers in the field of affective researches, and it beats out many other kinds of classifiers in terms of the recognition accuracy (Morrison et al., 2007), (Schuller & Rigoll, 2006), (Chandaka, Chatterjee, & Munshi, 2009). Thus, our evaluation results based on PNN are compared with those based on SVM. Table 1 classifies the results when using our 162 proposed acoustic features applied to the existing schemes, such as the GTI and segment-level features that include schemes such as GRTI and GATIR. 500-ms segments are constructed at fixed relative positions for GATIR (Schuller & Rigoll, 2006).

Table 1: Comparison of emotion recognition accuracy between existing segmentation schemes using segment features with global features

Feature groups	**Accuracy (%)**	
	SVM	**PNN**
GTI	67.0	70.0
GRTI (utterance + 2 segments)	69.0	80.0
GRTI (utterance + 3 segments)	69.7	83.3
GATIR (utterance + 2 segments)	68.0	76.7
GATIR (utterance + 3 segments)	69.3	80.0

As listed in Table 1, the emotion recognition accuracy is higher when using PNN then for SVM in every case, and therefore, we chose PNN for our purposes. These results are also consistent with other similar researches (Schuller & Rigoll, 2006), (Yu & Xu, 2007), which show there is a better potential for use as segment features for emotion recognition extracted by using RTI segmentation. Hereafter, we begin our pure segment features with a name beginning with *S* in order to discriminate those from the global features or both proposed in previous researches. We use a SATI (ATI) with different time intervals to conduct a first scenario that is different from that in the utterance-level analysis and finally choose 50 ms as the segment length for our analysis due to the performance.

We compare our proposed segment-level feature extraction strategies, which generate feature groups called eSATIR, miSATIR, and crSATIR in the sentences and paragraphs that follow. We also compare them with a segment-level feature extraction approach called SATIR, which is directly inspired from previous research. We have to define the number of segments we want to generate from each utterance before applying the proposed strategies. Since we use a majority vote in the decision model, we considered 10 segments as reasonable for use as the smallest number for voting. We also take note of the fact that some utterance lengths are as short as one second, and thus, 20 segments is considered to be the largest number for a majority vote. Table 2 provides a comparison of the emotion recognition accuracy between different segmentation schemes using purely segmented features. According to these comparison results, it is clear that 20 segments

better captures useful information and the voting from 20 segments provides for more fault-tolerance. The results also show that miSATIR and crSATIR can greatly increase the utterance-level speech emotion recognition accuracy, where crSATIR leads to the best results.

Table 2: Comparison of emotion recognition accuracy between different segmentation schemes using purely segmented features

Feature groups	Accuracy (%)	
	10 segments	20 segments
SATIR	73.7	88.3
eSATIR	75.0	89.7
miSATIR	90.3	95.7
crSATIR	92.3	98.1

5. DISCUSSION

This research further develops this new train of thought to a level that totally abandons the global features from the utterances. The analytical results in Section 4 indicate the robustness of this advancement, which leads to a higher level of recognition accuracy by using only the segment-level features in the proposed decision model. 50 ms is chosen as the segment length not only because of the better level of accuracy, but also because of the emotional variability and content. We proposed several segmentation approaches in order to select the appropriate number of segments within an utterance. SATIR is simply extracted from the selected segments at fixed positions according to the length of the utterance, and the recognition results can be seen as a reference. We introduce two kinds of features from the segmentation approaches that are based on information theory including eSATIR and miSATIR, but the improvement when using miSATIR is much larger than that for eSATIR, where eSATIR can only slightly increase the level of accuracy compared to SATIR. Since eSATIR doesn't take into consideration the relationship between the utterance and its segments, the segments generated by considering only the maximum entropy have a higher chance to obtain confusing information such as noise or non-representative information for the utterance label and this might be the cause for differences. However, the miSATIR and crSATIR approaches generate segments for the decision model with less redundant information, which contributes to a better understanding of the utterance label and a better comprehensibility of the learned model.

As Table 2 specifies, the crSATIR results outperform those of miSATIR. This phenomenon seems hard to explain at first glance. In lots of situations, they share the same purposes and the mutual information makes it more powerful for detecting the complex non-linear relationships between two feature vectors, and this helps in problem solving for a lot of difficult issues such as in network analysis (Battiti, 1994), (Steuer, Kurths, Daub, Weise, & Selbig, 2002). However, the situation for feature extraction is different from that in our case, with the aim of better extracting information for representing an utterance label. The mutual information, which is the strategy adopted in our research in order to reduce the amount of redundant information when extracting features from segments, is able to detect these non-linear relationships and avoid them to a large extent. However, the correlation coefficients strategy investigates whether a linear relationship

exists between feature vectors and minimizes it. In our case, two feature vectors with a small or no linear relationship might have a strong non-linear relationship, and this dynamic relationship can be considered useful information for better representing the utterance labels, which might benefit the decision model learning, so using crSATIR leads to an improved level of accuracy compared with using miSATIR.

6. APPLICATION PERSPECTIVE: EMOTION STRENGTH ANALYSIS

A very interesting potential application area is emotion strength analysis using segment-level speech emotion recognition. We use majority voting for the utterance labels prediction with the assumption that the label with the most predicted segments represents the utterance label. For better understanding the segment labels, we further looked into the ratio of the most predicted label that can represent the strength of the utterance emotion. SATI is used because we want to examine all the segments in terms of the emotions.

6.1. Experimental data

We used the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 1999) for evoking emotions with different strengths. The IAPS is an emotion stimulation system built from the results of many emotion experiments. The picture system is composed of about 1000 pictures labeled with a standard scale of valence (pleasure-displeasure) and arousal (exciting-sleepy). Therefore, it meets our requirement for stimulating emotions at different strengths. Figure 4 shows the four kinds of emotions we defined using the IAPS.

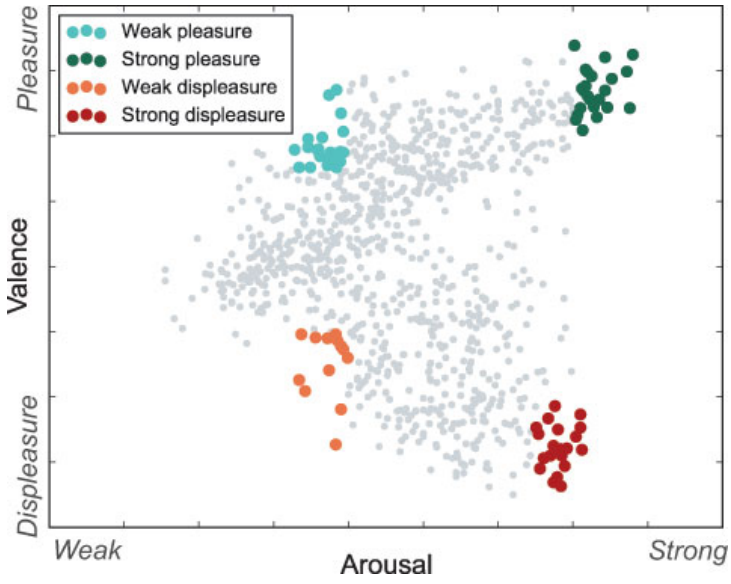

Figure 4: Defined emotion strength based on IAPS

The experimental approach was made up of four parts according to the pleasure and displeasure emotion stimulation, which includes the defined emotion strength (weak and strong). The detailed experimental protocol is demonstrated as follows. The pictures selected from the IAPS during the stimulation period (1 min.) were projected on a screen to evoke emotions. Participants were asked to read designed script with their evoked emotion while viewing each picture and their emotional speech signals were collected. They were requested to close their eyes to relax (2.5 min.) after viewing each picture and a control time of one minute while viewing a white screen was set before viewing the affective pictures. Seven Japanese males took part in the experiment. Data was

collected using the previously described procedures for estimating the emotional strength, which contains 312 samples including 156 pleasure (78 strong, 78 weak) and 156 displeasure (78 strong, 78 weak) data.

6.2. Results

We statistically analyzed the components of all the samples and then visualized the percentage of positive and negative emotion components using a bar chart with a standard deviation to illustrate the correlations between stimulations (Figure 4) and the output of the emotion components represented by using the segment-level predictions within an utterance using the proposed segment-level speech emotion recognition method. The results are shown in Figure 5.

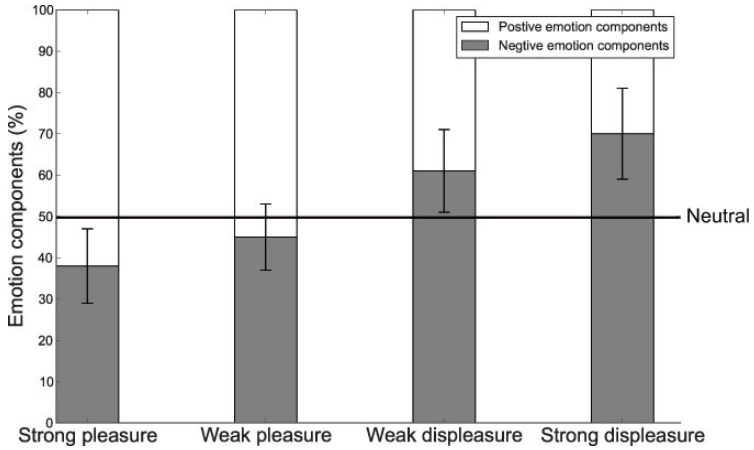

Figure 5: Statistical analysis for emotion components using segment-level speech emotion analysis for all speech samples

6.3. Discussion

The emotion recognition of utterances is one of the more attractive topics in speech analysis for HCI. However, emotion strength analysis has been a very essential but difficult research area. We discussed the potential for using segment-level frames for the emotion strength analysis within utterances. As shown in Figure 5, the proposed method can indeed reflect the strengths of emotions in utterance clusters for a number of spoken phrases or short sentences over a short period of time. However, difficulties still exist in applying it to a single utterance because of the variances in the emotional components regarding these utterances. Although further validation is necessary for collecting more solid findings in terms of the emotion strength analysis of utterances, segment-level speech emotion analysis creates a new focus for better recognizing human emotion strength using machines.

7. CONCLUSION

We proposed a novel emotion recognition strategy that uses only the segment-level features instead of the entire utterance-level features or both. We first introduced advanced relative segmentation methods using mutual information (miSATRI) and correlation coefficients (crSARTI), which can greatly increase the emotion recognition accuracy to more than 95% and 98%, respectively, using a validation database of speech signals from 50 participates in order to make the proposed method more efficient and accurate.

The proposed method also showed effectiveness in determining the emotional strengths of utterances over a period of time. It can provide hints about the emotion strength information

according to our validation results using the IAPS database.

ACKNOWLEDGMENTS

The authors would like to acknowledge Guillaume Lopez at Aoyama Gakuin University, Masaki Shuzo at Kanagawa University, AGI Inc., and all the participants for their significant contributions to the experiments.

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BIOGRAPHY

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Emotion and Interface Design

How to measure interface design emotional effect?

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Abstract: Traditionally, human-computer interaction is conceived and assessed through the restrictive scope of usability. Although this approach has led to an overall improvement of the interfaces ease-of-use, it should now be overstepped. The question of the positive affect of users has become crucial for the interface project stakeholders. Our research is mostly turned towards applied perspectives. Our general hypothesis is that design strategies may affect positively the user, and influence a better attractiveness of the interface. In this paper, our objective is to present and discuss a method to measure user's emotion during an interface interaction experience. The experimental setup gathers screen records, face recognition, galvanic skin response, and questionnaires. These complementary sources bring forward the behavioral, physiological, and subjective emotional responses of the user. We discuss how these resources can be used in order to measure the emotional effect of a specific user interface.

Keywords: Emotion assessment, interface-design, cognitive psychology.

1. INTRODUCTION

In the area of user interface design, during numerous years, it was advocated to apply a user-centered approach, putting forward ergonomic recommendations, or "golden rules" (Norman, 2002; Shneiderman, 2005). These recommendations tended to focus on users' cognitive and perceptual-motor abilities, seeking for an ever-reduced cognitive load required by tasks and interactions. Thus, human-computer interaction is traditionally conceived and assessed through the restrictive scope of usability (Bastien & Scapin, 1993) rather than based on what users felt when interacting with a system. Although this approach has led to an overall improvement of the interfaces ease-of-use, it should now be overstepped. Therefore, nowadays, humans and their interactions with systems are increasingly being studied. For instance, Don Norman suggests to analyze three different levels related to interface use: "knowing, doing and feeling" (Norman, 2005). Moreover, in recent years, the

"feeling" level has become a popular research topic in cognitive science and the science of design. When developing new products or systems, designers have to come up with design solutions that are both novel and adapted to their future users (Shneiderman, 2004; Bonnardel, 2012). Towards this end, designers have to take into consideration other dimensions than the ones related to the "usability". Especially, new systems must also inject a little fun and pleasure into people's lives (Norman, 2002). Thus, in addition to their functional characteristics, interactive systems must be regarded as conveying feelings through interfaces' design features. The question of the feelings of users – preferentially associated to positive emotions or affects - has become crucial for the interface project stakeholders. This new field of research is related to two general objectives:

- Understanding users' emotional processes;
- Understanding how to arouse conscious or unconscious emotion through an interface.

Therefore, our objective in this paper is to present and discuss a method to measure user's emotions during an interface interaction experience. Towards this end, we first define this concept and point out its characteristics in the context of user interface design. Then, we present a method that we suggest for measuring emotions in the context of interface use. This method will then be evaluated. Our results contribute to the definition of a reference-protocol pinpointing interaction and design features eliciting the user's affect. This protocol will then be used in the context of a software called SKIPPI, which aims to favor designer's creativity. PSYCLE participated to the project by analyzing end-users needs and representations, and by providing requirements for the SKIPPI application design. These studies questioned the emotional effect of the interface, in regards to the emotional value of the displayed content. A protocol of evaluation had to be drawn up in order to distinguish the emotional value of the interface design.

1.1. Defining emotion

To conceive an effective emotional assessment system, a first step is to understand the nature of emotion. In this section, we focus on the main models aiming at describing the emotional phenomena from the psychological domain.

A variety of approaches of emotional phenomena has been proposed in different fields of psychology: phenomenological, behaviorist, physiological, cognitive approaches (Strongman, 2003). Although no real consensus was established, recent models of emotions are based on the notion of appraisal, put in light by Arnold (1945), and Schachter (1959): a cognitive process is required to evaluate a stimulus in order to give rise to emotions. Following this view, the appraisal processes two components, internal and external (Mandler, 1982; Desmet, 2003; Scherer, 2005). This latter external component corresponds to the stimulus' features, whereas the internal component refers to the individual's past experiences and expectations. The sequence of fast but complex evaluations builds the relevancy of the stimulus (Frijda, 1986, Scherer & Tannenbaum, 1986), and prepares the user to react. This reaction may be expressed by cognitive, behavioral and physiological changes (Gil, 2009).

An example would make these notions clearer. At a railway entrance, escalators are located next to the traditional stairs, leading to the upper platforms. Usually, most public use the escalators, because they require less effort and less time. They are more efficient, therefore more usable, and this view is strengthen by our experiences. In 2009, a temporary art installation was setup in one of these stairs in a Stockholm subway (The fun theory, 2009). At night, the stairs steps had been covered in white and black, so that the overall stairway looked like a piano keyboard. The next morning, a first subway user noticed the change: a new cognitive evaluation was performed as the environment was unusually different. The user identified the external features of the painted stairs,

and compared them to his internal passed experiences; he identified a stairway to go upstairs, and a keyboard to play piano. This incongruity generated an emotion: surprise, leading to a desire to know more, curiosity. His heart rate increased a little (physiological reaction), and, smiling, he walked towards the piano stairway (behavioral reaction). As he walked up the stairs, the user heard the sound of the piano notes matching his steps. The artist had developed the metaphor further, increasing the incongruity effect, and the pleasure for the users. Some of the users played with the piano stairs, running up and down. Finally, although it was less efficient and usable than the escalators, most of the users chose the piano-stairs that day.



Figure 1: The piano-stairs: how emotional design can influence users behaviors

This example demonstrates how a positive experience may influence the users behaviors, beyond the actual usability of the interface. Preferences and decisions being based on affect (Vakratsas & Allen, 1999; Sanabria, Cho, Sambai, & Yamanaka, 2012), we perceive the relevancy of the appraisal notion for our study as a way to better guide the users towards an objective.

Scherer (2005) defined the emotion as being a relatively intense affective experience, whose cause is clearly identified, and which does not last very long. If the emotion leads to an action tendency, then Scherer defines it more precisely as an ‘utilitarian emotion’ (anger, fear, joy, disgust), whereas an ‘aesthetic emotion’ (such as admiration, ecstasy, fascination), would not lead to action.

Two main streams can be drawn to define emotion: a dimensional perspective and a discrete perspective.

This latter discrete perspective views emotions as a sum of categories, which can possibly be intersected or intensity-faded to get finer sub-categories. Several models were proposed, where the number of basic and global emotions varied. For instance, Plutchick (1980) considers eight primary emotions (joy/sadness, trust/disgust, fear/anger, surprise/anticipation), based on their ability to trigger a fight-or-flight behavior. These discrete models are quite popular, especially in the design field, because they are easily linkable to the ‘folk psychology’: most common vocabulary terms standing for different emotions are localized into discrete model schemes, making them easy to handle. This may constitute an advantage in certain conditions.

However, certain drawbacks were pinned on these discrete models. Numerous studies show that an emotion may be difficult to categorize (Barrett & Wager, 2006). A term-based categorization would imply to share a same cultural and language background. In the same view, it would imply to skip any inter-individual variation in the interpretation of the meanings of the terms. By definition, a discrete model limits the potential number of emotions, disallowing any deeper and more accurate identification and inducing biases.

For these reasons, other models of emotions co-exist, based on a dimensional perspective. Among researchers, the number of dimensions varies. However, two dimensions emerge of most of the dimensional models: valence and arousal (Russell, 1980, Russell & Barrett, 1999). Valence corresponds to a pleasure/displeasure scale, whereas activation corresponds to a sleepiness/excitation scale. These scales define a circumplex space where it is possible to locate any 'folk-psychology' emotional term.

Other scales may be superposed on this basis, such as dominance/submissiveness (Mehrabian, 1996), which stands for the capacity of the participant to control the stimulus. In the same view, Scherer (2005) proposes two scales that are compatible with Russell's scheme: goal conduciveness, and coping potential. This allowed Scherer to locate more precisely eighty frequently used emotions categories (Figure 1).

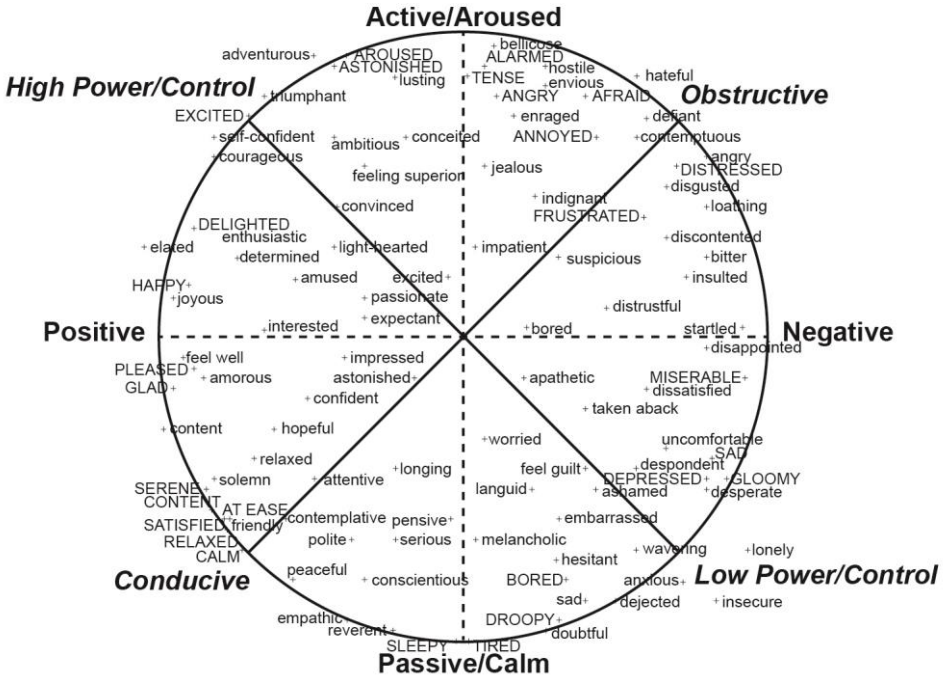

Figure 2: Alternative dimensional structures of the semantic space for emotions (Scherer, 2005)

1.2. Emotion and interface

Russell 's analysis of the effects of emotions (Russell, 2003) allows us to point out relevant connections with the concern of interface user experience. Indeed, a positive valence improves attention and positive judgments (Sanna, 1998; Park & Banaji, 2000; Schwarz & Bless, 1991), whereas arousal influences cognitive performance (Humphreys & Revelle, 1984) and attention selectivity (Easterbrook, 1959; Eysenck, 1982). Combining a high arousal and valence gives a person a sense of optimism in choosing goals and plans. Other works also demonstrated how positive emotions could improve task efficiency and learning (Bonnardel, 2011, Bonnardel & Moscardini, 2012, D'Mello & Graesser, 2012, Davis, 2009).

Such conclusions lead to a justification of efforts towards a positive emotional interface design. Therefore, in order to favor positive emotions from the users, it appears first necessary to determine whether and how an interface design may influence activation and arousal of the users' emotional response.

As stated above, the appraisal process resulting to the emotion is also fed by internal factors, such as user's passed experience, cultural background, concern and involvement with the task. Thus, the interface design, resulting from designers' work, is only one of the many variables eliciting end-users' emotions.

Desmet (2003) proposed a four components "basic model of product emotions": the emotion (1) results from an appraisal process (2), based on user's concern (3), and product's features (4). For Desmet (ibid.), user's "concern" stands for the individually perceived utility, this perception being potentially affected by personality traits. Desmet adds that the product component is not always the direct stimulus of the emotion; the product may also elicit thoughts which are the actual stimuli. This view is in line with Norman's proposal (2004), who distinguishes three emotional levels of the user affect with regard to a product: visceral, behavioral and reflective. The first visceral level is a direct gut feeling, whereas the two other levels are based upon the user's consideration over the interaction (behavioral), or a more social/intellectual judgment (reflective).

Considering the specificities of interface design as a product, our study requires to sharpen the "product" component. Therefore, we propose another model that highlights some specificities of an interface as a product of design (Figure 3).

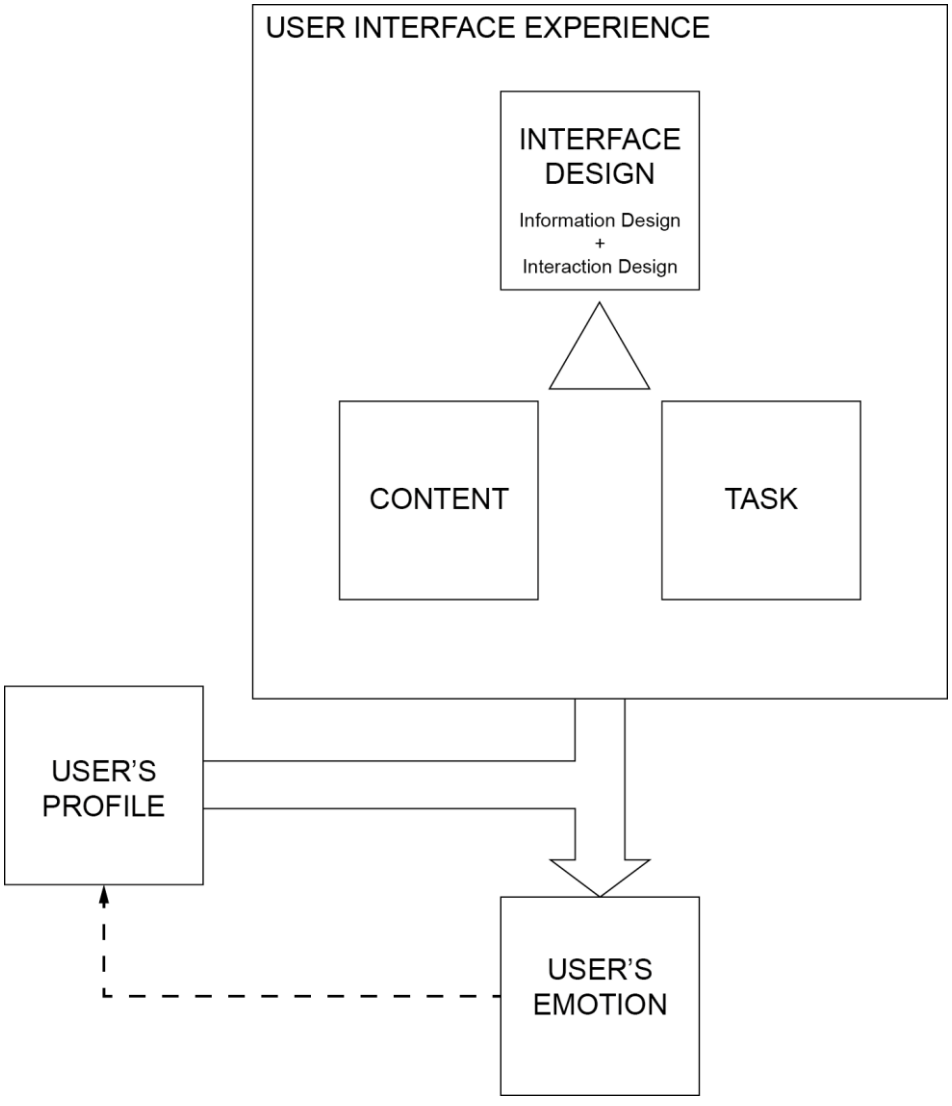

Figure 3: Model of user interface emotion

In this figure, the user's profile (internal) constitutes the baseline upon which the current interface (external) is appraised to give rise to emotions. In this view, this diagram matches the two internal/external components processed by the appraisal leading to emotions, as stated earlier. The diagram is also compatible with the "concern/product" dichotomy from Desmet's model.

Here, however, the "product" component is replaced by the label of "user interface experience". Two main considerations were taken into account for this change. First, the notion of "experience" refers to a continuous interaction with the product, implying ever-evolving changes of the system values. Second, our study focuses on "user interface". The specificities of screen-based interactive product lead us to distinguish three specific components, each of them constituting stimuli eliciting user's emotions:

- The "content" stands for the information and data to be communicated to the users. It gathers textual elements (e.g. titles, articles), pictorial elements (e.g. photographs, illustrations, and diagrams), videos, music. Typically, content is created by redactors, whereas the interface is defined by designers.
- The "interface design" stands for the layout and presentation strategies of the content and the functionalities. We refer to "information design" for information display strategies, and to "interaction design" for ways users interact with the interface, including the embedded functions.
- The "task" refers to the purpose of the interface which has to be handled by any users (search, read, compare, calculate, organize…). Performing this task may induce an emotion.

These three items define the user interface experience, and are closely related.

The "user's profile" refers to the specificities of the user, at the moment of the interaction. This item could potentially gather numerous inter-individual variables, such as cultural background, previous knowledge related to the content (brand, images, related articles…), to the interaction modes, user's personality, mood…

The user interface experience, considered as a global external stimulus is therefore assessed through the user's profile's internal scope, eliciting the emotion. This global process should be considered as continuous and iterative. The user's emotion contributes to the evaluation of the overall interface experience. It may affect the perceptions of the content, of the task, and slightly change the user's profile.

Indeed, these changes constitute the designer's goals, aiming at influencing the users' actions and behaviors.

2. EXPERIMENT

2.1. Specific objectives, participants and experimental conditions

Our first objective was to test the reliability of the chosen experimental setup to record the user's emotion during an interface usage episode.

Then, we wanted to test the sensitivity of this setup towards different interface design variations.

Eight participants, French native speakers, two males, six females, from 18 to 30 years old took part in the experiment. They were distributed randomly into two groups (see Figure 4).

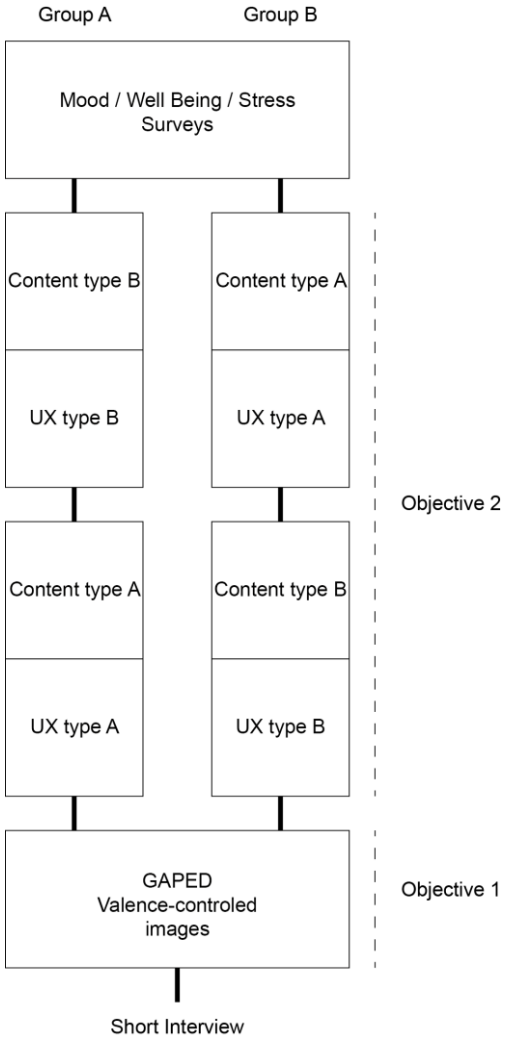

Figure 4: Experimental conditions overview

To pursue the first objective, we provided users with twelve images with strong high/low or neutral valence. These images were issued from the GAPED image base (Dan-Glauser & Scherer., 2010), validated worldwide. User's emotions were recorded during and after each image.

To pursue the second objective, we provided users with two different interfaces: UX type A and UX type B. Either type was compounded of four pages displaying a text, a picture, and a simple navigation bar. As we wanted to measure the effect of the interface design alone, excluding the task's and content's effects (Figure 3), content items alone were provided in a first stage. Nine items (four images, four text, one navigation bar) were therefore sequentially displayed. During and after each item display, user's emotions were recorded.

Thus, we assumed that the difference between the overall UX elicited emotion, and the content elicited emotion, stood for the interface design impact.

[UX emotion] x [User profile] = ([content emotion] + [interface design emotion] + [task emotion]) x [User profile]

[interface design emotion] = [UX emotion] - [content emotion]

We also considered that the task of watching and reading would similarly impact the results whether the content was provided individually or within an interface design.

However, it is not possible to successively provide a user with two different interface versions for a same content in order to compare the interface effect. The discovering impact of the first pass

would necessarily bias the second pass' perception. Therefore, two different contents were provided and balanced among two groups.

The GAPED image sources were assumed to convey a stronger valence, inducing a higher and longer emotional impact upon users, than the interface design stimuli. Therefore, we decided to pursue the first objective after to the second one.

Finally, in order to assess individual emotional baselines, three surveys were provided as a first stage, scoring mood, well-being and stress.

2.2. Material and setup

In this section, we present a set of methods and technics chosen to presumably fit the experimental conditions requirements.

- Methods to assess users emotions, considering a long lasting and low intensity stimulus.
- A set of surveys in order to assess invidual emotional baselines
- The interfaces used as stimuli to elicit emotions

Several pretests were set up in order to check the good understanding of the provided instructions by the users. Technical tests were also required to validate the monitoring and the synchronicity of the various recording sources.

2.2.1. Emotion assessment

We considered that measuring users' emotion requires to associate emotional states with at least cognitive and physical changes. These changes may be readable through three components: physiological, behavioral and cognitive (Gil, 2009).

Numerous studies have used physiological measurement and suggest that it constitutes a reliable method to assess users' emotional state. However, low arousal and long lasting stimuli such as user interaction are less present than stronger punctual stimuli. The galvanic skin response (GSR) is compatible with a continuous monitoring during the use experiment. It can also be considered as an objective measure over which the user has no control. The method that we proposed first relies on a monitoring of the variation of the skin conductance of the user, which indicates a change of activation. Typically, a punctual stimulus getting user's attention will result into the recording of a fall of the skin resistance level between one and five seconds after the stimulus occurred, and getting progressively back to normal. The drawback of the methods is a sensibility to external factors, generating non specific responses (NSR) and artefacts. Rest periods are therefore necessary in the stimuli presentation sequence when a precise identification of the eliciting event is required. In the specific context of an interface usage, the stimuli are long lasting. Therefore, we considered all the falls detected during the stimulus exposure as being relevant. A rest period of 15 seconds was setup between each stimulus presentation. We recorded the mean skin resistance, the number of falls, and falls amplitude. There is no normative reference for GSR measurement, with very large inter-individual differences being reported. Therefore, we use the GSR score to compare the effect of different stimuli, at a different time on the same individuals.

We also decided to analyze the behavioral component of users' emotions by analyzing changes on the user's face. This technic is inspired by the facial action coding system (FACS) (Ekman, 1970), analyzing 69 "action units" of face's muscles patterns, head orientation, and eyes gaze. Noldus' Facereader (Noldus, n.d) was developed in order to automate such analyses. The software performs a frame by frame analysis, and detects over 500 key points on the face. The resultant pattern is distributed among seven categories of emotion: neutral, happy, sad, angry, surprised, scared, and disgusted. The system was trained over 10000 manually annotated images. A valence score is

calculated as the difference between the happiness score, and the highest negative emotion score. Face analysis provides a continuous monitoring. The measurement can be considered as objective with the limitation of the potential user's conscious control of his face.

Finally, in the method we proposed, we measured the cognitive component through two systems of questions. The first one is the Geneva emotion wheel (GEW), which was developed following Scherer's emotional model (figure.2). A set of twenty emotion labels are arranged in a circle. Each label can be rated according to its intensity using a five points scale, from the center of the circle to its periphery. A drawback of using a label-based system lies in the limitation of the provided set of terms. Moreover, Scherer added a free response area, where the user may choose a word which better fits his feeling. The user may also indicate that no emotion was felt.

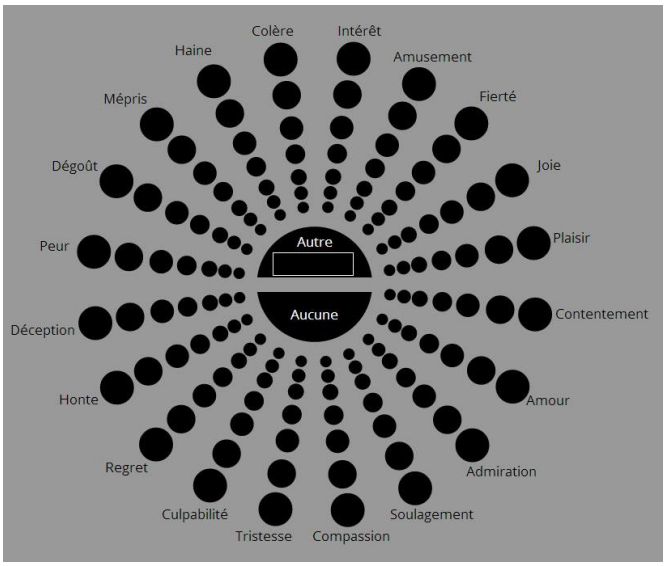

Figure 5: Screen capture of the GEW

Another drawback of label-based questionnaires lies in the necessary interpretation by the user of the label meaning. This may lead to different understandings of a same term among participants. Therefore, the second questionnaire we propose to use is the self-assessment manikin (SAM, Bradley & Lang, 1994). This questionnaire is composed of three scales, matching the three dimensions of the valence arousal dominance system. These scales make use of a pictures-based representation of emotional values. The questionnaire is therefore compatible with a wider range of population (children, participant of different languages or cultural background).

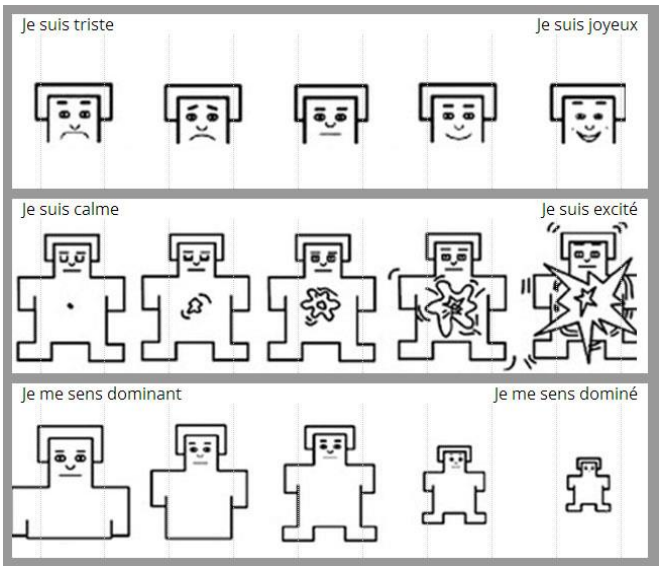

Figure 6: Screen capture of the SAM

Clickable screen versions of these two systems of questions were replicated for the purpose of the experiment (figures 5 and 6).

During pretests, some users did not fully understand how to use these questionnaires, especially when the initial textual instructions were partially read. Therefore, a video demonstration with voiced explanation was set up and these difficulties were successfully solved.

2.2.2. Mood, well-being and stress baselines assessment

Three surveys were also chosen in order to detect any exception or feature in the individual emotional baselines (Jolland, 2012) . Brief Mood Introspection Scale (Mayer & Gaschke, 1983) has been widely used to assess participants' mood (Baumeister, Bratslavsky, Murayen & Tice, 1998, Halberstadt, Niedenthal, & Kushner, 1995, Kokkonen & Pulkkinen, 2001), and was therefore chosen for this study.. The psychological well-being expression scale (Massé, Poulin, Dassa, Lamber, Bélair & Battaglini, 1998), is a four points Likert scale based on seventeen statements related to the user's emotional expressions during the last month. Stress was assessed by the Lafleur & Béliveau (1994) survey, composed of 109 items matching a large variety of psychic and physic stress symptoms.

2.2.3. Stimuli for measuring users' emotions

To pursue the first objective, we needed to use images acknowledged for their emotional impacts. Thus, we referred to the GAPED (Geneva Affective PicturE Database, Dan-Glauser & Scherer, 2010), a set of 730 pictures, rated among valence and arousal and validated worldwide. We selected the four images with the highest, lowest, and closest to zero valence score were selected to constitute a set of 12 images for this experiment.

The content used for the interactive mockups was related to two movies: "Le Mépris" for the content type A, and "Mulholland Drive", for the content type B. Texts and images were retrieved over the Internet from royalty free sources. Movies were chosen as a support of emotional content to present consistent text and images on a multiple pages sequence. The content provided differs between the two movies. "Le Mépris" (1963) was less likely to be known by participants than "Mulholland Drive" (2001). The content structure also differs. The text chosen for "Le Mépris" present a more abstract thematic approach of the movie whereas the "Mulholland Drive" article is closer to a story. "Mulholland Drive" was also chosen because of the specific atmosphere of the content, and for the picture colors which could be associated to a vivid colors interface design.

In the actual experimental setup, the “Mulholland Drive” type B interface (Figure 7) provides:

- a global layout composed in accordance with the golden section;
- a color background, matching the colors of the picture;
- a no-margin picture
- a centered title, with a larger font-size
- an animated page transition
- a fading-color effect on the navigation bar buttons

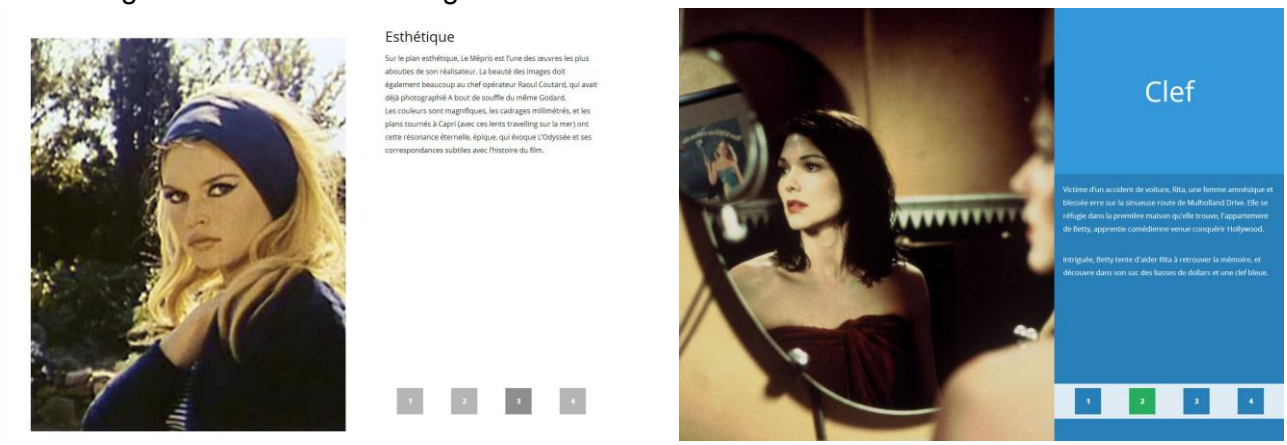

Figure 7: Screen captures of the pages (type A on the left, type B on the right)

3. ANALYSES, RESULTS AND DISCUSSION

Two computers were used to record the data, synchronized by their local time. Users interactions timestamps, as well as questionnaires answers were recorded in a MySQL database. A PHP script delivered a result score for each user for the mood, well being and stress levels. The users’ results were successfully checked by a normal distribution analysis.

Electrodermal activity was computed using Biopac AcqKnowledge 4.1. following the recommendations provided by Braithwaite, Watson, Jones & Rowe (2013). However we decided not to reject any SCR of low amplitude considering the long lasting and low intensity stimuli.

Facereader automated routine generated a 25 Hz valence score.

These data sources were compiled and synchronized using The Observer XT 11 from Noldus. Using this software, results were associated to the corresponding stimuli.

3.1. Findings related to objective 1

In this section, we present and discuss the ability of the experimental setup to measure a user’s emotion. Twelve images were presented to the users from the GAPED base, four negative, four neutral, four positive images. We compare the actual results measured by the experimental setup, to the expected value given by the GAPED.

3.1.1. Results based on questionnaires

The answers to the questionnaires are consistent with the emotional value of the GAPED images. The GEW clearly presents a split between negative emotions for negative images (in red), and positive emotions for positive images (in green). Moreover, neutral images are located at the center of the diagram. However, the neutral images slightly tends towards sadness and compassion. A consistent explanation would be that these images induce a low activation, as shown by the SAM questionnaire, and in accordance with Scherer's model of emotion (Figure 2). All the activation levels are negative: the participants feel calm. The SAM is also clearly relevant for the valence level. However, the dominance measurements do not show any major distinctions. Although many studies dismiss this item from the SAM questionnaire, this result could be explained by the lack of interactions with the stimuli.

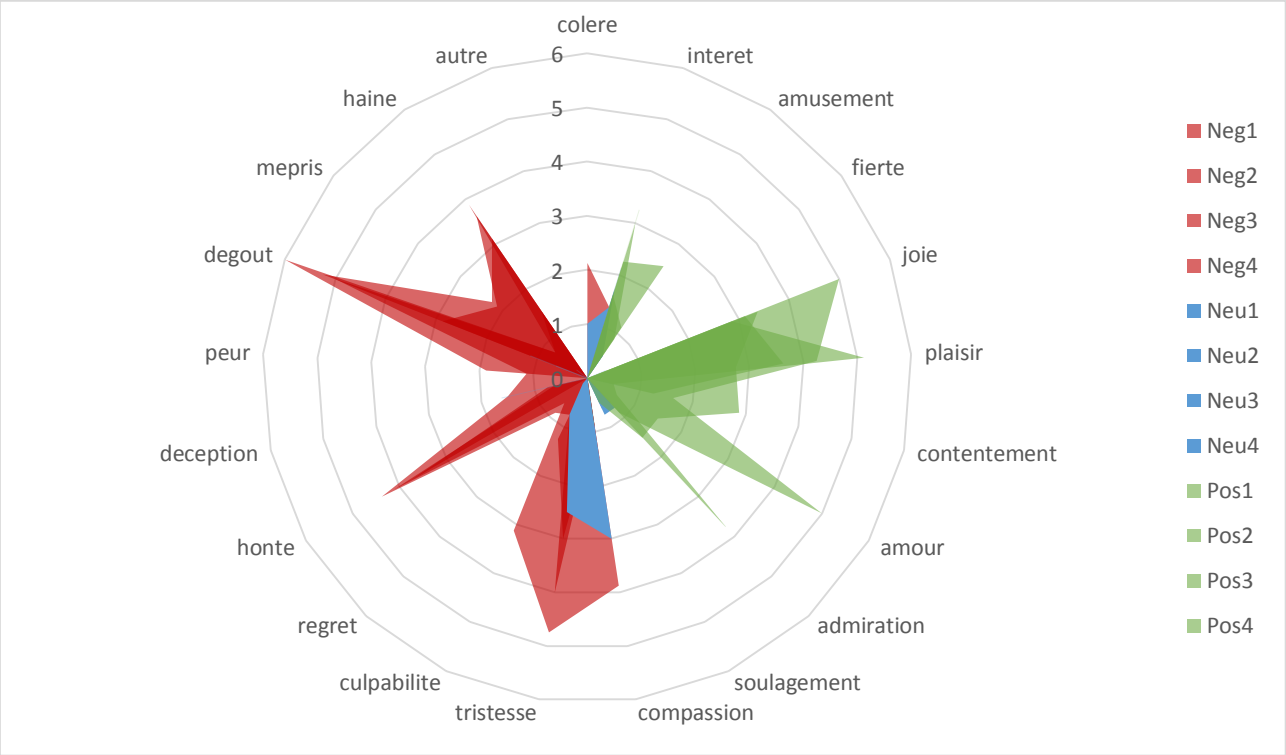

Figure 8: Participant's answers to the GEW questionnaire during the GAPED phase (means per image)

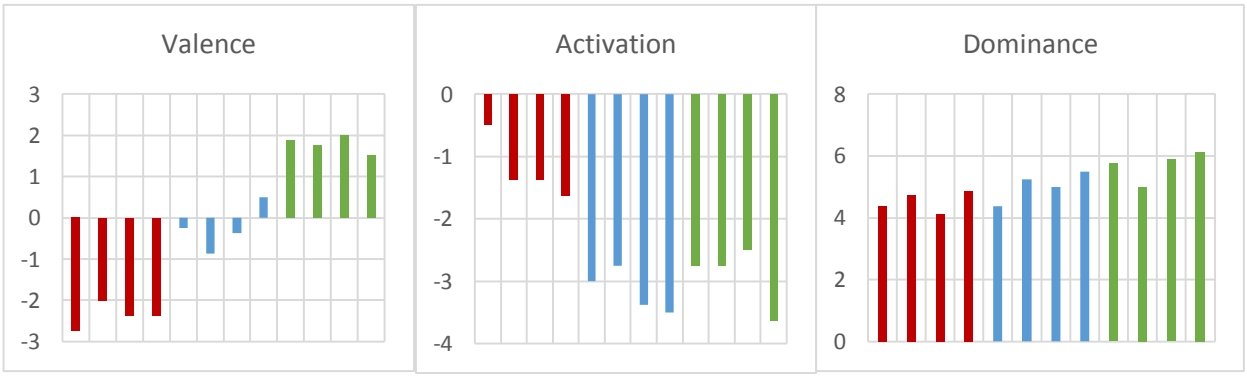

Figure 9: Participant's answers to the SAM questionnaire during the GAPED phase (means per image)

Therefore, these two questionnaires seem relevant and complementary to record subjective emotional feedbacks from users. However, the picture-based stimuli used in this section are

presumably of higher arousal than an usual interface design, and these inferences should be handled carefully.

3.1.2. Results based on FaceReader analyses

FaceReader is a software featuring an automated detection of participant's emotion from a video analysis. The results per image and participant (Figure 10) present a large dispersion. And more, no consistent pattern is distinguishable among participants, which could have explained a potential inter-individual difference. By calculating a mean per valence group (Figure 11), a slightly trend can be observed matching the expected results. However, the values are much less distinctive than the expected GAPED scores. Therefore, it seems difficult to use FaceReader in that context.

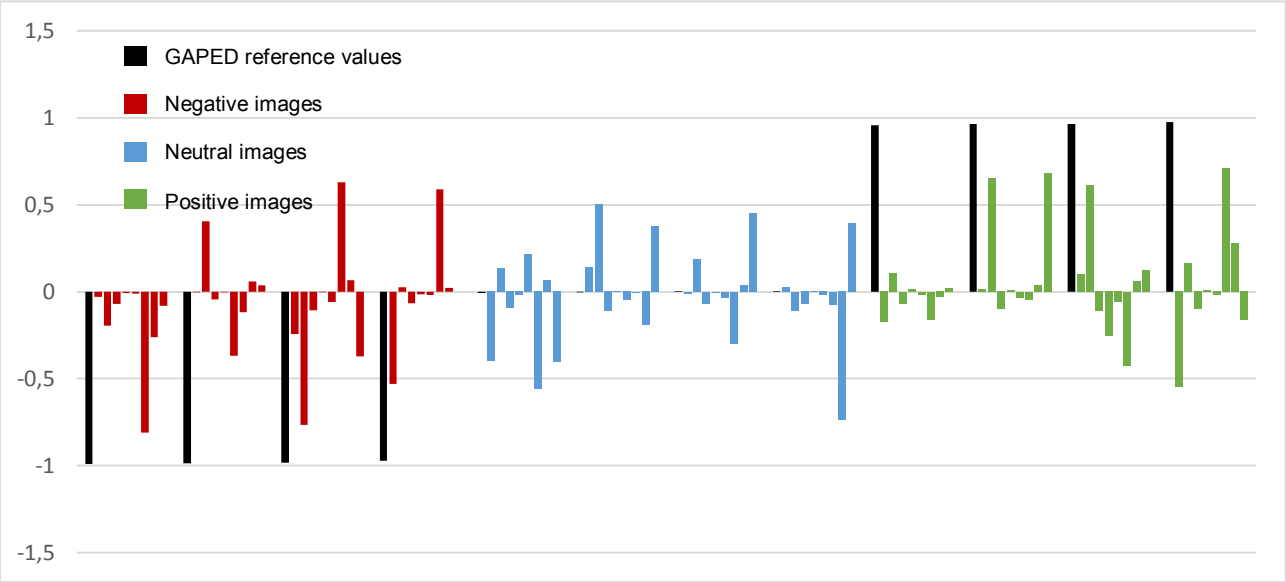

Figure 10: Valence score per image and per participant

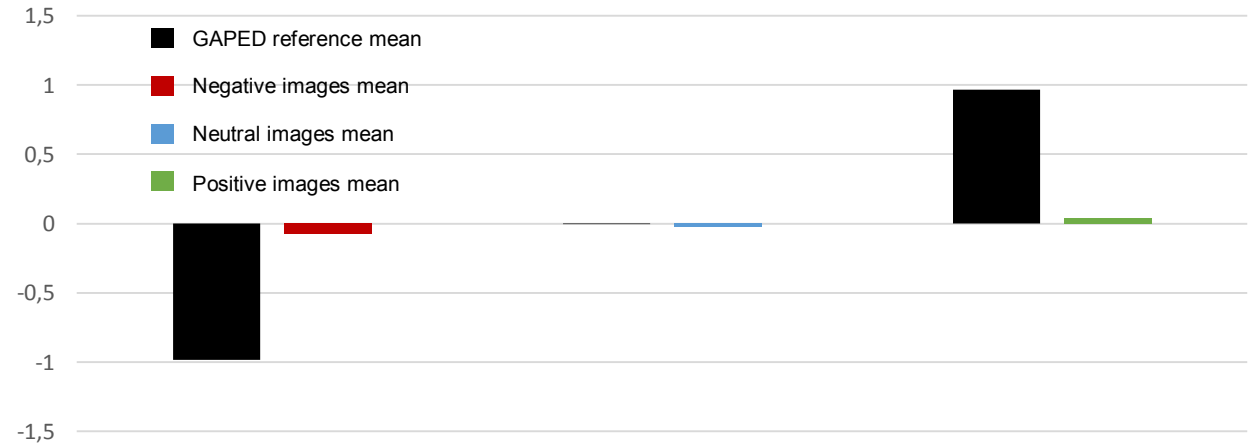

Figure 11: Mean valence score per image group

The difficulties met with FaceReader should however be confirmed in further studies. A frame by frame manual monitoring in order to detect miss-leadings in the face identification should be added to the protocol, as it may happens with barbed users, and hands on face gestures. Otherwise, during later interviews, some users declared that they could have "laughed on the other side of their face", their reaction being more elicited by the succession of extreme images than by their actual content.

3.1.3. Results based on electrodermal actvity

Our results did not match our expectations, as nearly no skin conductance variation had been recorded during the exposure to the GEW pictures. We also observed this during the 'Objective 2' phase.

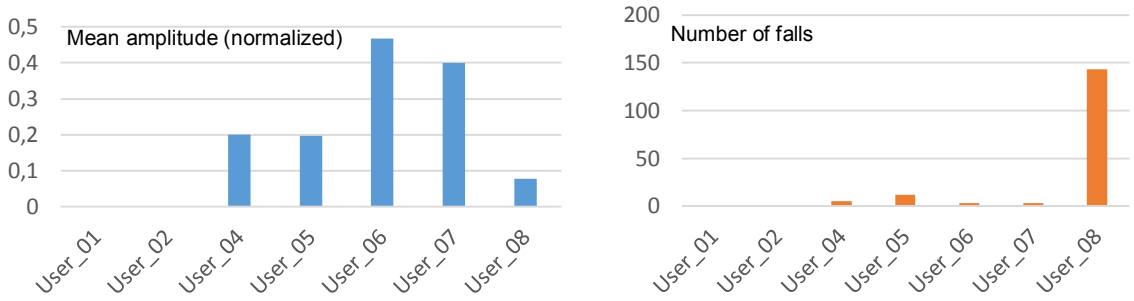

Figure 12: GSR results during questionnaires & resting periods
* Partial records for users 1 and 2, no records for user 3

In fact, we noticed that most of the detected GSR falls were taking place outside of the stimuli periods. Most of these periods match a stronger activity of the participants: they work at answering questionnaires. Some other activity periods match waiting phases: these waiting screens were setup in order to obtain a baseline for the EDA recording of the following stimulus. Paradoxically, these periods were sometimes used by the participants to relax and stretch during the 40 minutes experiment.

These results mean that the provided task (watching a picture, reading a text, or both), generates much less activation than the task of answering questionnaires about emotions. This low activation impact of the provided pictures is consistent with the SAM questionnaire results.

Therefore, we will not dismiss the GSR method for our next studies, as it may be relevant to measure the impact of the user experience generating activation, particularly the task component, and presumably the interaction design sub-component (figure 2).

3.2. Findings related to objective 2

The 'Objective 1' phase of our experiment consisted of presenting GAPED pictures, whose valence score is known, to users in order to assess the efficiency of several emotional measurement methods. This phase presented the GEW and the SAM questionnaires as being relevant and complementary to express users' emotions. However, the Face Reader results were not satisfying. The GSR did not prove to be useful in the specific context of this experiment. Therefore, questionnaires only will be selected to pursue our second objective.

In this 'Objective 2' phase, two different interfaces were presented to the users. Our objective is to determine whether the method we used is efficient enough to distinguish differences in the emotions possibly conveyed by two different interface designs. Following our earlier statement, the interface effect can be estimated as the difference between the overall experience effect, and the effect elicited by the content only.

The following diagrams present the effect produced by the content alone (blue and green), and the overall effect (red), for two different interfaces (type A and type B).

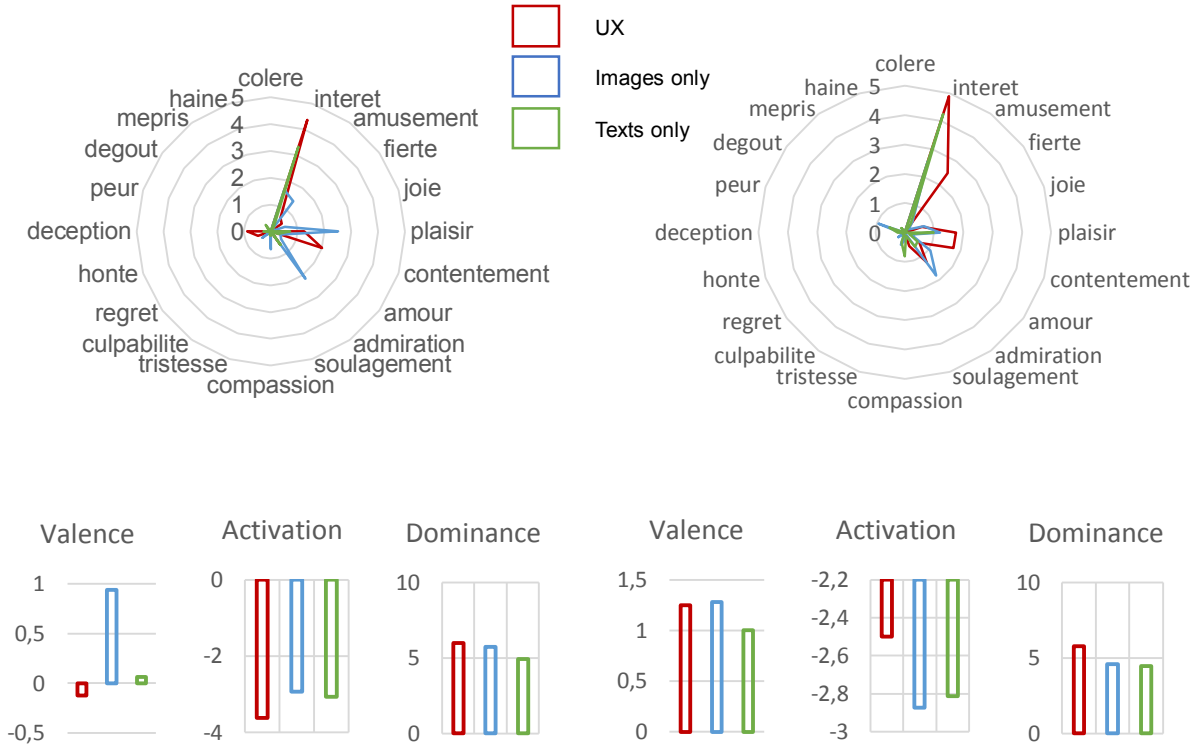

Figure 13: Participant's answers to the questionnaires, design type A on the left, design type B on the right

The following diagrams present a comparison of the resultant interface design effects depending on the two types of design:

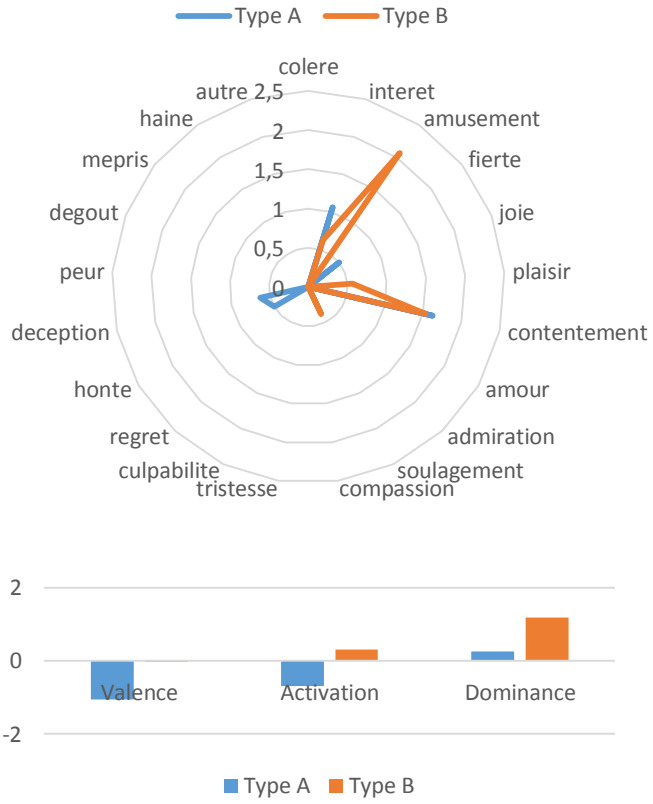

Figure 14: Comparison of emotions produced by two different interfaces

These results show that the type B interface is perceived as being more fun, and slightly more pleasurable than the type A interface. The two questionnaires lead to a similar interpretation on this point. Both interfaces elicit a similar level of contentment. The activation and dominance levels are higher with the type B interface.

These results are confirmed by the terms chosen by the users to describe their experience with the two interfaces during the short interview at the end of the experiment.

Table 1: Emotional terms used by the participants to describe the two interfaces

	User 1	User 2	User 3	User 4	User 5	User 6	User 7	User 8
Type A white		Neutral	Neutral	-		-		More tiring
Type B colorful golden section animation	More attractive, pleasant, friendly.	More friendly Too flashy Attacked	Nicer More positive	-	More implication, and interest. Motivating	-	Better Pleasurable	More attractive, much more pleasure

These results are consistent with previous studies. Interface color lead to a better attractiveness, and may influence cognitive performance (Bonnardel, Piolat & Le Bigot, 2011; Cyr, Head, & Larios, 2010). The higher activation and dominance levels of the type B interface could also be explained by its animation features.

Therefore, the GEW and SAM questionnaires seem to provide an accurate way of assessing the emotional impact of both the content and the overall experience. Moreover, the tested process of indirect measurement of the interface design effect lead to consistent results.

4. CONCLUSION

Emotional design has become a crucial issue for interface designers. However, most of designers' practices are empirical, and methods are required to better assess the emotional effect of an interface design. In this paper, we tested several assessment methods considering the specificities of an interface design: a continuous and changing stimulus, eliciting low-intensity emotions. Moreover, we detailed a user interface emotion model, specifying the role of the design among other components. We proposed a method to measure the emotional effect of this specific component.

Our first results showed that some usual emotion assessment methods were not adapted to the specific context of an interface user experience. Face behavioral does not seem to be a reliable source. The analysis of the electrodermal activity did not provide any insights for our experimental mockups. However these results should be relativized as secondary results orientate its adequacy towards more developed interactions, and higher level tasks. On the other hand, SAM and GEW questionnaires, even if asynchronous and subjective, allowed us to distinguish the emotional effects of the two different interfaces.

These findings will supplement further works in order to specify an emotional assessment protocol fitting the interface design particularities. This method will then contribute to measure and compare the emotional effect of various interface design solutions.

ACKNOWLEDGMENTS

This work is supported by the French national research agency (ANR) under the SKIPPI research project. We thank very much Carole Bouchard and Vincent Rieuf (LCPI) for their supportive role in this work.

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BIOGRAPHY

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1B - Kansei Design in Taiwan 1

New Love in Homes:

Exploring the Attitudes of New Young-Olds in Taiwan towards Electronic Pets

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Abstract: Similar to many developed countries; Taiwan has its problem of ageing populations also. According to statistics released by the Taiwan government, the population that aged 65 or more has reached 11.3% in Taiwan by the end of June 2013. This figure has far exceeded the threshold of being an ageing society, which is 7% according to the UN. In addition, the average retirement age in Taiwan has also dropped to 57.1 in 2011. These retiring elders who currently aged 49 to 67 are “Baby Boomers”. People of this age group were much better educated and wealthier than their previous generations. In order to distinguish them from their previous generations, they were defined as “New Young-Olds” in this research. For the purpose of facilitating a smoother transformation into retirement life for the New Young-Olds, this study initiated an exploration on their attitudes and needs towards electronic pets. It is hope that new possibilities for a happier retirement of the New Young-Olds and new opportunities for the electronic industry in Taiwan might be found here. Therefore, a questionnaire survey was conducted during August to September in 2013; with 396 valid respondents, the survey result showed that the respondents can accept electronic pets much better than their previous generation. Further explorations for the specific needs of the New Young-Olds towards electronic pets were also done to find out suggestions of product development strategies for the electronic industry in Taiwan.

Keywords: ageing society, Baby Boomers, New Young-Olds, electronic pets, happier retirement.

1. INTRODUCTION

The problem of ageing population had emerged in many developed countries in recent years for two reasons: Firstly, the high birth rate after the World War II that created the baby boom has dropped down reversely as the economy went on its way of development. Secondly, the standard of medical care was improving concurrently with the economic development. According to the “Static Statistics of Population by Age Group” released by the Directorate General of Budget,

Accounting and Statistics (DGBAS) of Executive Yuan (www.dgbas.gov.tw), the composition of ageing population has been reached 11.3% by June 2013 in Taiwan. This figure has far exceeded the threshold of being an ageing society, which is 7% according to the definition set by the UN.

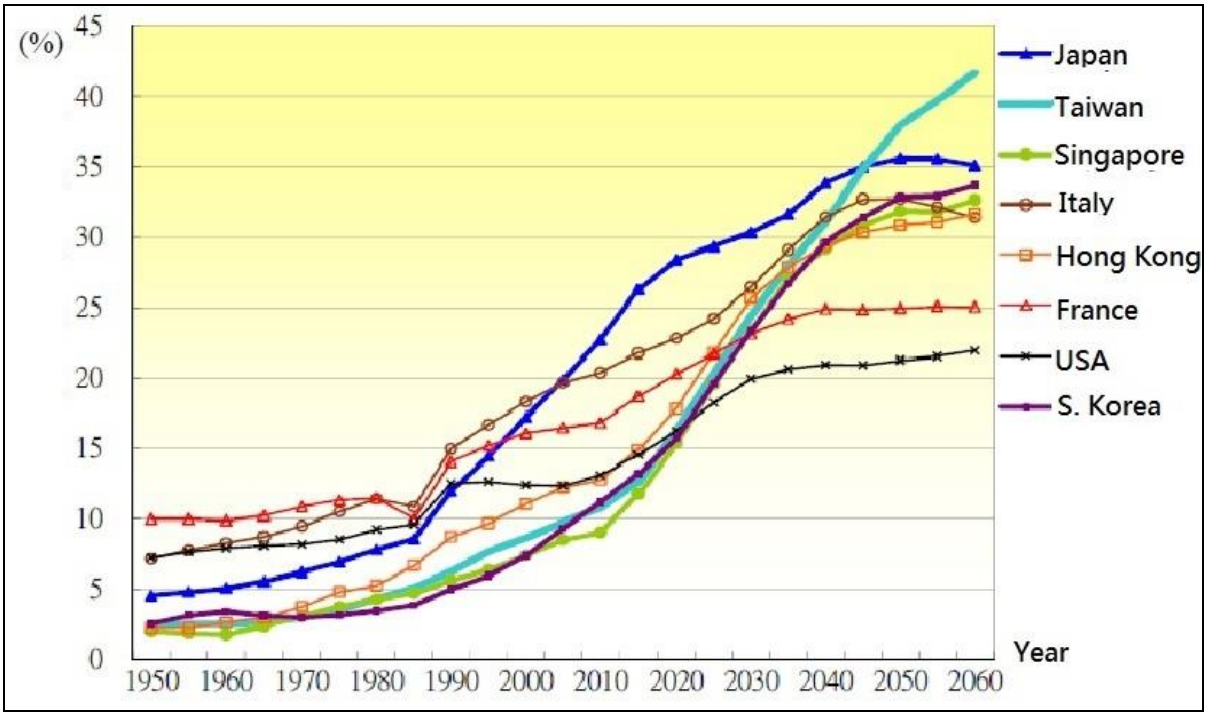

Figure 1: International comparison between the composition of ageing population
(Source: Lou & Fan, 2010)

The newly retired or potentially retiring Young-Olds who currently aged between 49 and 67 are "Baby Boomers". This demographic group is characterized with much better education level and economic wellbeing than their previous generations because of the postwar economic development in many countries. In order to distinguish from "Young-Olds" who were aged 65~74, those who aged 55~64 currently were defined as "New Young-Olds" in this research. For the purpose of facilitating a smoother transformation through the embarrassing years of dramatic change in their social status, and finding new possibilities for happier retirement of these New Young-Olds, this study initiates an exploration on their attitudes and preferences towards electronic pets, in the hope of finding evidences that electronic pets can make their life better. If this assumption can be proven, then new opportunities may also be found here for the electronic industry in Taiwan.

Following these research objectives, a questionnaire survey was conducted among "Young-Olds" and "New Young-Olds" during August to September in 2013; with 396 valid respondents, the result showed that New Young-Olds can indeed accept electronic pets much better than their previous generations. Further explorations for their specific needs and preferences towards electronic pets were also done in this study to find out suggestions of product development strategies for the electronic industry in Taiwan.

2. LITERATURE REVIEW

2.1. Defining "New Young-Olds"

Neugarten (1974) was the first researcher who argued that the demographic group of "old age"

needed to be further differentiated into “Young-Old” and “Old-Old”, by which she defined the former group as aged 65~74 and the latter as aged 75~84. In this study, she created the term “Young-Old”, which later became a widely adopted terminology denoting a generation of aged people who are “not as old” as their former generation.

In addition, it is accepted that Baby Boomers were born between 1946 to1964; thus they are aged 49 to 67 in 2013. Since the Young-Olds are aged 65~74 (Neugarten, *ibid.*), the author held that there is a need to separate the group who are born within the core decade of baby boom period and aged 55~64 at the time of this study. This age-group is different from their previous generations for the high economic development in their early years. This background had effectively enhanced their education level and made their values much more adaptive to various contemporary advancements, especially gadgets that utilizing advanced technologies such as electronic pets. Therefore, this study had defined the age group that aged 55-64 currently as “New Young-Old”.

2.2. The Concept of Active Ageing

In coping with the problem of unemployment for people in their mid and later life due to policies of early retirement, Davey (2002) pioneered in putting forward the idea of “active ageing”. Following Davey’s concept, the WHO (2002) adopted this idea and published the policy framework of “active ageing”, in which the term was defined as “the process of optimizing opportunities for health, participation and security in order to enhance the quality of life as people age”. In this definition, there are three points that consisted of its theme; they are “health, participation and security”. It also emphasized that improving the health and wellbeing of elders will not only be good to the aged themselves, but will also be good to the macro-economy.

3. METHODOLOGY

3.1. Research Orientation

In order to achieve the goals of life quality enhancement for ageing population, i.e. “health, participation and security” according to the WHO policy framework (*ibid.*) mentioned earlier, the researcher held that well designed electronic pets would be very much advantageous for such a fulfillment. Therefore, this research was set out to find the evidence that the group of New Young-Olds is very different from the previous generation in terms of their acceptance towards electronic gadgets. In order to gather and analyze the attitudes and preferences of New Young-Olds in Taiwan towards electronic pets, the method of questionnaire survey was adopted for this research. It is also hoped that the results of this research could offer helpful references for the electronic industries in Taiwan to figure out their product development strategies in this field.

3.2. Creating Questionnaire

For the purpose of reaching a wider scope of targeted respondent group to enhance the reliability of this survey, the questionnaire was designed in two versions. Initially, an online version was designed for use in an online survey, and a secondary version was created in WORD format for uses in both e-mails and printouts. The questions had covered topics of lifestyle, values, attitudes, consumer behavior, preferences, needs, requirements, and key emotional design factors concerning electronic pets, and also background factors of respondents were included. However, in order to comply with the limit of paper length of this conference, only the survey results of consumer preferences, needs, and requirements were reported in this paper. Furthermore, as

there are four categories of electronic pet, i.e. the types of hi-tech toy, smart-action, entertainment appliance, and virtual interaction (Chen, 2007), the acceptance of these four types of electronic pets was also explored. There were 59 questions originally, later downsized to 30 questions in 12 pages following suggestions from the test respondents, with an incentive of 50 Taiwan dollars of convenient store coupon for each respondent. The Figure 2 below shows a sample of the first three pages of this questionnaire.

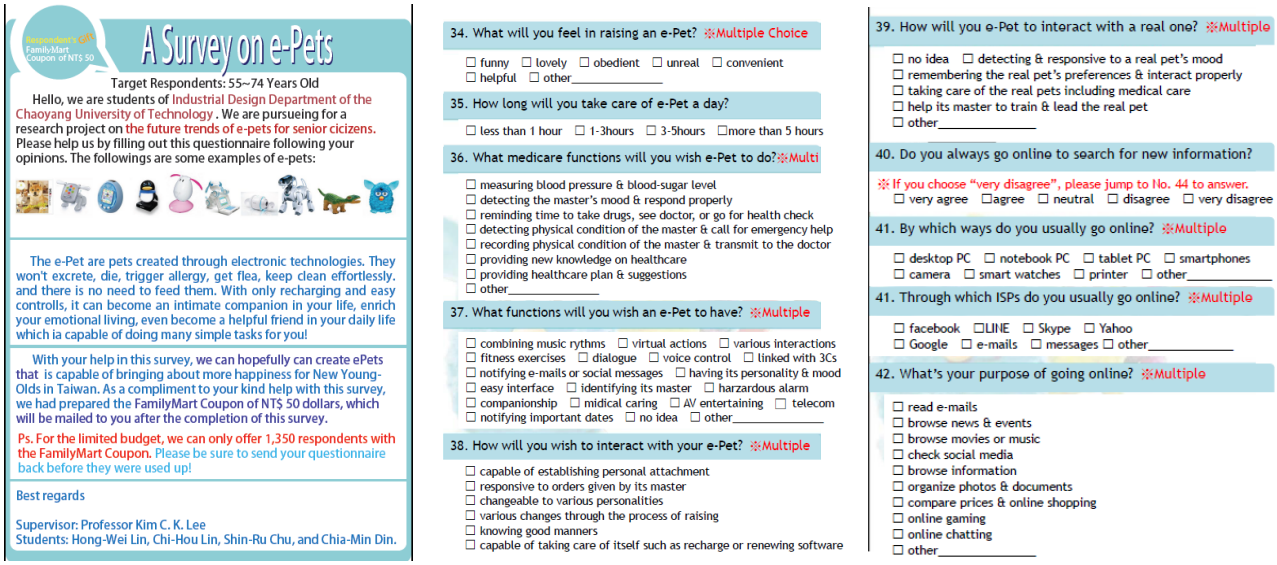

Figure 2: Sample of the questionnaire (translated for this paper)

3.3. Conducting Surveys

This survey was conducted between August and September in 2013. The online questionnaire was posted on the survey website called "MySurvey" (http://www.mysurvey.tw/). The researcher also sent 146 emails and 675 Facebook messages to urge friends to help directly and further redirecting the e-mail or message to their friends and suggest them to help as well. For those respondents who were not convenient in using the online questionnaire, printout version of questionnaires were also delivered. There was a total amount of 961 copies mailed out. In order to keep the project schedule on time, the replies were cutoff at mid-September. The online survey got 301 replies, with 207 valid respondents among them. In addition, there were 241 replies of the printout version, with 190 valid respondents obtained. Therefore, the total number of valid respondents was 396. As the total population of those who aged from 55 to 74 in Taiwan is 4,418,234, the marginal error was ±4.925% under the confidence level of 95%; thus the survey results were valid for doing further research analyses. There were two ways for screening valid respondents. Initially, the age of respondents were checked, only those who fell into the range of 55-74 were taken as valid. Then the answers to a test question hidden in a series of attitude measurement questions were examined. Since the test question was "I did not pay attention to read the questions before I tick any answer", hence any respondent who answered "Strongly agree" or "Agree" to this question was considered as invalid. The rate of replied questionnaire and the rate of valid respondents were shown in Table 1.

Table 1: The rate of replied questionnaire and the rate of valid respondents

Category	Delivered	Replied	Invalid by Age Group	Invalid by Test Question	Valid Respondents	Valid Rate
Online Questionnaire	821	301	68	27	206	28.41
Printout Questionnaire	961	241	17	34	190	19.77
Total	1782	542	85	61	396	23.49

3.4. Analyzing Survey Results

3.4.1. The Acceptance of Four Types of Electronic Pets

In order to assess the acceptance of the four categories of electronic pet for the reference of electronic industries in the formulation of product strategies, all optional answers in the questionnaire were categorized according to their relevance with these four categories of electronic pet; then on the replied questionnaires, the number of ticked options were counted manually, summed up, and calculated with the following formulas:

(1) ticking rate (acceptance) = actual number of ticking ÷ maximum number of ticking ×100%

(2) maximum number of ticking = number of options in the category × number of valid respondents

According the survey results indicated in Table 2 below, the acceptance of the four categories of electronic pet among all respondents was almost equally well. Therefore, it was concluded that these four categories of electronic pet should all be allocated with similar degree of efforts in terms of product development.

Table 2: The acceptance of four types of electronic pets

Types of Electronic Pets	Number of Options in the Category	Actual Number of Ticking	Maximum Number of Ticking	Ticking Rate (%)
Hi-Tech Toy	20	2367	7920	29.9
Smart-Action	30	3738	11880	31.5
Entertainment Appliance	40	3931	15840	24.8
Virtual Interaction	36	4207	14256	29.5

3.4.2. Preference of Functions of Electronic Pets

In order to study the respondents' preference of functions of electronic pets, nine options of possible functions were presented in this question, as shown in Table 3. The survey results indicated that the four groups of respondents had all ranked their preferences a little bit differently. In summing these results up, the ranking of the top five choices among them can be put into the following order: (1) Showing pleased gesture at caresses of its owner. (2) Learning the teachings of its owner. (3) Having lovely appearance and facial expressions. (4) Adapting to personalities as its owner's wish. (5) Moving around happily.

Table 3: The preference of functions of electronic pets

Preference of Functions	Male				Female			
	55-64	%	65-74	%	55-64	%	65-74	%
Learning the teachings of its owner.	88	14.55	28	19.18	48	11.54	20	16.67
Moving around happily.	70	11.57	15	10.27	57	13.70	13	10.83
Adapting to personalities as its owner's wish.	72	11.90	17	11.64	43	10.34	19	15.83
Showing pleased gesture at caresses of its owner.	95	15.70	19	13.01	68	16.35	12	10.00
Having lovely appearance and facial expressions.	83	13.72	16	10.96	59	14.18	11	9.17
Greeting its owner everyday warmly.	68	11.24	16	10.96	48	11.54	15	12.50
Pleasing its owner by lovely gestures.	48	7.93	16	10.96	38	9.13	19	15.83
Exercising or playing together with its owner.	56	9.26	11	7.53	45	10.82	3	2.50
Playing games with its owner.	25	4.13	8	5.48	10	2.40	8	6.67
Total	605	100	146	100	416	100	120	100

3.4.3. Preference of the Weight of Electronic Pets

For the investigation of the respondents' preference of the weight of electronic pets, three options were presented in this question resembling the weight of mineral water in daily use for easier differentiation, as shown in Table 4. The survey results showed a clear and identical preference among the four groups of respondents towards the weight that is similar to a bottle of mineral water of 600 c.c. capacity.

Table 4: The preference of the weight of electronic pets

Preference of the Weight	Male				Female			
	55-64	%	65-74	%	55-64	%	65-74	%
The weight of a 600 c.c. bottle of mineral water.	116	63.39	28	71.79	113	11.54	20	62.50
The weight of a 1500 c.c. bottle of mineral water.	62	33.88	8	20.51	26	13.70	11	34.38
The weight of a 5000 c.c. bottle of mineral water.	5	2.73	3	7.69	3	10.34	1	3.13
Total	183	100	39	100	142	100	32	100

3.4.4. Preference of Sizes of Electronic Pets

For the investigation of the respondents' preference of sizes of electronic pets, five options were presented in this question resembling the sizes of different balls in common use for easier

differentiation, as shown in Table 5. The survey results showed the four groups of respondents had ranked their preferences a little bit differently in terms of gender. It seems that the preference of females was smaller than males. To rank the top two choices among them collectively, they can be ordered as: (1) The size of a volleyball ball, and (2).The size of a softball.

Table 5: The preference of sizes of electronic pets

Preference of Sizes	Male				Female			
	55-64	%	65-74	%	55-64	%	65-74	%
The size of a baseball.	46	25.14	8	20.51	46	32.39	8	25.00
The size of a softball.	47	25.68	11	28.21	49	34.51	6	18.75
The size of a volleyball ball.	68	37.16	14	35.90	28	19.72	12	37.50
The size of a basketball.	19	10.38	5	12.82	17	11.97	6	18.75
The size of a yoga ball.	3	1.564	1	2.56	2	1.41	0	0
Total	183	100	39	100	142	100	32	100

3.4.5. Preference of Operational Interfaces of Electronic Pets

In terms of determining the respondents' preference of operational interfaces of electronic pets, seven options were presented, as shown in Table 6. The survey results showed the first choice of the four groups of respondents were all ranked as "voice control". Although the second and the third choices seemed to be different slightly from each other, they can be ordered as the followings while ranking them collectively: (2) touch control / highly automatic (equal between the two), and (3) mobile phone apps.

Table 6: The preference of operational interfaces of electronic pets

Preference of Operational Interfaces	Male				Female			
	55-64	%	65-74	%	55-64	%	65-74	%
Remote Control	10	5.49	5	12.82	9	6.34	2	6.25
Touch Control	28	15.38	10	25.64	34	23.94	4	12.50
Voice Control.	85	46.70	11	28.21	73	51.41	13	40.63
Highly Automatic.	31	17.03	10	25.64	9	6.34	2	6.25
Internet Control.	6	3.30	0	0	1	0.70	0	0
Mobile Phone Apps	14	7.69	0	0	11	7.75	10	31.25
With Body Gesture	9	4.92	3	7.69	5	3.52	1	3.13
Total	183	100	39	100	142	100	32	100

3.4.6. Needs for Futuristic Functions of Electronic Pets

This question was created in order to predict the respondents' needs for futuristic functions of electronic pets in the four groups of different ages and genders. Twenty-one options of descriptions of futuristic functions were presented here, as shown in Table 7. The survey results indicated that the four groups of respondents had all ranked their first choice of futuristic function as "Monitoring health conditions", and also the agreed second choice as "Remote connections with medical institutions". This result indicated a strong need of automatic and remote health monitoring and connecting capabilities. However, the other futuristic function needs of the four groups of respondents presented a little difference to each other. In summing these results up, the ranking of the top six choices among them can be put into the following order: (1) Monitoring health conditions.

Table 7: The needs for futuristic functions of electronic pets

Needs for Futuristic Functions	Male				Female			
	55-64	%	65-74	%	55-64	%	65-74	%
Going online and browsing information.	32	5.19	8	4.73	26	5.78	2	1.43
Making visual phone calls.	35	5.67	8	4.73	23	5.11	8	5.71
Monitoring health conditions.	**93**	**15.07**	**18**	**10.65**	**93**	**20.67**	**18**	**12.86**
Remote connections with medical institutions.	62	10.05	8	4.73	36	8.00	16	11.43
Smart digital secretary.	34	5.51	4	2.37	21	4.67	1	0.71
Rich in interactive capability.	38	6.16	11	6.51	19	4.22	6	4.29
Virtual interactive games.	21	3.40	11	6.51	17	3.78	5	3.57
Combining with various 3C products.	22	3.57	8	4.73	17	3.78	6	4.29
Behavior simulations capability.	36	5.83	7	4.14	11	2.44	5	3.57
Dialogue capacity with its owner.	40	6.48	9	5.33	28	6.22	10	7.14
Smart learning capability.	40	6.48	9	5.33	28	6.22	7	5.00
Long battery durability.	23	3.73	9	5.33	13	2.89	12	8.57
Information browsing and provision.	5	0.81	4	2.37	6	1.33	1	0.71
Raising and growing capacity for its owner.	7	1.13	3	1.78	2	0.44	8	5.71
Aiding social activities of its owner.	7	1.13	2	1.18	10	2.22	2	1.43
Playing games with real pets.	25	4.05	12	7.10	13	2.89	10	7.14
Nimble and agile enough to follow up its owner.	18	2.92	10	5.92	22	4.89	9	6.43
Night vision capability.	18	2.92	7	4.14	13	2.89	2	1.43
Reading out aloud and translation ability.	18	2.92	7	4.14	13	2.89	2	1.43
Automatic recharge capability.	31	5.02	12	7.10	23	5.11	8	5.71
Exercise companionship capability.	12	1.94	2	1.18	16	3.56	2	1.43
Total	6	100	169	100	450	100	140	100

(3) Remote connections with medical institutions. (3) Dialogue capacity with its owner. (4) Smart learning capability. (5) Rich in interactive capability, and (6) Behavior simulation capability.

3.4.7. Needs for Futuristic Life Impacts of Electronic Pets

This question was devised in order to predict the respondents' needs for futuristic life impacts of electronic pets. Twelve descriptions of futuristic life impacts were provided here as options, as shown in Table 8. The survey results indicated that the four groups of respondents had all ranked their top four choices of futuristic life impacts slightly different to each other. In summing these results up, the ranking of the top six choices can be put into the following order: (1) Automatic connection for first-aid in emergencies. (2) Enrich fun and happiness in life. (3) Automatic health monitoring. (4) Remote connections with medical institutions. (5) A reminder for important dates and activities, and (6) A major emotional attachment.

Table 8: The needs for futuristic life impacts of electronic pets

Needs for Futuristic Life Impacts	Male				Female			
	55-64	%	65-74	%	55-64	%	65-74	%
Enrich fun and happiness in life.	85	14.24	14	10.77	48	10.98	12	13.04
Enhance fun and happiness between friends.	31	5.19	8	6.15	26	5.95	3	3.26
Enhance interactions between friends.	45	7.54	5	3.85	28	6.41	10	10.87
Remote connections with medical institutions.	66	11.06	7	5.38	50	11.44	10	10.87
Automatic connection for first-aid in emergencies.	81	13.57	17	13.08	59	13.50	10	10.87
Automatic health monitoring.	69	11.56	9	6.92	53	12.13	15	16.30
A major emotional attachment.	36	6.03	15	11.54	27	6.18	1	1.09
A reminder for important dates and activities.	53	8.88	12	9.23	53	12.13	10	10.87
A family visual connection hub.	27	4.52	8	6.15	19	4.35	11	11.96
A living information center.	37	6.20	13	10.00	31	7.09	1	1.09
Enhance memory and reaction capacity.	33	5.53	13	10.00	20	4.58	6	6.52
Enhance health and confidence.	34	5.70	9	6.92	23	5.26	3	3.26
Total	597	100.0	130	100.0	437	100.0	92	100.0

3.4.8. Preferred Type of Games of Electronic Pets

In order to explore the respondents' preferred type of games of electronic pets, nine options were provided as shown in Table 9. The survey results showed the top three choices of the four groups of respondents were all ranked identically as follows: (1) Brain power games (2) Rhythmic games, and (3) Games of body gestures.

Table 9: The preferred type of games of electronic pets

Preferred Type of Games	Male				Female			
	55-64	%	65-74	%	55-64	%	65-74	%
Games of Body Gestures	52	13.94	9	10.74	23	9.43	7	12.73
Adventurous Games	38	10.19	5	5.95	10	4.10	4	7.27
Brain Power Games	88	23.59	24	28.57	84	34.43	14	25.45
Strategic Business Games	21	5.63	4	4.76	17	6.97	5	9.09
Roleplaying Games	29	7.77	7	8.33	13	5.33	1	1.82
Sports Games	29	7.77	7	8.33	13	5.33	1	1.82
Rhythmic Games	50	13.40	13	15.48	46	18.85	10	18.18
Raising and Growing Games	30	8.04	9	10.71	16	6.56	3	5.45
No Idea	36	9.65	6	7.14	22	9.02	10	18.18
Total	373	100	84	100	244	100	55	100

3.4.9. Preferred Healthcare Functions of Electronic Pets

Table 10: The preferred healthcare functions of electronic pets

Preferred Healthcare Functions	Male				Female			
	55-64	%	65-74	%	55-64	%	65-74	%
Monitoring blood pressure and blood sugar.	91	16.73	22	17.89	68	17.66	19	19.19
Detect the owner's mood and response properly.	83	15.26	23	18.70	58	15.06	10	10.10
Reminder of visiting doctors, health checking, and the tine of taking medicines.	98	18.01	24	19.51	75	19.48	20	20.20
Monitoring physical conditions and connect for first-aid in emergencies.	106	19.49	21	17.07	61	15.84	19	19.19
Record physical conditions and send to the family doctor automatically.	67	12.32	13	10.57	46	11.95	14	14.14
Presenting knowledge on keeping good health.	60	11.03	15	12.20	52	13.51	12	12.12
Providing consultations on health enhancement.	38	6.99	5	4.07	25	6.49	5	5.05
Others	1	0.18	0	0	0	0	0	0
Total	544	100	123	100	185	100	99	100

This question was aimed at uncovering the respondents' preferred healthcare functions, seven options provided here, as shown in Table 10. The survey results showed the top three choices of

the four groups of respondents were all ranked identically as follows:
(1) Reminder of visiting doctors, health checking, and the tine of taking medicines.
(2) Monitoring physical conditions and connect for first-aid in emergencies, and
(3) Monitoring blood pressure and blood sugar.

4. RESEARCH FINDINGS

4.1. Acceptance of Electronic Pets

The survey results showed that electronic pets can hopefully be well accepted by New Young-Olds in Taiwan. In addition, the four categories of electronic pets, i.e. the types of hi-tech toy, smart-action, entertainment appliance, and virtual interaction can all be accepted equally well.

4.2. Needs and Requirements of Electronic Pets

4.2.1. Preferred Functions

The preferred functions of electronic pets were ranked in the following order:
(1) Showing pleased gesture at caresses of its owner.
(2) Learning the teachings of its owner.
(3) Having lovely appearance and facial expressions.

4.2.2. Preferred Weight and Sizes

The weight of electronic pets is preferable to be in “light weight”, and its preferred size is between a volleyball ball and a softball.

4.2.3. Preferred Operational Interfaces

The preferred operational interfaces of electronic pets were ranked in the order of voice control, automatic control, touch control, and mobile phone control apps.

4.2.4. Preferred Futuristic Functions

The most expected six futuristic functions of electronic pets can be put into the order as follows: (1) Monitoring health conditions. (2) Remote connections with medical institutions. (3) Dialogue capacity with its owner. (4) Smart learning capability. (5) Rich in interactive capability, and (6) Behavior simulation capability.

4.2.5. Preferred Futuristic Life Impacts

The most envisioned futuristic life impacts of electronic pets can be ranked in the following order: (1) Automatic connection for first-aid in emergencies. (2) Enrich fun and happiness in life. (3) Automatic health monitoring. (4) Remote connections with medical institutions. (5) A reminder for important dates and activities, and (6) A major emotional attachment.

4.2.6. Preferred Type of Games

The preferred type of games of electronic pets were ranked in the following order:
(1) Brain power games, (2) Rhythmic games, and (3) Games of body gestures.

4.2.7. Preferred Healthcare Functions

The preferred healthcare functions of electronic pets were ranked in the order as:
(1) Reminder of visiting doctors, health checking, and the tine of taking medicines.
(2) Monitoring physical conditions and connect for first-aid in emergencies.
(3) Monitoring blood pressure and blood sugar.

4.3. Strategic Considerations of Product Development

The past five decades of development of electronic industry in Taiwan was focused in building technological foundations both in manufacturing and design mainly, so that a world class capacity of product design and development was well established. However, it was a pity that they largely remained at the top of OEM and ODM operational models so far. Such a long stagnation in the same status without proper effort in striving up-stream had in effect eroded the strength that they had earned. Jumping away from the OEM/ODM operational model is surely a long and tough way to go; nonetheless, there will be no chance without beginning. In order to make proper use of the solid foundation established earlier, it is never too late to start.

If there are some Taiwanese electronic industry which will make their endeavor in developing electronic pets, this paper is trying to provide them with some useful references in terms of user requirements. Before any part of these references can be accepted, some suggestions on strategic considerations of product development may play a key role to make it happen. An important strategic thinking to be argued here is that the home market of Taiwan is actually always wasted too easily. For those who had been acquainted with OEM/ODM business, Taiwan market is not even big enough to be a piece of cake; after all, it is impossible to remain in the OEM/ODM business forever. Whenever we find that it is an imperative for us to end this business model, this home market will always be useful enough. Although it is not big indeed, still, our home ground has several merits of being a convenient touchstone for a big market, assuming that we are going to find one by our own efforts. Firstly, it is small but enough to engage in a small test launch of new products. Secondly, it is convenient and completely at our own disposal. Thirdly, the Baby Boomers in Taiwan have many things in common with Baby Boomers in other countries; thus it is not impossible to make inferences of needs and wants between these corresponding groups.

4.4. The Target Market

As mentioned early in this paper, the target market recommended for testing newly developed electronic toys is the group of New Young-Olds. In 2003, the population of this group in Taiwan was 2,970,109. In addition, 46.16% among this population (1,371,002) are high school educated or higher. (Static statistics of population by age group, http://www.dgbas.gov.tw) They not only have good educations, but also have sound career development and sufficient incomes. The most important of all is that they are knowledgeable enough to accept any product based on brand new technologies. Therefore, it is not difficult to sell tens of thousands of products to them, which is an amount good enough for early trial marketing of any independently developed new product.

4.5. Suggestions on Product Strategy

Based on the survey results and the arguments made so far, the following product strategies are provided as reference of an overall direction of product development of electronic pets.

4.5.1. Using Windows of Market

The concept of using windows of opportunities as an entry is an effective way to get into any market. For example, the former section had suggested that Taiwan market can be used for test launches for products that will target at the global market eventually. In this context, Taiwan market is taken as a window of opportunity for the global market. Moreover, this concept can also be applied in a smaller context, e.g., we can take the group of New Young-Olds as a window of opportunity of winning Taiwan market. Furthermore, the context can go even further smaller as to take the group of university graduates among New Young-Olds as a window of opportunity of winning the whole of new Young-Olds.

4.5.2. Social Needs of New Young-Olds

As mentioned earlier, two important characteristics of New Young-Olds are that they are higher educated and well developed in their careers. These two points mean that they have many friends and also their family members. Now that they are approaching their retirement, they are going to see friends, relatives, and family members as more important than ever for satisfying the needs of good interpersonal relationships. Under such a psychological background, if we can develop our electronic pets to have more social assistant functions, then they will be much better accepted by this user group.

4.5.3. Needs of Personal Healthcare

Although the New Young-Olds are still not too old; however, they all know very well that they are becoming old. Hence they will keep in mind to make several preparations and many ways of prevention. On the one hand, they will pay more attentions in ways of keeping better health, and they will also try many ways to arrange things that can be in favor of themselves in case of illness on the other. Therefore, our electronic pets must be equipped with many healthcare capabilities to satisfy these needs. Also, there is one more thing to take care here; i.e. although they need healthcare functions, but they mostly feel shy to make this known for others. Therefore, these functions must be kept in low profiles, or being covered with some kinds of disguise, which will make the user feel more comfortable with it.

5. CONCLUSIONS

Since low mortality rate and low birth rate always happen together, developed countries are inevitable of becoming ageing societies, and there is no exception for Taiwan. In order to make it a happier and healthier ageing or even aged society, this study was aimed at providing a solution to this problem through suggestions of product development strategies of electronic pets. Through a questionnaire survey, the preferences, needs, and requirements of New Young-Olds in Taiwan were explored, and product strategies were suggested. It was found that electronic pets can well be accepted by the New Young-Olds in Taiwan, hope that both the electronic industry and New Young-Olds will be better-off with the helps of this study.

ACKNOWLEDGMENTS

This paper is the result of a research project under the sponsorship awarded by the Ministry of Science and Technology of Taiwan, ROC. The project name is “Ideal Innovation Leadership in Industrial Designer's Expectations”, and the project number is NSC 102-2221-E-324-027. The author would like to express his appreciations for this sponsorship here.

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BIOGRAPHY

The author was an industrial design manager from 1976 to 1997 of SAMPO Corporation, a major home appliances and electronics manufacturer in Taiwan. The team that the author led was a leading design force and an important cradle for training newly graduated industrial designers in Taiwan during that period. In order to extend this experience of training young designers, the author took an early retirement and devoted to design academia at the Industrial Design Department of Chaoyang University in 1997, and earned his PhD degree in Design Management from the University of Leeds in the UK in 2005.

An Investigation of Washing and Dressing Behaviors in Bathrooms in Taiwan

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Abstract: Bathrooms are generally shared among family members of different generations in Taiwanese households. According to statistics, 85.8% of bathrooms in Taiwan are shared among more than two people (Taiwan Design Center, 2006). However, the internal size of a bathroom in Taiwan is normally 5 square meters and contains general fixtures such as a washbasin, a toilet, and a bathtub. Considering that a washbasin, in which users can wash their faces or assorted items, might be the most frequently used fixture in a bathroom, this study chose it as the research target. As most bathrooms in typical households are considered communal spaces, the different habits of bathroom users and the similarities or variations in their physical conditions present a challenging issue for designers, who must consider individual user needs during design.

This study conducted on-site observations of the washing and dressing behaviors of bathroom users in different groups, and interviewed users concerning their bathroom usage experience. The specific morning bathroom usage procedures of 15 users were recorded. The users consisted of adults, children, and elderly people. The time allocated for each bathroom user was approximately 10 minutes, which began with observing the usage procedures and then subsequently transcribing these procedures into texts. After analyzing the same behaviors of different bathroom users, a conclusion was drawn about similar problems that occurred to general bathroom users. Finally, new indexes were designed to address those problems, as well as similar problems, were analyzed, consolidated, and summarized into four categories: water volume and temperature adjustment, face-washing and cleaning method, handrail setting and height, and storage space. Through the case study, this research aimed to define the problems encountered by users while washing and dressing in a bathroom, further discuss these problems, and seek for solutions.

Keywords: Bathroom Space; Washing and dressing behaviors; Observation method

1. INTRODUCTION

1.1. Research Motives and Purposes

Bathroom space is a household space shared by family members on a daily basis, regardless whether adults, children, the elderly, or those with poor mobility. The bathroom space in Taiwan is generally 5 square meters, and there is no dry-wet separation design between the washing area and toilet. Statistics show that 85.8% of bathroom space in Taiwan is shared by at least 2 persons (Taiwan Design Center, 2006); moreover, the elderly and children are likely to have accidents in bathrooms. This study aims to identify the usage habits and differences of Taiwanese users, in order to propose design references. Hence, this study discusses the design and configuration of washing and dressing spaces in a Taiwanese household environment, and improves such spaces in order to better cater to the use demands of different groups.

This study focuses on family bathroom space regarding the demands and attitudes of users toward washing, and understand how users of different generations or with physical disabilities use the basins for washing and dressing.

2. INTRODUCTION

2.1. Research Motives and Purposes

In the design of Taiwanese residences, bathroom spaces are narrow and without dry-wet separation. According to the Hondao Senior Citizen's Welfare Foundation, the bathroom is one of the three most dangerous places in the home. According to the Ministry of Health and Welfare, 44% of accidental falls of elderly people take place at home, mostly in bathrooms. Children are apt to slip and get injured, climbing and falling, be scalded by hot water, drown,ingest detergent by mistake, receive an electric shock, etc. It is hoped that the problems incurring in bathroom could be discovered, and future designs would improve bathroom environments, in order to mitigate the danger.

2.2. Development of bathroom and toilet utensil

The most commonly bathroom and toilet facilities in Taiwan include washbasin, bathtub, and toilet. However, according to Construction and Planning Agencystatistics, 87% of the Taiwanese are accustomed to showering while using the washbasin as support to enter and exit the bathtub, resulting in falling and breaking of washbasin due to poor weight endurance. Slippery floors also contribute to bathroom accidents, thus, for the sake of safety, there should be a dry-wet separation design for the toilet.

The Construction and Planning Agency, Ministry of the Interior (CPAMI), plans a book called Physical Manual of Residential Bathroom Space, which could help people learn about toilet facilities. In the Manual, the dimensions for commonly seen toilet facilities are stipulated. Commode includes table-board, scaffolding, and wall mounting types (Figure 1). In order to save space, residences in Taiwan tend to select wall mounting commodes, with a width of appropriately 60cm and height of 80-85cm (from table-board to the ground). However, in recent years, scaffolding and table-board types are increasingly advocated.

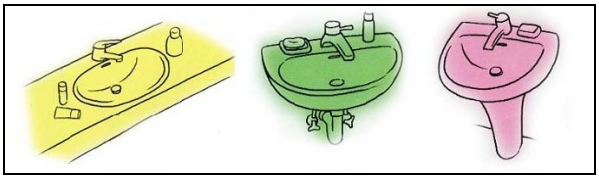

Figure 1: Basic patterns of commode (CPAMI, Physical Manual of Residential Bathroom Space)

2.3. Obstacle factors to use commode

The obstacle factors to use commode are ranked from top to bottom as: soreness of waist from long-time standing, no space available for storage, height is inconvenient for use, faucet is not easy to use, unclear marking of cold and hot water, and height of mirror.

Table 1: Obstacle factors to use washbasin by four groups of testes(A Study of Behavior in the ResidentialBathroom Environment,2006)

Obstacle factors	Aged group (%)	Ordinary group (%)
Soreness of waist from long-time standing	68.5	35.2
No space is available for storage	37.0	22.4
Height is inconvenient for use	16.3	26.4
Faucet is not easy to use	14.1	5.2
Unclear marking of cold and hot water	7.6	1.7
Height of mirror	4.3	6.6

The height of the commode is most inconvenient. The difference in the heights of users leads to differences in the use of commode. Usually, men believe that the commode is so short that they must bend over to use, which leads to soreness of the waist; moreover, they are apt to contact the commode while bending, crouching, or standing up. On the contrary, the commode seems too high for children to use, while the disabled deem it appropriate to have sufficient height and room under the commode for entrance and exit of wheelchair, otherwise those in a wheelchair could not use the commode, which means that the height of commode must match that of the wheelchair. The height of mirrors must also consider different users. Another problem in using the commode is storage. The table-board commode could provide flat space for temporary storage; however, when puddles occur due to splashing, it is likely to dabble, stain, or cause incrustation to the bath supplies. In terms of gender, females have more demand for the commode. Female respondents state that (Cheng, 2007) they will wash underclothes in the commode, and will consider the space and equipment to wash clothes (such as, washbasin, bucket, etc). In addition to washing and dressing in the bathroom, female respondents also tend to do their hair, shave eyebrows, use emulsions, etc; therefore, it is best to design bigger mirrors and larger tabletops to store articles.

2.4. Dimension for behavioral space

In bathroom and toilet use, people also need to put on and take off clothes, bend over for washing face, pick up articles beside the shower, and defecate. Therefore, movement space must be reserved in bathroom and toilet areas, which are necessary from the perspective of human engineering.

According to the Usability Research of the Space on Bathroom and Toilet, Ching-yi Lin proposed

relevant statements regarding the current bathroom and toilet use (Lin, 2002), as for the space for a commode, in order not to let the water flow from front side while washing the face, people mostly bend over. According to the standard height of people in Taiwan, the height of the commode is likely to be set around 75cm. Another concern about face-washing is that some people use this space for hair washing. Therefore, while planning the height of the commode, it is better to consider the habits of users. Human engineering references (Narasaki, 2002) also point out that, for the closestool and bathtub used by the elderly people, there must be necessary safety facilities and safety height (Figure 2).

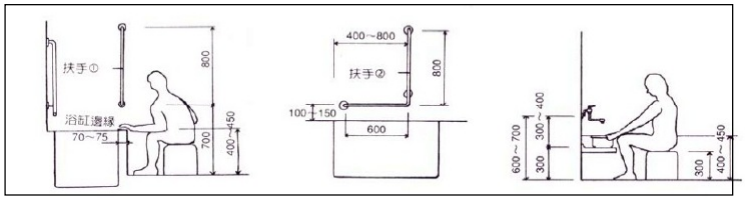

Figure 2: Comparison of auxiliary handrail of bathtub and table dimension (Narasaki, 2002, P116, 118)

Due to different personal heights, the height for a commode differs as well. Based on Figure 3, the best height of commode for ordinary users is 800±50mm, while that for wheelchairs is around 700mm (Figure 4).

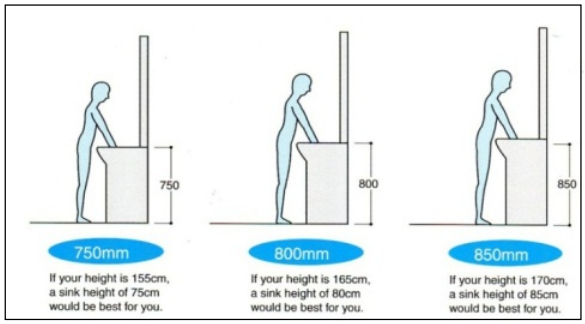

Figure 3: Most suitable heights of commode for people of differingheights

Source: The Concept of Universal Design, 2004, P25



Figure 4:Most suitable heights of commode for wheelchair users

Source: Toto Machine Co., LTD 2006, P74

In terms of residential patterns, open and independent residences in Taiwan tend to place the bathroom and toilet under the stairs, which limits building and surface spaces. Therefore, the bathroom and toilet space are usually squeezed in. Differences in residence patterns have minor

impact on bathroom and toilet spaces in Taiwan, while the major influential factors remain the limitations and obstacles to the elderly, due to their degrading physical abilities to use equipment and adapt to an environment. As a result, in order to consider the bathroom and toilet space for the elderly, consideration must be given to degrading physical abilities, the design of proper auxiliary tools to enhance the safety of elderly in mobility in bathroom and toilet, and avoid accidents. (Chen Ming-Shih, 2005)

It is important for the configuration of bathroom and toilet devices to consider the actions of users in order to maintain the fluency of action. The actions and scope of bathroom and toilet users shall be considered, and further plan a fluent device configuration. Many hidden accidents are likely to occur in bathroom and toilet spaces, thus, this study intends to learn the usage actions, trouble and inconvenience experienced in bathrooms and toilets, discover the problems and summarize reasonable advice in product design for bathroom and toilet spaces, as seen from the views of users, and provide reference for future research and design.

2.5. Study on relevant cases

Regarding studies on the use of washing and dressing spaces by different groups, Japanese scholars conducted relevant case studies regarding commodes in the homes of the elderly, which mainly focus on commode, as caretakers could take care of 2 elderly people at the same time. The commode applies asymmetric design, and considers that wheelchair users could use the commode by getting close, as well as more table space.

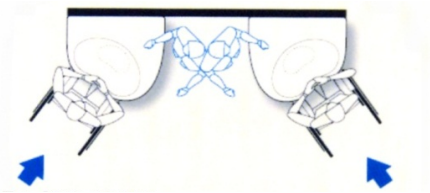

Figure5: Asymmetric commode (Source: Annual Design Review of JSSN Vol10. No.10,2004)

3. Research Method

This research in divided into 2 stages, preliminary research and field interview observations. It is intended that the research results of both present cases.

3.1. Preliminary research

In order to actually study the problems faced by different groups in bathrooms and toilets, preliminary research is conducted in the form of interviews, field survey, and observation. In terms of case selection, different patterns of residences are the main research target, including shared apartment, independent family home, and single-person suite for preliminary research. The users of each age group are selected as sampling survey (the elderly, middle-aged, and the young).

3.2. Field interview observation

The Post-Occupancy Evaluation method employed. The different family patterns found in preliminary research might derive different spatial configurations. Moreover, the different habits of use by respondents would affect use behavior. Therefore, in the case survey, it is more than interview and observation in many cases. Residence patterns and basic data are also the focus of the survey, which are then compared in an awareness survey.

3.3. Procedure and objective of interview and observation

This research is a relevant survey for use behavior, and its main difficulty lies in the implementation of behavior observation. As use of bathroom and toilet is private, actual behavior observation is impossible, thus, this study used behavior simulation observation and interviews to learn of bathroom and toilet habits in order to further understand their behavior model. The main content of observations and interviews include users, use behavior, use of space, etc. Use behavior is understood via interviews with respondents and observation of space. The procedures of observations and interviews are as shown in Figure 6.

Therefore, this study employs the non-participation observation approach to understand the washing and dressing conditions of respondents in bathroom and toilet to learn the mood response of users, while the products are used from the interview with the respondents. It is hoped that respondents can be interviewed face-to-face in natural and familiar environments, in order to understand the daily habitual washing and dressing behavior of users.

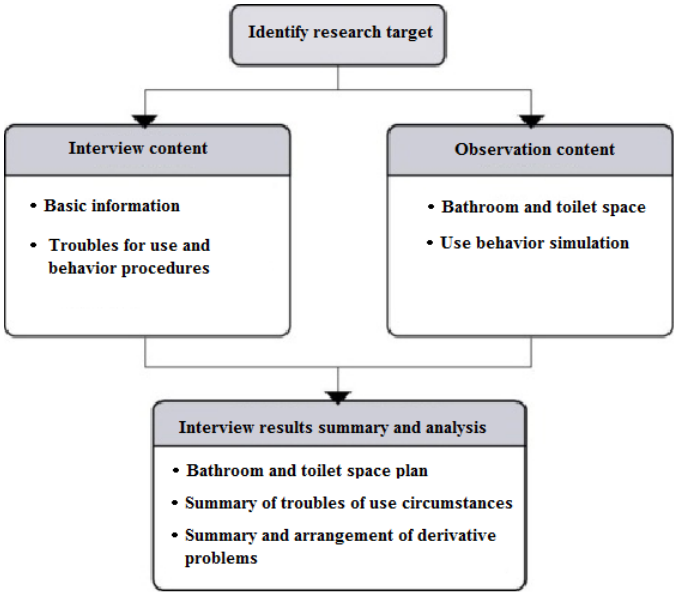

Figure 6: Procedures of Interview and Observation

3.4. Survey of users

3.4.1. Objective of survey

(1) Under different family patterns, the obstacles experienced by different groups in the use habits and behaviors of bathroom and toilet.

(2) Understand the expectations of different groups regarding bathroom and toilet space, and conduct a survey on improvement awareness.

3.4.1. Selection of respondents

As this research needs to learn the living behaviors of respondents, and conducts 30-40min interview and observation records, it conducts line and use behavior simulation in the form of purposive sampling (Wu, 2003, P.1-9), as well as multiple case studies of different residence patterns, including general users, children, and the elderly people, selects 3-5 samples from each

group. Their physical and psychological status must be apparently healthy, and mentality must be clear enough to interpret issues. Moreover, due to health status, apprehension, ability, and writing skills, the query mode of the questionnaire employs one-to-one Q & A interviews by the researcher with the respondents. As the respondents are limited by time, ability, and expense, this study only selects part of central Taiwan as the location of research respondents.

4. Research Results

4.1. Case interview and observation of washing and dressing behavior

This study has 15 respondents, 8 male and 7 female, which are averagely distributed among various age groups. This study mainly focuses on the morning washing and dressing behavior of respondents. As the respondents might not use the washing and dressing space freely at home, besides the videos recorded by respondents at home on the washing and dressing space in the morning, we also requested respondents complete a personal basic information form, and interviewed them on their usage obstacles. After analysis and summary, the types can be categorized into 3 orientations in order to discuss the behavior mode, product use methods, and storage items of each person.

Table 2: Basic information of respondents

Respondents / Project	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15
Gender	M	M	M	M	M	M	M	M	F	F	F	F	F	F	F
Age	9	11	8	26	19	25	18	57	20	20	21	21	51	53	85
Height	135	130	125	180	177	173	176	168	150	165	154	152	152	163	145
Residence pattern	Independent suite	Independent suite	Independent suite	Independent suite	Single-person	Apartment	Apartment	Apartment	Apartment	Apartment	Apartment	Apartment	Apartment	Apartment	Apartment
Family members	5 F1*	5 F1	5 F1	4	1	4 F2	4 F2	4 F2	2 F3	2 F3	5	5	5 F4	4 F2	5 F4
Faucet pattern	Rotating	Rotating	Rotating	single handle	single handle	single handle	single handle	single handle	single handle	single handle	Rotating	single handle	single handle	single handle	single handle
Pattern of commode	Scaffolding	Scaffolding	Scaffolding	Table-board	wall mounting	wall mounting	wall mounting	wall mounting	wall mounting	wall mounting	Scaffolding	Table-board	Scaffolding	wall mounting	Scaffolding
Distance from ground	80cm	80cm	80cm	78cm	77cm	81cm	81cm	81cm	80cm	80cm	81cm	78cm	81cm	81cm	74cm

(* F refers to family members)

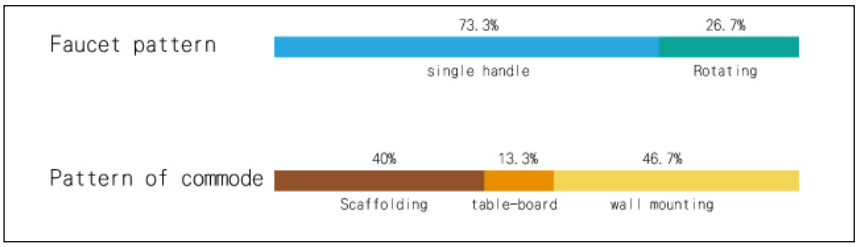

Figure 7: Shared space as the pattern for washing and dressing space in the same type of survey

In order to cover respondents of different groups, we select users of different age groups (the elderly, middle-aged, and the young). F indicates that users of different age groups use the same bathroom and toilet space. Some respondents have single-person suites. In order to discuss the most suitable height of commode for respondents, we measured the heights of the commodes, usually between 74~81cm. N1, N2, and N3 (children) believe that the height of commode is just right for use, while N15 (the elderly) deems that the height could be increased a little. The respondents in general accept the current height of the commode. As is seen in Figure 7, the single-handle faucet is mostly commonly used by families due to its convenience in operation, while the elderly-styled bathroom and toilet applies a rotating faucet due to simplicity in structure. The commode mostly uses the wall mounted type due to its safety and lower price. However, the table-board commode is preferred providing the toilet space is large enough.

4.2. Human behavior mode

According to the survey on the methods of face washing, most users prefer to wash the face by splashing with hands, while the elderly tend to wash face with water in washbasin. The difference might be attributable to users' habits or generations. A minority of respondents use a towel to wipe after washing the face. N1, N2, N3, N12, N13, and N15 respondents do not have the habit of washing the face in the morning, the majority of which are children. According to the survey, while the respondents hold water to splash the face, the water tends to be splashed around, which makes the commode wet. Although respondents that wash the face with reserved water take long time in cleaning the commode, thus, the waster splashed is greatly reduced. N4, N6, and N7 respondents do not use reserved water to wash face because they believe the commode is dirty. In terms of teeth brushing, users generally use a tooth glass, while the young group holds water with the hands for the sake of convenience; however, the commode might get wet; users in general bend over to spit, those users directly spitting would make the commode wet. Due to height difference with male users, female users tend to directly spit; children are taught by parents to get into the healthy habit of bending over for spitting. N13 and N15 respondents clean the toothbrush with water held in mouth during teeth brushing, in order to save water. As the case is the behavior mode of same family members, particular behavior mode is excluded due to personal habits.

Table 3: Human behavior mode

Type \ Respondents				N1	N2	N3	N4	N5	N6	N7	N8	N9	N 10	N 11	N 12	N 13	N 14	N 15
Human behavior mode	Face washing	Wash with reserved water									✓						✓	
		Hand splashing with water						✓	✓	✓		✓	✓	✓				
		Wipe with towel								✓	✓							
		Not wash		✓	✓	✓	✓								✓	✓		✓
	Teeth brushing	Brushing toothbrush	Direct wash	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
			Gargle and brush toothbrush													✓		✓
		Ways to get water	Use tooth glass	✓	✓	✓		✓			✓			✓	✓	✓	✓	✓
			Hold water with hands				✓		✓	✓		✓	✓					
		Spitting habit	Direct spitting	✓										✓	✓			✓
			Bending spitting		✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	

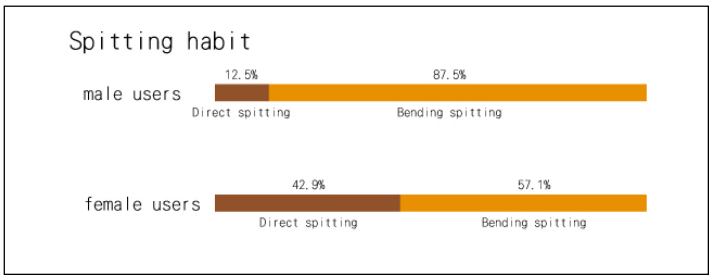

Figure 8: Difference of male and female in spitting habits

4.3. Product use method

To be discussed through faucet and commode. According to the survey, many respondents use the single-handle faucet because of the convenience for switching, and for this reason, the switch is more frequently used. Compared with a rotating faucet, those using a single-handle faucet tend to switch the water volume to the max, which makes the commode wet. However, most respondents could adjust the water volume to the appropriate state. Most respondents do not adjust the temperature, which might be attributed to the seasonal temperature during the survey. Male respondents are more frequent in opening of the faucet, as compared with female users; however, female users take a longer time. Most respondents are accustomed to hold up the commode with left palm while brushing teeth, and bend over to avoid foam falling in the mouth. Some users do not hold up the commode with hand, as in the case of a scaffolding commode, due

to incapability of such commode to support heavy weight, thus, users tend not to use support. Regarding the standing position, males are relatively taller, thus, almost all the respondents bend over to use the commode. Due to height, female users seem to deem it as easier to use. In order to particularly avoid water splash during use, N13 and N14 bend over to the utmost extent to use the commode.

Table 4: Product use method

Type \ Respondents				N1	N2	N3	N4	N5	N6	N7	N8	N9	N 10	N 11	N 12	N 13	N 14	N 15
Product use method	Faucet	Control of water volume	Large volume				✓					✓	✓					✓
			Intermediate volume	✓	✓			✓	✓	✓	✓			✓	✓	✓	✓	
			Small volume			✓												
		Temperature control	No control	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓
			Control						✓	✓	✓							
		Times of opening		4	3	4	5	6	4	8	6	3	3	4	3	2	8	3
	Commode	Standing position	Up-right	✓								✓	✓	✓	✓			✓
			Slightly bending over		✓	✓	✓	✓	✓		✓							
			Utmost bending over							✓						✓	✓	
		Auxiliary support	Support with palm	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓			
			Support with elbow										✓			✓	✓	
			Without support											✓				✓

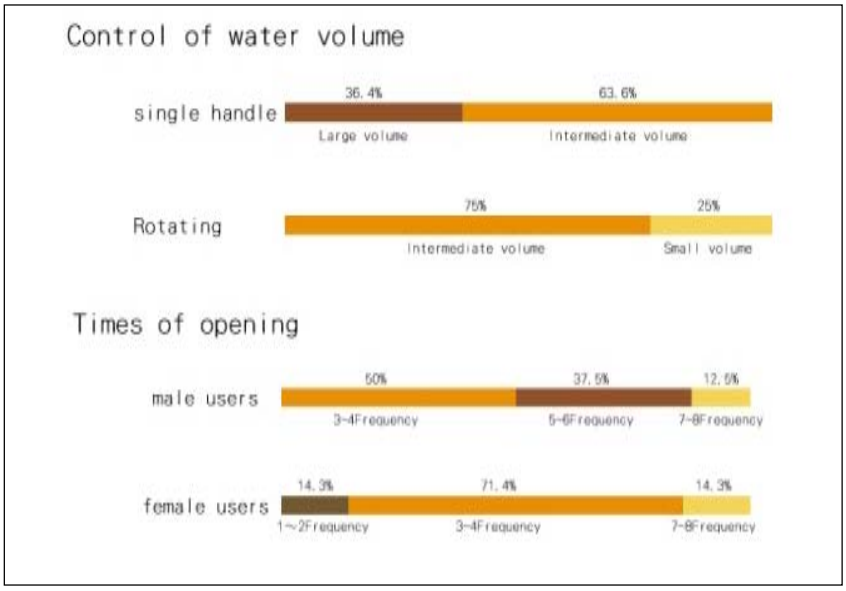

Figure 9: Control circumstances of faucet use

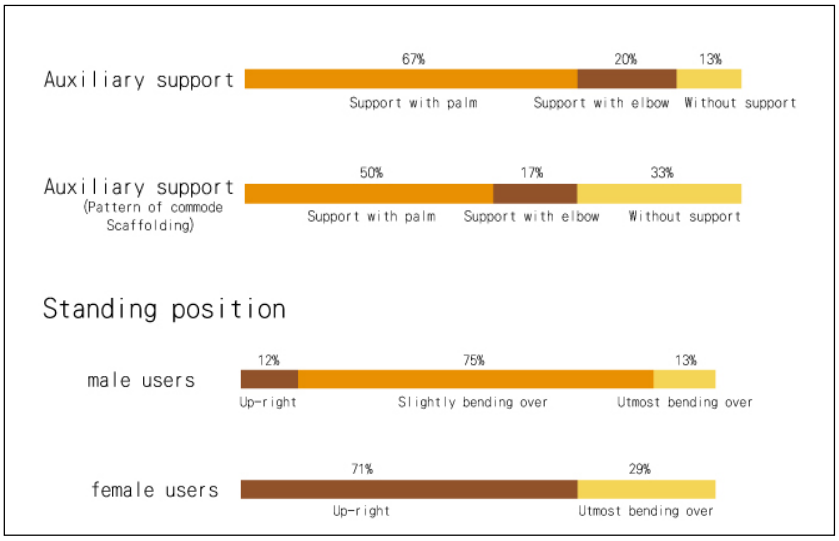

Figure 10: Commode use status by respondents

4.4. Environmental arrangement

According to the survey, most users tend to place the tooth glass alongside the commode, while the minority of users holds the tooth glass, which might be attributed to personal habits and the storage space of the commode. In terms of adjacent stored items, in addition to teeth brushing gear, cosmetics and other small articles are also placed in the washing and dressing space. The items for female users are more than those for male; therefore, they require proper storage space.

Table 5: Stored items

Type \ Respondents			N1	N2	N3	N4	N5	N6	N7	N8	N9	N 10	N 11	N 12	N 13	N 14	N 15
Stored items	Position placement of tooth glass while in use	Held by hand		✓											✓		✓
		Placed on the platform	✓		✓		✓						✓	✓		✓	
		Inner side of commode								✓							
		Without tooth glass				✓		✓	✓		✓	✓					
	Adjacent stored items *	Teeth brushing gear				✓	✓		✓		✓		✓	✓	✓	✓	✓
		Face washing gear				✓	✓		✓		✓		✓	✓	✓		✓
		Cosmetics				✓					✓		✓	✓	✓		✓
		Contact lenses and other gear				✓	✓		✓		✓		✓	✓	✓		✓

* Family members share the commode

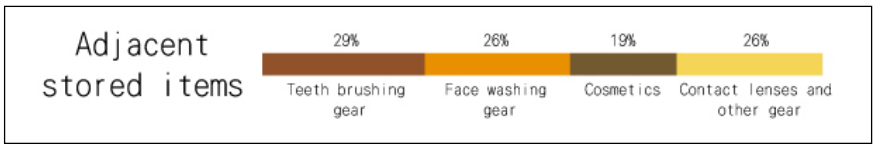

Figure 11: Conditions of adjacent stored items

5. Conclusions and Future Studies

The above four conclusions could be the basis to discuss the design of bathroom and toilet spaces, as well as the follow-up design orientation. The non-participation method and satisfaction survey are employed to verify whether newly designed commodes and faucets live up to the four indices and expectations of the public.

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The impact of relevancy and unexpectedness on the communication effect of design

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Abstract: When the human brain receives information that contradicts preconceived ideas and concepts, the new information would be compared with the preconceived knowledge, during which a schema would be used as a framework to determine the relevancy of the new information. Based on the cognitive framework schema, Stafford and Walker (1996) conducted a study on the interplay between schema and consistently inconsistent information. They found that information of moderate inconsistency tends to trigger the interest of information receivers, and in turn, has better communication effect. The definition of moderate inconsistency is that the overall representation of a design is inconsistent with the receiver's schema or unexpected to the receiver, yet the constituent elements of the design are relevant.

In the pursuit of a design that has good communication effect, this study first conducted a "preliminary survey", which required 11 subjects to determine moderately inconsistent design samples that possessed the characteristics of "unexpectedness" and "relevancy" from some award-winning design artworks. Afterwards, these sample artworks were placed into three categories: high, medium, and low groups of relevancy, as based on the relevancy of these artworks' design elements (products, graphics, verbal descriptions, etc.). Then, a survey on communication effect was conducted to probe into the impact of relevancy on communication effect. A total of 120 subjects participated. The questionnaire content included five scales: comprehension, interest, impression, affection, and novelty. The measurement was based on a 5-point Likert scale (Likert, 1932).

The results indicated that there is a corresponding relationship between the unexpectedness of the overall design that constitutes moderate inconsistency and relevancy, which is a constituent element of designs. Moreover, a higher relevancy of constituent elements, such as graphics, verbal descriptions, and products, means a better effect in enhancing a design's comprehensibility. Meanwhile, a comprehensible design can better facilitate the design's communication effects. In

brief, emphasizing on the unexpectedness of a design and having a good command of the relevancy between a design's constituent elements helps to produce a comprehensible, interesting, and memorable communication effect.

Keywords:relevancy, communication effect, graphic design.

1. INTRODUCTION

Through experience and study, information receivers establish a relevant knowledge classification structure, which is called a schema in the Schema Theory. Schema, a knowledge and cognitive structure, is the basic mode for humans to understand things and acquire knowledge and experience. Therefore, it is the fundamental element of information processing. One schema refers to a kind of information structure, while schemata refer to a string information structure. According to the basis of the Schema Theory, when faced with external stimulus or information, information receivers will develop the cognitive schemata processing mode and have relevant emotional evaluation reaction pursuant to the results of the mode.

According to the Schema Theory, everyone has an original cognitive structure in mind, and when external information enters and is compared with all original existing knowledge, information consistency, inconsistency, relevancy, and irrelevancy will be created. Goodman (1980) explained the conformity between cognitive schema and theme by means of relevancy and expectancy. By relevancy, the researcher defined that the conveyed information is relevant to the theme, and the constituent elements of the information can clearly reflect the theme. Expectancy was defined as the degree that the information, which possesses the previously existing knowledge structure, is evoked after cognitive processing (Note 1).

Mandler (1982) suggested that cognitive structure, as a kind of schema, comes from the previous experience of the information receivers, and is the result of the interaction of all types of stimulus in the environment. Moreover, the inner cognitive structure of the information receivers was explained as a kind of experience organization. The cognitive structure will influence the behaviors and ideas of the information receivers. Every time the information receivers receive new information stimulus, they will verify it according to the schema of common points, and recognize and evoke the expectations and standards of the information. Novel stimulating information will cause information receivers have more motivation to process the information and try to solve the conflict between the information stimulus and cognitive schema. However, if the inconsistency degree between the information and the cognitive schema structure is too great or too small, the reaction evaluation of the information by the information receivers will not be enhanced. Only when the two are moderately inconsistent can the information receivers' evaluation and emotion towards information processing achieve the highest level. Mandler (1982) indicated that the relationship between the consistency of the schema and emotional evaluation is in Inverted U type. "The relationship between the consistency of the schema and emotional evaluation is in Inverted U type, i.e. when conveyed information is moderately inconsistent with the cognition schema, positive emotional reaction is triggered" (Note 2).

The Inconsistency Theory, with the Schema Theory as the basis, was applied earliest in the social cognition field. Stafford and Walker (1996) put forward the definition and illustration of consistency and inconsistency of schema, as based on the above research results, and shown in Table 1:

Table 1: Consistency and inconsistency of schema

Name	Illustration
Consistent	Expected and relevant
Moderately inconsistent	**Unexpected but relevant**
Extremely inconsistent	Neither expected nor relevant

Their study pointed out that, moderate inconsistency between design theme and schema tends to trigger the interest of information receivers, and in turn, has better communication effect. As indicated by the above table, moderate inconsistency is defined as unexpected but relevant. In short, the constituent elements of designed graphics, verbal descriptions, brands, etc., are relevant, or the subject and theme is relevant, but the overall representation of a design is inconsistent with the cognitive schema. The design is presented in an unusual, unique, and unexpected fashion.

Heckler and Childers (1992) developed a comprehensive definition of inconsistency on the basis of the two dimensions (relevancy and expectancy) of Goodman's definition, as well as the concept of information evaluation. Moreover, by means of the three dimensions, they explored the impact of the consistency of graphics and verbal descriptions on the memory effect (Note 3).

2. PRELIMINARY SURVEY

Based on relevant research results, this study further explores the relationship between the two dimensions of relevancy and unexpectedness, as well as the impact of the relationship on the communication effect of moderately inconsistent design, by means of the three constituent elements, as proposed by Pieters and Wedel(2004), picture element, text element, and brand element(Note 4). Therefore, a preliminary survey regarding unexpectedness and relevancy is conducted first, in which researchers must first determine moderately inconsistent design samples that possess the characteristics of unexpectedness and relevancy, which are mainly the representative award-winning artworks of Times Advertising Awards, Chinese Advertising Awards, and print ads of foreign ARCHIVE magazines, within 5 years.

The questionnaire includes three parts. Part 1 surveys the relevance between graphics, verbal descriptions, and brands, covering three sections, namely the relationships between graphics and verbal descriptions, between brands and verbal descriptions, and between graphics and brands. Part 2 is the survey on the unexpectedness of the advertisements. Part 3 focuses on the comprehension degree of the advertisements. The above items are evaluated based on a 5-point Likert scale (Likert, 1932), which is the interval scale comprising of number 1 (disagree very much), 2 (disagree), 3 (no opinion), 4 (agree), and 5 (agree very much).

In the results of the preliminary survey, the samples were placed into three categories: high relevancy (samples 4, 6, 3, 5), medium relevancy (samples 12, 11, 7, 10), and low relevancy (samples 13, 9, 14, 2, 8), as based on the compound average of the three sections of "graphics and verbal descriptions", "brands and verbal descriptions", and "graphics and brands", in Part 1. The divided samples will serve as the classification evidence in the effect survey of the next stage. In addition, according to the survey results of the unexpectedness degree of Part 2, the scores of

samples 1 and 15 are not higher than 0, which indicates expectancy. This does not conform to the unexpectedness in moderately inconsistency, thus, the two samples will be deleted in the following study. Statistics analysis is conducted on the 13 moderately inconsistent designs, from 2 to 14, as shown in Table 2.

Table 2: Average value of unexpectedness and relevancy of each sample

Sample	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Unexpectedness	1.09	0.36	0.27	0.82	0.27	0.36	0.18	1.09	0.55	0.09	0.55	0.73	0.55
Relevancy	0.30	1.36	1.79	1.33	1.73	1.06	0.24	0.58	0.97	1.12	1.18	0.70	0.48

According to the above results, the samples are divided into three groups by means of the relationship between relevancy and unexpectedness, as shown below. It can be concluded that, among the above moderately inconsistent designs, those whose relevancy is higher than unexpectedness outnumber those otherwise.

Relevancy higher than unexpectedness: samples 6, 4, 11, 7, 3, 12, 5, and 10.

Relevancy equal to unexpectedness: samples 8, 13, and 14.

Relevancy lower than unexpectedness: samples 2 and 9.

3. SURVEY ON COMMUNICATION EFFECT

The survey on communication effect is aimed at verifying the impact of relevancy and unexpectedness on communication effect. There are 120 subjects, divided into two groups of designers and common people. The survey items fall into five groups of comprehension, interest, impression, affection, and novelty. The above items are evaluated based on a 5-point Likert scale (Likert, 1932). The samples are divided into three groups for comparison and exploration, which relevancy is respectively higher than, equal to, and lower than, unexpectedness, according to the results of the preliminary survey. Then, the samples are divided into three groups of high, medium, and low relevancy. The new samples are numbered and placed into the three groups, and compared with the original samples, as shown in Table 3.

Table 3. Comparison table of original and new samples

Number of Original Samples												
4	6	3	5	12	11	7	10	13	9	14	2	8
Number of New Samples												
High relevancy				Medium relevancy				Low relevancy				
1	2	3	4	5	6	7	8	9	10	11	12	13

The results of the communication effect survey indicate that the average value of every item of the above has moderately inconsistent design, with the exception of sample 13, which impression

value is -1.98 and affection value is -1.93, which are above 0 and belong to the positive appraisal. This result conforms to the relationship (Inverted U type) between the consistency of the cognitive schema and the emotional value reaction, as stated in Mandler (1982), i.e. when conveyed information is moderately inconsistent with the cognitive schema, positive emotional and value reactions are triggered.

The average value of the evaluated items of all the samples is as shown in Table 4. Sample 1 (0.81) has the highest comprehensive assessment and relevancy. Sample 13 (0.09) has the lowest comprehensive assessment and relevancy. Among the five evaluated items, the three with the highest average values are sequentially, sample 1 (0.81), sample 2 (0.75), and sample 9 (0.75); and the three with the lowest are sample 13 (0.09), sample 5 (0.28), and sample 12 (0.28).

Table 4: Average value of each item of all samples (common people(C) and designers(D))

Sample		Comprehension		Interest		Impression		Affection		Novelty		Average value	
		D	C	D	C	D	C	D	C	D	C	D	C
High relevancy	1	1.26	1.12	0.81	1.10	0.73	0.98	0.40	0.64	0.39	0.72	0.72	0.91
	2	1.35	0.95	0.79	0.55	0.90	0.76	0.68	0.52	0.63	0.36	0.87	0.63
	3	1.16	0.90	0.82	0.47	0.92	0.60	0.79	0.41	0.71	0.21	0.88	0.52
	4	1.10	1.00	0.82	0.67	0.61	0.69	0.57	0.22	0.58	0.52	0.74	0.62
Medium relevancy	5	0.63	0.55	0.29	0.10	0.34	0.17	0.26	-1.93	0.31	0.17	0.36	0.19
	6	1.03	1.24	0.50	0.79	0.50	0.97	0.21	0.64	0.34	0.72	0.52	0.87
	7	0.89	0.88	0.53	0.78	0.24	0.74	0.13	0.29	0.40	0.72	0.44	0.68
	8	0.98	1.02	0.61	0.57	0.42	0.69	0.21	0.19	0.26	0.64	0.50	0.62
Low relevancy	9	1.23	1.00	0.84	0.71	0.77	0.74	0.47	0.45	0.66	0.64	0.79	0.71
	10	0.87	0.81	0.58	0.57	0.52	0.66	0.40	0.48	0.44	0.50	0.56	0.60
	11	1.05	0.59	0.92	0.53	0.63	0.45	0.77	0.53	0.55	0.19	0.78	0.46
	12	**0.63**	**-1.97**	**0.61**	**0.45**	**0.31**	**0.12**	**0.13**	**-1.88**	**0.26**	**0.38**	**0.39**	**0.16**
	13	0.27	0.14	0.32	0.17	-1.97	-1.98	-1.97	-1.90	0.10	0.02	0.13	0.04

The one with the red background denotes the highest average value in each item, while the yellow one denotes the lowest.

Later, the two groups of subjects respectively explored the evaluation of the five items, and obtained different results of the samples with the highest and lowest assessment. For example, designers deem the sample with the highest comprehensive assessment is Sample 3(0.88), while that of the common people is Sample 1(0.91). However, these two samples both have high relevancy. Both the designers and common people think the sample with the lowest assessment is Sample 13(0.09), which is regarded as having the lowest relevancy.

Independent sample t testing is conducted, with the different specialty backgrounds of the two groups of subjects as the grouping variable, and the five evaluated items as the test variables. According to the results, the t values for the two groups of subjects in the five items, comprehension, interest, impression, affection, and novelty are 2.254, 1.011, -0.676, 0.856, and 0.856, respectively. The P value for the comprehension item is lower than 0.05, which reaches a significant level. In other words, the two groups of subjects, designers and common people, show differences in their evaluations of the comprehension items regarding the moderately inconsistent design. The difference is significantly below the 95% confidence level.

Later, the researcher examines the co-variations between two or more continuous variables, and analyzes the correlation coefficient of the evaluated items. The correlation coefficient of the five items, as evaluated by the 120 subjects, is analyzed by means of Pearson product moment correlation. The results are as shown in Table 5. When the significance level is 0.01, the five items are in significant correlation, and the correlation coefficient are all positive numbers, which indicates that all the variables are in positive correlation to each other.

Table 5: Correlation coefficient between all evaluated items

Evaluated Items	Item with the Highest Relevancy	Correlation Coefficient
Comprehension	Impression	0.464
Interest	Affection	0.839
Impression	Interest	0.756
Affection	Interest	0.839
Novelty	Affection	0.778

The correlation coefficient results suggest that, four of the five evaluated items are in high correlation to each other and show significant relevancy. In other words, a moderately inconsistent design with a high comprehension level contributes to leaving a deep impression. The design with a high interest level cannot only leave a deep impression, but can also enhance the affection level. The improvement of the novelty level of the design can contribute to elevating the affection level.

The relationship between consistency and unexpectedness in the moderately inconsistent design is analyzed by means of Repeated Measures ANOVA. Among the three groups, which relevancy is higher than, equal to, or lower than unexpectedness and the one with the best communication effect is as shown in Table 6.

Table 6: Multiple comparison analysis of relevancy and unexpectedness

(I) factor	(J) factor	Average Difference (I-J)	Standard Error	Significance
Relevancy＞ unexpectedness	unexpectedness＞Relevancy	.199*	.057	.001
	Relevancy = unexpectedness	.141*	.043	.001

Relevancy = unexpectedness	Relevancy＞unexpectedness	-.141*	.043	.001
	unexpectedness＞Relevancy	.059	.059	.322
Relevancy< unexpectedness	Relevancy＞unexpectedness	-.199*	.057	.001
	Relevancy = unexpectedness	-.059	.059	.322

*. When the significance level is 0.05, the average value shows significant difference.

The multiple comparison analysis results of the above three groups indicate that, when the significance level is 0.05, the average value of the group which relevancy is higher than unexpectedness is higher than the other two groups, and shows significant difference. However, the average values of the other two groups have no significant difference. This study found that in moderately inconsistent design, better communication effect can be achieved when the relevancy of the constituent elements is higher than the unexpectedness.

4. CONCLUSION AND SUGGESTION

4.1. Conclusions

]This study explored the relationship between unexpectedness and relevancy in design, as well as its impact on the communication effect of moderately inconsistent design. The research results of the above preliminary survey and communication effect survey are as follows:

1. The average values of the above moderately inconsistent design samples are all above 0, and thus, belong to a positive appraisal. This result conforms to the relationship (Inverted U type) between the consistency of cognition schema and emotional value reaction, as stated in Mandler (1982), i.e. when conveyed information is moderately inconsistent with the cognition schema, positive emotional and value reactions are triggered. This study again confirms that positive emotion reaction can be produced when the design theme is moderately inconsistent with the cognition schema.

2. Evaluated Items

The important evaluated items for moderately inconsistent designs are sequentially, comprehension, interest, and impression. In other words, moderately inconsistent design is characterized by easy comprehension, interest, and deep impression. Among the items, comprehension is evaluated with the highest average value. Moreover, it is the item with the highest values for most samples. The conclusion is, as follows. Since the samples used in this study are all relevant and unexpected moderately inconsistent designs, comprehension is relatively high, and comprehension is the item that should be given top priority for moderately inconsistent design. Therefore, enhancing the comprehension level of the design is the basic effect of mastering moderately inconsistent design.

After the compiling all the average values, it can be clearly seen that, the three samples with the highest average values for each evaluated item all have high relevancy, the three with the lowest values belong to medium relevancy, and low relevancy groups and have low relevancy. Thus, it can be concluded that the high relevancy between constituent elements of design is conductive to enhancing the communication effect.

3. Relevancy and Unexpectedness

Relevancy and unexpectedness, which constitute the moderately inconsistent design, show

different features and are in binary relation to each other. For example, the high relevancy between constituent elements contributes to enhancing comprehension of the design. However, high comprehension will relatively lower the unexpectedness level. On the contrary, low relevancy means a low comprehension level, which elevates the unexpectedness level.

In moderately inconsistent samples, better communication effect can be created when the relevancy of constituent elements is higher than the unexpectedness. The high relevancy between constituent elements of design (graphics, verbal descriptions, brands) contributes to enhancing the comprehension of design, thus, elevating the other communication effect of the design.

The difference in relevancy between constituent elements influences the communication effect of the design. For example, in moderately inconsistent design with high relevancy, the comprehension effect outperforms the other four evaluated items. In designs with medium relevancy, the affection effect outperforms the novelty. In designs with low relevancy, the interest effect outperforms the impression, and the impression and novelty effects outperform affection.

4. Subject

The two groups of subjects, namely, designers and common people, have differences in cognition of comprehension regarding moderately inconsistent designs; however, the two groups of subjects show some common ground. The samples with the highest evaluation by both groups have high relevancy, while the lowest evaluation has low relevancy. Meanwhile, the samples with the lowest values in comprehension, as evaluated by designers, are all evaluated by common people as the lowest in impression, affection, and novelty. The samples with the highest values in comprehension, as evaluated by designers, are all evaluated by common people as the highest in interest, impression, affection, and novelty.

At the same time, the correlation coefficients of the values for each item evaluated by common people are all in positive correlation to each other. Among these, the correlation coefficient between interest and affection, impression and interest, and novelty and affection, are all in high-positive correlation to each other, while that between comprehension and impression is in moderate positive correlation. Moreover, for common people, a moderately inconsistent design with a high comprehension level easily leaves a deep impression. A design with a high interest level easily leaves deep impressions and enhances the affection level. Elevated novelty can also enhance the affection level. Comparatively speaking, the correlation coefficient between interest and affection, impression and interest, and novelty and affection, are all in high-positive correlation to each other, while that between comprehension and impression is in moderate positive correlation. For the designers, a moderately inconsistent design with high comprehension level easily creates interest. The design with high interest level easily leaves a deep impression and enhances affection and novelty levels.

4.2. Suggestions

Based on the above empirical survey, this study clarified the communication effect of moderately inconsistent design from the perspective of relevancy, the constituent element, and unexpectedness of the overall design. The purpose is to elevate the communication effect of the design by making flexible use of relevancy and unexpectedness. This paper proposes some suggestions upon the effective application of relevancy and unexpectedness in design, as reference for the designers in developing design strategies and creative ideas.

1. Constituent elements, graphics, verbal descriptions, and brands, are the elements used to interpret design information. The high relevancy between the three can easily cause the information receivers to have association, thus, enhancing the comprehension of the design, and elevating the communication effect. Therefore, designers should put forward relevant graphics and titles pursuant to the theme appeal of the brands, and emphasize the relevancy between the three elements, in order to enhance comprehension of the design and elevate the communication effect.
2. Relevancy and unexpectedness, which constitute a moderately inconsistent design, show different features and are in binary relation to each other. For example, the high relevancy between constituent elements contributes to enhancing the comprehension of design. However, a high comprehension level will lower the unexpectedness level relatively. Moreover, good communication effect can be achieved when the relevancy ratio is higher than the unexpectedness ratio. Therefore, in designing, it is suggested to first consider the comprehension element and emphasize the relevancy between graphics, verbal descriptions, and brands, before considering how to exhibit design performance, such as novelty and features.
3. To make works conform to moderately inconsistent design, it is suggested that they possess the features of easy comprehension, interest, and deep impression. In other words, if designers can effectively master the relevancy between constituent elements and emphasize unexpectedness, they can produce comprehensible, interesting, and memorable communication effects.

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Analyzing automotive interior images and their perceived-value with Kansei Engineering

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Abstract: Automotive interior design plays a very important determinant when people purchase a car. Therefore, an automotive with interior design satisfying drivers emotional needs will outshine the others without one. This study applying Kansei engineering approach, tried to find key elements of car interior that influence the drivers emotion most. The study consists of four stages:

(1) Interviews with marketing experts: divided cars into high-class, middle-class and entry-class three categories under European, American and Asian three regions using car pictures available on the market.
(2) Design elements extracting by design experts: disassembled car interior into 17 design items and 55 categories.
(3) Kansei evaluation experiments: eight most meaningful vocabularies to drivers were extracted to evaluate the image of car interiors. They were: luxury, interesting, stylish, casual, dynamic, precise, technological and lively.
(4) Perceived value constructing with questionnaire survey: using the four dimensions proposed by Sweeney and Soutar as the basis to measure and construct the perceived value for the eight adjectives extracted previously.

The study explored the weights for design elements of car interiors using Kansei Engineering technique and quantification type I, and further measured the perceived value for the eight adjectives. It was hoped to provide effective guidelines for car interior designers in the future.

Keywords: Kansei Engineering, Kansei Image, Auto Interior Design, Perceived Value

1. INTRODUCTION

In addition to the pursuit of power performance, how to enhance the qualia of auto interior and

meet consumers' desire has become an important issue for auto development. As the majority of auto buyers already have been familiar with auto exterior in the purchase stage, an executive form auto company has pointed out that "consumers usually spend 5 minutes for viewing auto exterior, but fifteen minutes for checking its interior." Which also revealed the importance of automotive interior design. Therefore, designers must understand consumers emerging emotional needs about auto interior in order to create core value of the car culture

Japanese scholar, Mitsuo Nagamachi, had proposed in 1995 a consumer-oriented product development technology - Kansei Engineering, which has grown rapidly in recent years. The approach of Kansei Engineering can help clarify people emotional preferences and hence, can be applied to design practice. That this new research area not only injected new life to the engineering fields but also brought precise interpretation of the emotional preferences, has been confirmed by the studies of Kansei Engineering globally (Chen et al., 2000; Chen et al., 2001). Consumer perception, on the other hand, is a complementary study to Kansei research from the marketing perspective. Being one of the important factors influencing consumer behavior, "perception" is formed through human senses, including vision, hearing, tactile, taste, and sense of equilibrium etc. Therefore, "sense" is the basis of perception, and also a subjective conscious activity with one's own personal expectations, values and experiences of environmental awareness. Considering the complexity and diversity of the composing components of auto interior, which makes it more difficult to evaluate, in addition to emotional preferences, perceived value of auto interior are also analyzed with Kansei engineering approach in this study.

2. RELATED RESEARCHES

2.1. Applications of Kansei engineering

Kansei engineering was proposed by Professor Mitsuo Nagamachi from Hiroshima University in 1970s aiming at fulfilling human needs and trying to convert consumers' feeling and preferences to the design elements in new product development (Nagamachi, 1995). Employing Kansei engineering methods to assess the image of auto interior space, especially the feeling of spacious and oppression, Tanoue et al. (1997) developed a comfort diagnostic system for auto interior space. Muneo (1998) also proposed a product design process satisfying consumers' cognition model to provide designers an integrated design environment. Meanwhile, Hirohiko (1999) developed a technique for visualizing consumers' cognition construct with Kansei Engineering technique, using a series of charts to illustrate the relationships between product attributes and consumers' subjective value.

Literature indicates that human contact with things and images frequently and considerably on a daily basis, and the eye in the visual system plays an important role receiving visual information. In order to watch and detect properly, human has to blink 15,000 times a day. In this study, we evaluate Kansei preferences and perceived value of auto interior based on the sense of "vision" only.

2.2. Perceived values

Value is the ratio of the overall benefits consumers received over the total cost paid for. Woodruff (1997) believed that "the perception of value occurs at every stage of the purchase process, including pre-purchase stage." Zeithaml (1988) argued that "the perception of value is at a rather individual level than that of quality, and belongs to a higher level of abstraction" in addition, "the perceived value is the exchange between what a customer got and paid, but the quality is just part

of he/she got.” Parasuraman and Grewal (2000) proposed a measure of perceived value with four dimensions, including acquisition value, transaction value, in-use value and redemption value. "Acquisition value" means that consumers believe they can obtain more benefits by purchasing a product or service, this benefit mostly relates to monetary one, which indicates whether there is a feeling of "earn"; "transaction value" is the feeling of euphoria, consumers think they got a good deal and feel joy; "in-use value" refers to the utility benefits consumers got from the use of products or services; while "redemption value" is the residual benefits or value available for other purposes when the product comes to the end of its life.

Sweeney and Soutar (2001) divided perceived value into four categories: (1) Quality value: measured by the quality of services or products obtained; (2) Emotional value: measured by customers’ emotion affected during purchasing or consuming a product or service; (3) Price value: measured by the comparison between the price and function of a product or service obtained; (4) Social value: measured by the social image after consumers buy or use the product. McCain (2005) considered the "perceived value" of services can be measured by five dimensions, such as: convenience, reliability, response, assurance and concern. In short, perceived value is the overall assessment of paid and got for a consumer.

3. RESEARCH METHODS AND PROCEDURES

The study is divided into four stages: (1) samples screening and adjectives selection, (2) design elements extraction, (3) Kansei evaluation experiments and (4) perceived value surveys.

3.1. Samples screening and adjectives selection

First, a large number of existing auto interior designs on the market was collected. Then, 5 car experts were invited to screen the sample pictures and select most appropriate adjectives for later use in experiments. Picture samples selected include interior space, driver's seat, interior texture and color tone, and spatial variations. Adjectives selected include: luxury, interesting, stylish, casual, dynamic, precise, technological and lively.

3.2. Design elements extracting

In this stage, design experts were invited to break down auto interior designs into functions (items in KE) and solutions (categories in KE).

3.3. Kansei evaluation experiments

Followed by the first stage, 30 subjects with more than 5 years driving experience were invited to evaluate picture samples against each adjective. In the first round, samples were sorted into strong, medium and weak three groups. Then, each group was further divided into strong, medium and weak three sub-groups. Total was nine levels. Quantification Type I (Hayashi, 1950) was employed in the study for establishing the relationships between design elements and adjectives.

3.4. Perceived value surveys

Integrated with Kansei engineering approach, the four dimensions of perceived value (quality, emotional, price and social) proposed by Sweeney and Soutar (2001) were adopted to measure the eight adjectives (luxury, interesting, stylish, casual, dynamic, precise, technological and lively) chosen by experts at the first stage. Internet questionnaires were employed at this stage of the study, and only those who have driving experience qualified for the test. Total of 48 questionnaires were collected and al of them were valid ones.

4. RESULTS AND ANALYSES

4.1. Samples screening and adjectives selection

Only those available on Taiwan market were collected. Sample pictures covered interior space, driver's seat, interior texture and color tone, and spatial variations and grouped into Asian, American and European three regions. Each was further divided into three classes. (Figure 1) Adjectives selected include: luxury, interesting, stylish, casual, dynamic, precise, technological and lively.

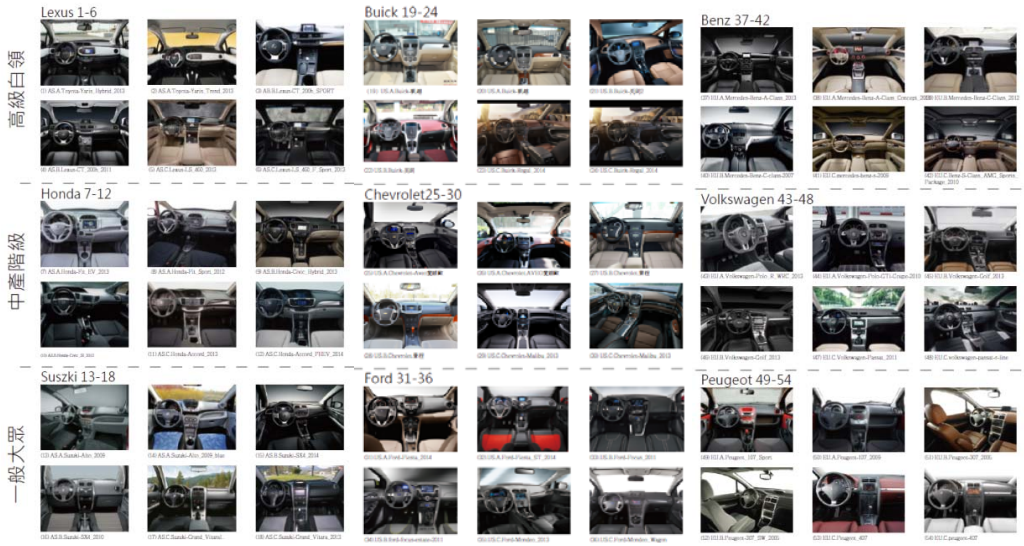

Figure 1: Sample pictures of Asian, American and European from left respectively

4.2. Design elements extracting

17 design items (functions) and 55 categories (solutions) were resulted from the interview with design experts.

4.3. Kansei evaluation experiments

With Quantification Type I analysis, partial correlation coefficients of each items (x1 ~ x17) and scores of each categories were calculated. The higher the partial correlation coefficient, the higher the weight of the item is, and means that item has greater influence to the Kansei adjective. The value of each category represents the impact to the adjective, the higher the stronger, and plus sign before the value indicates positive effect while minus sign negative. R^2 is the coefficient of determination, indicating how well data points fit a statistical model, and hence the forecasting explanatory power to each Kansei adjective. The results of statistical analysis for each Kansei adjective follow.

4.3.1. Luxury

Item "console style" has the highest partial correlation coefficient 0.562 to “luxurious", and category "touch screen" has the positive highest point; R (multiple correlation coefficient) is 0.727, strongly correlated. (Table 1)

4.3.2. Interesting

Item "console style" has the highest partial correlation coefficient 0.561 and category "touch screen" has the highest point; R= 0.512, highly correlated. (Table 2)

Table 1: Results of statistical analysis for “luxury”

Items	Categories	Scores	Partial correlation coefficient	Items	Categories	Scores	Partial correlation coefficient
X1-dashboard display color	white on black	-2.440	0.407	X8-shift lever material (continued)	leather + teak head	-45.660	0.413
	red on black	-10.290			leather + plastic head	-6.168	
	yellow on black	21.300		X9-shift lever & cup holders style	straight bar	-2.782	0.042
X2-dashboard display style	digital - digital	-18.208	0.248		coated leather style	0.712	
	digital - pointer	4.122		X10-color of central armrest	harmony /door panel	0.083	0.004
	analog - pointer	-14.368			contrast /door panel	-0.198	
X3-dashboard display backlight design	cold (G, B)	9.607	0.363	X1- glove box & trim material	plastic	-7.250	0.457
	warm (Y, O, R)	-18.295			metal	31.444	
	gradients	-22.428			plastic teak	2.073	
X4-steering wheel material	rough leather	0.462	0.497		leather	14.511	
	smooth leather	-1.885		X12-seat color	two colors	-8.776	0.177
	rough plastic	-18.431			monochrome	4.575	
	two-tone leather	37.777			2 – 3 colors	-0.201	
	plastic wood	25.375		X13-seat material	leather + fabric	-5.514	0.303
X5-steering wheel shape	round /dashboard	2.689	0.299		leather	11.613	
	polygonal	8.241			fabric	-13.666	
	traditional	-24.550		X14-air-vent color	silver frame + black blades	22.275	0.548
X6-console material	metal	1.800	0.390		silver frame + silver blades	23.110	
	plastic teak	41.758			black frame + black blades	-22.368	
	plastics metal	17.267		X15-air-vent style	square /R corner	21.803	0.476
	plastics - rough	-10.654			round	-14.538	
	plastic /metal trim	4.360			round + square	-24.944	
X7-console style	no screen /buttons	-26.097	0.562		rectangular	-17.715	
	screen /button	-1.059		X16-door panels color	brown, khaki, cream	9.588	0.192
	screen /knob	-23.471			black, gray, silver	-6.102	
	touch screen	30.835		X17-color of reading lights + glasses case + sunroof switch	same as auto interior	-2.021	0.065
X8-shift lever material	leather /metal head	8.052					
	embossed leather head	-11.523			different from car interior	3.176	

Constant: 143.444; R=0.727; R^2=0.528

4.3.3. Stylish

"Air-vent color" has the highest partial correlation coefficient 0.616 to “stylish", and category "silver frame + silver blades" has the highest point; R= 0.681, strongly correlated. (Table 3)

Table 2: Results of statistical analysis for “interesting”

Items	Categories	Scores	Partial correlation coefficient	Items	Categories	Scores	Partial correlation coefficient
X1-dashboard display color	white on black	-2.449	0.220	X8-shift lever material (continued)	leather + teak head	-29.668	0.207
	red on black	33.216			leather + plastic head	-9.459	
	yellow on black	28.018		X9-shift lever & cup holders style	straight bar	-23.623	0.311
X2-dashboard display style	digital - digital	-10.741	0.100		coated leather style	6.043	
	digital - pointer	0.509		X10-color of central armrest	harmony /door panel	1.059	0.039
	analog - pointer	5.306			contrast /door panel	-2.514	
X3-dashboard display backlight design	cold (G, B)	-0.387	0.131	X1- glove box & trim material	plastic	-0.624	0.313
	warm (Y, O, R)	-3.854			metal	29.404	
	gradients	16.973			plastic teak	-12.041	
X4-steering wheel material	rough leather	15.695	0.299		leather	-12.488	
	smooth leather	-2.583		X12-seat color	two colors	2.086	0.035
	rough plastic	-14.256			monochrome	-0.736	
	two-tone leather	32.185			2 – 3 colors	-1.510	
	plastic wood	-2.455		X13-seat material	leather + fabric	-11.724	0.163
X5-steering wheel shape	round /dashboard	2.192	0.381		leather	3.280	
	polygonal	12.995			fabric	4.401	
	traditional	-32.564		X14-air-vent color	silver frame + black blades	15.838	0.357
X6-console material	metal	-4.626	0.304		silver frame + silver blades	20.116	
	plastic teak	-24.012			black frame + black blades	-16.314	
	plastics metal	-29.475		X15-air-vent style	square /R corner	13.374	0.456
	plastics - rough	9.894			round	24.003	
	plastic /metal trim	-4.661			round + square	-9.218	
X7-console style	no screen /buttons	-40.228	0.561		rectangular	-32.466	
	screen /button	9.592		X16-door panels color	brown, khaki, cream	6.169	0.130
	screen /knob	-0.757			black, gray, silver	-3.926	
	touch screen	23.804		X17-color of reading lights + glasses case + sunroof switch	same as auto interior	1.555	0.052
X8-shift lever material	leather /metal head	3.691			different from car interior	-2.444	
	embossed leather head	6.282					

Constant: 136.148; R=0.512; R^2=0.262

4.3.4. Casual

"Glove box & trim material" has the highest partial correlation coefficient 0.426 to “casual", and category "plastic teak" the highest point; R= 0.559, highly correlated. (Table 4)

Table 3: Results of statistical analysis for “stylish”

Items	Categories	Scores	Partial correlation coefficient	Items	Categories	Scores	Partial correlation coefficient
X1-dashboard display color	white on black	-2.830	0.347	X8-shift lever material (continued)	leather + teak head	-91.347	0.357
	red on black	0.377			leather + plastic head	-8.412	
	yellow on black	10.384		X9-shift lever & cup holders style	straight bar	-14.755	0.183
X2-dashboard display style	digital - digital	-15.925	0.238		coated leather style	3.775	
	digital - pointer	4.749		X10-color of central armrest	harmony /door panel	7.305	0.265
	analog - pointer	-20.766			contrast /door panel	-17.349	
X3-dashboard display backlight design	cold (G, B)	11.040	0.358	X1- glove box & trim material	plastic	-4.228	0.605
	warm (Y, O, R)	-22.126			metal	29.163	
	gradients	-21.915			plastic teak	-20.081	
X4-steering wheel material	rough leather	-1.006	0.376		leather	-10.747	
	smooth leather	1.277		X12-seat color	two colors	-5.941	0.233
	rough plastic	-20.563			monochrome	6.589	
	two-tone leather	35.694			2 – 3 colors	-15.600	
	plastic wood	17.994		X13-seat material	leather + fabric	-1.872	0.213
X5-steering wheel shape	round /dashboard	6.608	0.288		leather	7.467	
	polygonal	4.640			fabric	-10.147	
	traditional	-29.104		X14-air-vent color	silver frame + black blades	26.912	0.616
X6-console material	metal	0.214	0.246		silver frame + silver blades	27.518	
	plastic teak	0.314			black frame + black blades	-26.979	
	plastics metal	-19.851		X15-air-vent style	square /R corner	25.555	0.517
	plastics - rough	-7.277			round	-9.334	
	plastic /metal trim	16.139			round + square	-18.693	
X7-console style	no screen /buttons	-27.828	0.553		rectangular	-35.769	
	screen /button	-0.430		X16-door panels color	brown, khaki, cream	-0.005	0.001
	screen /knob	-32.013			black, gray, silver	0.003	
	touch screen	34.646		X17-color of reading lights + glasses case + sunroof switch	same as auto interior	-2.290	0.067
X8-shift lever material	leather /metal head	8.535			different from car interior	3.598	
	embossed leather head	-9.145					

Constant: 143.667; R=0.681; R^2=0.464

4.3.5. Dynamic

"Console style" has the highest partial correlation coefficient 0.561 to “dynamic", and category "touch screen" the highest point; R= 0.650, strongly correlated. (Table 5)

Table 4: Results of statistical analysis for “casual”

Items	Categories	Scores	Partial correlation coefficient	Items	Categories	Scores	Partial correlation coefficient
X1-dashboard display color	white on black	-0.736	0.237	X8-shift lever material (continued)	leather + teak head	-51.404	0.315
	red on black	-12.853			leather + plastic head	0.306	
	yellow on black	31.252		X9-shift lever & cup holders style	straight bar	-15.610	0.290
X2-dashboard display style	digital - digital	5.771	0.258		coated leather style	3.993	
	digital - pointer	2.059		X10-color of central armrest	harmony /door panel	3.322	0.191
	analog - pointer	-19.563			contrast /door panel	-7.890	
X3-dashboard display backlight design	cold (G, B)	-0.915	0.194	X1- glove box & trim material	plastic	0.684	0.426
	warm (Y, O, R)	2.386			metal	-27.229	
	gradients	-18.270			plastic teak	36.076	
X4-steering wheel material	rough leather	9.065	0.266		leather	-0.025	
	smooth leather	-1.600		X12-seat color	two colors	1.027	0.158
	rough plastic	3.648			monochrome	2.234	
	two-tone leather	-25.928			2 – 3 colors	-10.453	
	plastic wood	-21.289		X13-seat material	leather + fabric	0.544	0.119
X5-steering wheel shape	round /dashboard	1.221	0.076		leather	-2.941	
	polygonal	0.638			fabric	4.153	
	traditional	-4.939		X14-air-vent color	silver frame + black blades	4.832	0.369
X6-console material	metal	4.525	0.369		silver frame + silver blades	-40.478	
	plastic teak	-30.393			black frame + black blades	0.202	
	plastics metal	-22.075		X15-air-vent style	square /R corner	1.156	0.352
	plastics - rough	1.159			round	-18.115	
	plastic /metal trim	7.100			round + square	15.080	
X7-console style	no screen /buttons	-9.350	0.217		rectangular	-10.950	
	screen /button	1.794		X16-door panels color	brown, khaki, cream	-7.420	0.216
	screen /knob	5.805			black, gray, silver	4.722	
	touch screen	0.289		X17-color of reading lights + glasses case + sunroof switch	same as auto interior	-0.758	0.035
X8-shift lever material	leather /metal head	3.466			different from car interior	1.192	
	embossed leather head	-9.114					

Constant: 142.000; R=0.559; R^2=0.313

4.3.6. Precise

“Console style" has the highest partial correlation coefficient 0.650 to “precise", and category "touch screen" the highest point; R= 0.723, strongly correlated. (Table 6)

Table 5: Results of statistical analysis for “dynamic”

Items	Categories	Scores	Partial correlation coefficient	Items	Categories	Scores	Partial correlation coefficient
X1-dashboard display color	white on black	-2.794	0.273	X8-shift lever material (continued)	leather + teak head	-55.195	0.290
	red on black	29.555			leather + plastic head	-13.751	
	yellow on black	10.292		X9-shift lever & cup holders style	straight bar	-34.050	0.377
X2-dashboard display style	digital - digital	-1.316	0.056		coated leather style	8.710	
	digital - pointer	1.069		X10-color of central armrest	harmony /door panel	-18.021	0.279
	analog - pointer	-6.567			contrast /door panel	7.954	
X3-dashboard display backlight design	cold (G, B)	6.756	0.244	X1- glove box & trim material	plastic	-0.862	0.531
	warm (Y, O, R)	-18.889			metal	26.827	
	gradients	5.306			plastic teak	-28.871	
X4-steering wheel material	rough leather	16.714	0.365		leather	-22.161	
	smooth leather	-3.137		X12-seat color	two colors	-2.056	0.101
	rough plastic	-22.255			monochrome	3.077	
	two-tone leather	36.233			2 – 3 colors	-8.927	
	plastic wood	17.812		X13-seat material	leather + fabric	-7.852	0.125
X5-steering wheel shape	round /dashboard	4.528	0.355		leather	4.949	
	polygonal	11.643			fabric	-1.353	
	traditional	-36.870		X14-air-vent color	silver frame + black blades	28.765	0.560
X6-console material	metal	1.716	0.327		silver frame + silver blades	14.646	
	plastic teak	-13.883			black frame + black blades	-27.196	
	plastics metal	-23.990		X15-air-vent style	square /R corner	12.998	0.530
	plastics - rough	6.202			round	21.911	
	plastic /metal trim	4.896			round + square	-7.194	
X7-console style	no screen /buttons	-39.756	0.561		rectangular	-49.841	
	screen /button	16.195		X16-door panels color	brown, khaki, cream	1.402	0.025
	screen /knob	-32.035			black, gray, silver	-0.892	
	touch screen	27.851		X17-color of reading lights + glasses case + sunroof switch	same as auto interior	-2.263	0.064
X8-shift lever material	leather /metal head	8.742			different from car interior	3.556	
	embossed leather head	-4.577					

Constant: 137.389; R=0.650; R^2=0.423

4.3.7. Technological

"Console style" has the highest partial correlation coefficient 0.641 to “technological", and category "touch screen" the highest point; R= 0.705, strongly correlated. (Table 7)

Table 6: Results of statistical analysis for “precise”

Items	Categories	Scores	Partial correlation coefficient	Items	Categories	Scores	Partial correlation coefficient
X1-dashboard display color	white on black	-2.635	0.339	X8-shift lever material (continued)	leather + teak head	-96.162	0.394
	red on black	1.204			leather + plastic head	-2.927	
	yellow on black	24.661		X9-shift lever & cup holders style	straight bar	5.760	0.078
X2-dashboard display style	digital - digital	4.953	0.274		coated leather style	-1.473	
	digital - pointer	-13.021		X10-color of central armrest	harmony /door panel	6.608	0.270
	analog - pointer	-24.144			contrast /door panel	-15.693	
X3-dashboard display backlight design	cold (G, B)	11.326	0.390	X1- glove box & trim material	plastic	-4.653	0.530
	warm (Y, O, R)	-25.116			metal	31.564	
	gradients	-14.032			plastic teak	-10.795	
X4-steering wheel material	rough leather	-4.860	0.307		leather	-5.993	
	smooth leather	2.900		X12-seat color	two colors	-3.082	0.115
	rough plastic	-14.050			monochrome	3.216	
	two-tone leather	-6.979			2 – 3 colors	-7.197	
	plastic wood	18.941		X13-seat material	leather + fabric	0.028	0.190
X5-steering wheel shape	round /dashboard	4.650	0.369		leather	6.142	
	polygonal	10.327			fabric	-9.620	
	traditional	-34.603		X14-air-vent color	silver frame + black blades	12.303	0.321
X6-console material	metal	11.177	0.376		silver frame + silver blades	-0.757	
	plastic teak	2.930			black frame + black blades	-28.630	
	plastics metal	23.209		X15-air-vent style	square /R corner	28.623	0.571
	plastics - rough	-14.733			round	-32.681	
	plastic /metal trim	16.822			round + square	-25.533	
X7-console style	no screen /buttons	-19.222	0.650		rectangular	-24.944	
	screen /button	4.414		X16-door panels color	brown, khaki, cream	-7.436	0.148
	screen /knob	-51.697			black, gray, silver	4.732	
	touch screen	29.662		X17-color of reading lights + glasses case + sunroof switch	same as auto interior	0.988	0.031
X8-shift lever material	leather /metal head	7.632					
	embossed leather head	-15.299			different from car interior	-1.553	

Constant: 139.611; R=0.723; R^2=0.523

4.3.8. Lively

“Console style" has the highest partial correlation coefficient 0.515 to “lively", and category "touch screen" the highest point; R= 0.632, strongly correlated. (Table 8)

Table 7: Results of statistical analysis for "technological"

Items	Categories	Scores	Partial correlation coefficient	Items	Categories	Scores	Partial correlation coefficient
X1-dashboard display color	white on black	10.113	0.275	X8-shift lever material (continued)	leather + teak head	-91.356	0.388
	red on black	5.156			leather + plastic head	-5.585	
	yellow on black	-2.982		X9-shift lever & cup holders style	straight bar	-17.608	0.198
X2-dashboard display style	digital - digital	-6.239	0.088		coated leather style	4.504	
	digital - pointer	2.144		X10-color of central armrest	harmony /door panel	5.711	0.198
	analog - pointer	-10.163			contrast /door panel	-13.564	
X3-dashboard display backlight design	cold (G, B)	11.345	0.292	X1- glove box & trim material	plastic	-3.101	0.524
	warm (Y, O, R)	-23.921			metal	29.151	
	gradients	-18.380			plastic teak	-28.999	
X4-steering wheel material	rough leather	5.906	0.241		leather	-11.059	
	smooth leather	2.074		X12-seat color	two colors	3.695	0.100
	rough plastic	-22.454			monochrome	0.545	
	two-tone leather	31.150			2 – 3 colors	-10.858	
	plastic wood	22.764		X13-seat material	leather + fabric	-3.561	0.233
X5-steering wheel shape	round /dashboard	2.458	0.308		leather	10.522	
	polygonal	14.674			fabric	-13.547	
	traditional	-36.721		X14-air-vent color	silver frame + black blades	35.353	0.586
X6-console material	metal	14.153	0.302		silver frame + silver blades	-19.456	
	plastic teak	-32.960			black frame + black blades	-29.263	
	plastics metal	-12.439		X15-air-vent style	square /R corner	30.791	0.515
	plastics - rough	-6.385			round	-25.645	
	plastic /metal trim	14.965			round + square	-20.985	
X7-console style	no screen /buttons	-44.594	0.641		rectangular	-38.230	
	screen /button	14.711		X16-door panels color	brown, khaki, cream	-7.072	0.112
	screen /knob	-50.299			black, gray, silver	4.500	
	touch screen	39.766		X17-color of reading lights + glasses case + sunroof switch	same as auto interior	-2.190	0.055
X8-shift lever material	leather /metal head	10.717			different from car interior	3.442	
	embossed leather head	-24.770					

Constant: 141.796; R=0.705; R^2=0.497

In summary, the statistical analysis results from Quantification Type I against the eight adjectives are summarized in Table 9 to show the highest partial correlation coefficients and multiple correlation coefficients.

Table 8: Results of statistical analysis for “lively”

Items	Categories	Scores	Partial correlation coefficient	Items	Categories	Scores	Partial correlation coefficient
X1-dashboard display color	white on black	-0.865	0.237	X8-shift lever material (continued)	leather + teak head	-55.195	0.290
	red on black	-15.146			leather + plastic head	-13.751	
	yellow on black	16.770		X9-shift lever & cup holders style	straight bar	-34.050	0.377
X2-dashboard display style	digital - digital	5.057	0.258		coated leather style	8.710	
	digital - pointer	-1.482		X10-color of central armrest	harmony /door panel	-18.021	0.279
	analog - pointer	6.408			contrast /door panel	7.954	
X3-dashboard display backlight design	cold (G, B)	-1.081	0.194	X1- glove box & trim material	plastic	-0.862	0.531
	warm (Y, O, R)	-10.580			metal	26.827	
	gradients	4.235			plastic teak	-28.871	
X4-steering wheel material	rough leather	14.849	0.266		leather	-22.161	
	smooth leather	-6.410		X12-seat color	two colors	-2.056	0.101
	rough plastic	-7.427			monochrome	3.077	
	two-tone leather	41.050			2 – 3 colors	-8.927	
	plastic wood	-4.745		X13-seat material	leather + fabric	-7.852	0.125
X5-steering wheel shape	round /dashboard	0.750	0.076		leather	4.949	
	polygonal	4.757			fabric	-1.353	
	traditional	-15.772		X14-air-vent color	silver frame + black blades	28.765	0.560
X6-console material	metal	-10.382	0.369		silver frame + silver blades	14.646	
	plastic teak	-47.478			black frame + black blades	-27.196	
	plastics metal	-65.135		X15-air-vent style	square /R corner	12.998	0.530
	plastics - rough	8.922			round	21.911	
	plastic /metal trim	12.232			round + square	-7.194	
X7-console style	no screen /buttons	-37.818	0.217		rectangular	-49.841	
	screen /button	13.863		X16-door panels color	brown, khaki, cream	1.402	0.025
	screen /knob	-11.302			black, gray, silver	-0.892	
	touch screen	21.271		X17-color of reading lights + glasses case + sunroof switch	same as auto interior	-2.263	0.064
X8-shift lever material	leather /metal head	7.315			different from car interior	3.556	
	embossed leather head	8.559					

Constant: 141.407; R=0.632; R^2=0.399

4.4. Perceived value surveys

The section will divide into two parts one is Descriptive statistics and reliability analysis, the other Validity analysis and factor analysis.

Table 9: The highest partial correlation coefficients and multiple correlation coefficients

Adjectives	Items w/highest partial correlation coefficients	Partial correlation coefficients	Categories w/highest point	Multiple correlation coefficients
Luxury	Console style	0.562	Touch screen	0.727
Interesting	Console style	0.561	Touch screen	0.512
Stylish	Air-vent color	0.616	Silver frame + silver blades	0.681
Casual	Glove box & trim material	0.426	Plastic teak	0.559
Dynamic	Console style	0.561	Touch screen	0.650
Precise	Console style	0.650	Touch screen	0.723
Technological	Console style	0.641	Touch screen	0.705
Lively	Console style	0.515	Touch screen	0.632

4.4.1. Descriptive statistics and reliability analysis

Total of 48 valid questionnaires was collected, men 54% and women 46%. The majority of subjects were 21-30 and 31-40 years old, most of them afford buying a car. In terms of driving experience, 21% of them were less than three years, 19% 3-5 years, and 60% more than 5 years, which indicated that most of the respondents have years of driving experience. As for education level, 58% of them have university degrees and 42% have master degrees and up. Reliability analysis wise, the α value for "price value" was 0.838, "emotional value" 0.870, "quality value" 0.836, and "social value" 0.820. Therefore, we can say that the reliability of each variable in this study has reached high reliability standards.

4.4.2. Validity analysis and factor analysis

In this study, the questionnaire was revised by experts to meet the criteria of content validity. Two main factors were extracted for "Quality value" (Table 10), 57.7% and 24.0% (totaling 81.7%) of the variance could be explained respectively. Consisted of four questions, namely: interesting, dynamic, lively and casual, factor one was entitled as: “Encouraging”. Factor two made up of technological and luxury questions was entitled "Utility." As the factor loadings of "stylish" and "precise" did not reach 0.5, they were deleted.

Table 10: Exploratory factor analysis for “Quality value” dimensions

Variables	Questions	Factor loadings		Eigenvalues and Percentages of Explained variance (%)	
		Factor 1	Factor 2	Factor 1	Factor 2
Quality value	Interesting	0.904		3.223	1.443
	Dynamic	0.868		(57.720)	(24.045)
	Lively	0.859			
	Casual	0.836			
	Technological		0.829		
	Luxury		0.778		
Factor named		Encouraging	Utility		

Three main factors were extracted for "Emotional value" (Table 11), 38.1%, 24.7% and 19.6% (totaling 82.4%) of the variance could be explained respectively. Consisted of four questions, namely: precise, stylish, dynamic and interesting factor one was entitled as: “Fashionable”. Factor two made up of casual and lively questions was entitled "Ease." Formed by technological and luxury questions, factor three was named as "Extravagant."

Two main factors were extracted for "Price value" (Table 12), 48.5% and 18.2% (totaling 66.7%) of the variance could be explained respectively. Consisted of four questions, namely: technological, luxury, precise and dynamic, factor one was entitled as: “Practical”. Factor two made up of four questions, namely: casual, stylish, lively and interesting, was entitled "Hedonic."

Table 11: Exploratory factor analysis for “Emotional value” dimensions

Variables	**Questions**	**Factor loadings**			**Eigenvalues and Percentages of Explained variance (%)**		
		Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
Emotional value	Precise	0.908			3.050	1.979	1.571
	Stylish	0.903			(38.129)	(24.738)	(19.634)
	Dynamic	0.728					
	Interesting	0.724					
	Casual		0.943				
	Lively		0.6978				
	Technological			0.860			
	Luxury			0.845			
Factor named		Fashionable	Ease	Extravagant			

Table 12: Exploratory factor analysis for “Price value” dimensions

Variables	**Questions**	**Factor loadings**		**Eigenvalues and Percentages of Explained variance (%)**	
		Factor 1	Factor 2	Factor 1	Factor 2
Price value	Technological	0.886		3.882	1.460
	Luxury	0.807		(48.527)	(18.249)
	Precise	0.804			
	Dynamic	0.696			
	Casual		0.797		
	Stylish		0.784		
	Lively		0.756		
	Interesting		0.749		
Factor named		Practical	Hedonic		

Two main factors were extracted for "Social value" (Table 13), 47.7% and 22.3% (totaling 70.0%) of the variance could be explained respectively. Consisted of six questions, namely: dynamic, interesting, casual, precise, lively and stylish, factor one was entitled as: “Youthful”. Factor two made up of technological and luxury questions, was entitled "Honorable."

Table 13: Exploratory factor analysis for “Social value” dimensions

Variables	Questions	Factor loadings		Eigenvalues and Percentages of Explained variance (%)	
		Factor 1	Factor 2	Factor 1	Factor 2
Social value	Dynamic	0.898		3.813	1.783
	Interesting	0.831		(47.667)	(22.289)
	Casual	0.779			
	Precise	0.769			
	Lively	0.756			
	Stylish	0.713			
	Luxury		0.855		
	Technological		0.838		
Factor named		Youthful	Honorable		

5. CONCLUSSIONS AND SUGGESTIONS

Along with Kansei engineering approach, in-depth interviews and experiments were employed to explore consumers’ Kansei evaluation about automotive interior design. The results showed that the “style of central consol” was considered as the most influential factor for adjectives "luxury", "interesting", “dynamic", “precise”, “lively” and “technological”, and “touch screen” had the highest point for that item. That the operation of touch-screen is similar to that of contemporary IT devices explains that the Hi-tech IT equipments play a key role to the sense of "precise” and “technological”. As “touch” operation is funnier than traditional knobs or mechanical buttons, it also contributes to the feeling of “dynamic” and “interesting”. Item "glove box & trim material" has the most weight to the feeling of "casual" and “plastic teak” can make auto interior the most casual feel.

As for the perceived value, total of 48 valid questionnaires were collected. Through exploratory factor analysis, two factors were extracted for dimension “quality value” named "Encouraging" and "Utility". Three were extracted for “emotional value” and named as "Fashionable", "Ease" and "Extravagant". Two for "price value" named "Practical" and "Hedonic” and two extracted for "social value" and named as "Youthful" and "Honorable". The results of this study can provide auto interior designers a handy reference for future development of new design.

As this study has focused on the visual Kansei evaluation of automotive interior design, some other sensory (such as hearing, touch, smell, etc.) need to be further explored for better comprehend the overall Kansei feelings of auto interior.

ACKNOWLEDGMENTS

The authors of this manuscript would like to thank National Science Council (NSC) of Taiwan for the financial support thru project number: NSC 101-2221-E-214-078-.

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THE COST-EFFECTIVE APPEAL OF CROSSOVER B-CAR INTERIORS TO CONSUMERS

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Abstract: The design of a crossover B-car interior was used to explore the relationship between marketing considerations, survey participants' emotional responses, and product design. Research methodology was based on Kansei Engineering. Seventeen experts with professional automotive knowledge, including editors of car magazines and experienced car users were interviewed using the Evaluation Grid Method (EGM) about their preferences and reactions to interior design schemes of crossover B-cars. Additionally, automobile consumers were surveyed through a questionnaire used to ascertain participants' participants' preferences for pictures depicting design elements of crossover B-car interiors. The results of the questionnaire were analyzed using Quantification Theory Type I. According to the interviews of the experts, the tow cost-effective, more appealing items relating to crossover B-car interior, as determined by the semantic structure of EGM, were "economical and practical" and "customized for consumers needs". In addition, the two interior items were related to particular reasons and detail design elements found in the analysis of the questionnaire using Quantification Theory Type I. The current study suggests that specific products in this case car interiors,and their design are related to consumers' motivations about cost-effectiveness, functionality, and form. Additionally, the study demonstrates that consumer preferences and motivations influence their responses to specific design schemes.

Keywords: Cost-effectiveness, Appeal, Car Interior Design, Consumer Psychology, Kansei Engineering, EGM, Quantification Theory Type I

1. BASIC SECTIONS OF A MANUSCRIPT

It has been found that a consumer's intention to buy a manufactured good is closely related to the potential purchaser's perception and emotional responses to the form, purpose, and design of the product. This phenomenon has been studied extensively through the investigation of purchased intention in relation to consumers' psychological responses via the Five-Factor Model, a model used to describe branded products using attributes of human personality (Guido et al., 2010). The different aspects of consumers' cognitive response to a product have also received recent attention, showing that consumers' reactions to the visual form of a product includes response characteristics that related to their aesthetic impression, semantic interpretation, and symbolic association of the manufactured good (Crilly, Moultrie, and Clarkson, 2004).

In 1995, Bloch introduced a conceptual model along with several propositions that describe how the form of a product might elicit a variety of psychological and behavioural responses from a consumer. As suggested by Bitner's (1992) work on architectural design, these psychological responses include both cognitive and affective components (Bloch, 1995).

For example, a product form that contains metal surfaces has been found to elicit a consumer impression of "durability". This association between product form and response characteristic is also applicable to car interiors (Leder and Carbo, 2005). Aspects of cognitive and affective psychological response are specifically relevant to the design of car interiors, as they are intentionally created to be functional, and to evoke positive emotional responses from consumers. In fact, Karlsson (2003) used the Semantic Environment Description (SMB) method to measure consumers' impressions of vehicle interiors and proposed suggestions for how design, engineering and marketing interact.

Consumers often buy into a product on the basis of their perceived economic benefits and have to goal of putting the least amount of money into a purchase with the greatest value. Saving motives of consumers often consist of two important factors: moderation and self control. From a psychological standpoint, such factors could lead consumers to regularly put away some resources in order to meet an end goal (Lewis, Webley, & Furnham, 1995; Wärneyd,1999). In other words, the decision to save involves complex psychological and sociao-psychological processes (Furnham & Angyle, 1998). Therefore, deliberations on cost effectiveness can be considered motivations that can potentially change a consumer' behavior in terms of purchase incentive. These finding have several implications for marketing research in relation to psychology and could be advantageous for studying strategies that use motivation to modify a person's behavior. In fact, these strategies are already being used to study the effect of social marketing aimed at communicating the importance of safe driving through the forums of cognition, affect, and intention. In addition, cost effectiveness can also be viewed as goal attainment for consumers. This point is worth addressing since marketers spend considerable resources on motivating people to consume products and services as a means of goal achievement (Bagozzi & Dholakia, 1999)., which implies that consumers change their behavior based strongly on the fulfilment of a goal.

Mass customization is the ability to provide individually designed products and services to every customer through high process flexibility and integration at reasonably low cost (Silveria, 2001). In this study, we subdivided mass customization into: "customized for the needs of a specific population" and "customized for individual preference". In addition, mass customization can be further categorized into different levels by degrees of involvement.

Japanese scholar, Mitsuo Nagamachi, founded a new consumer-oriented technology of product development- called Kansei Engineering. Defined as the technology of transforming consumers' feelings and impressions of products into the elements of functionality and design, the technology aims to link the vague physiological and psychological demands of consumers to

the development of a vehicle based on users' evaluation and preferences with regard to form Nagamachi, 2002). Consequently, this technology allows for the design of a product aimed at reflecting an induced feeling. After completing the necessary stages in the Kansei methodology, the final steps of validation remain, where subjective evaluations are carried out by semantic differential methods, and then analyzed using multivariate analyses. To summarize, "Kansei Engineering" is designed to realize human affections and preferences by leading a consumer-centered study. This type of methodological framework is growing in popularity and has been implemented by such companies as Nissan, Mazada, and Mitsubishi (Nagamachi, 1995).

In the current study, we argue that crossover B-Car interiors are particularly attractive to consumers because of certain particular elements that we have named "appeal factors". In the automobile industry, a "crossover" refers to a vehicle built on a car platform that combines, in highly variable degree, features from a sedan with features of a sport utility vehicle (SUV), a muti-purpose vehicle (MPV) or a recreational vehicle (RV). A crossover vehicle aims to combine multiple functionalities into one form including cross-country capabilities, comfort and controllability. Accroding to the definition of the Commission of The European Communities, the crossover type of B-Car belongs to the "small cars" subgroup.

Lastly, according to Barron's Accounting Dictionary, cost-effectiveness is defined as being, among decision alternatives, the one in which cost is lower than its benefit. The current study probes consumers' cost-effective needs for the interior of a vehicle. We hypothesize that the popularity of crossover B-cars can be of assistance to designers of car interiors by enabling them to target the cost-effective psychological preferences of consumers.

2. METHODS

Kansei Engineering was applied to evaluate and analyz consumers' impressions of crossover B-car interiors in order to develop a survey and analysis system. The purpose of this survey and analysis system was to appeal to consumers' cognition and perceptions of car interiors in order to provide necessary insight and assistance for designers and evaluation groups. In this study, we applied both qualitative and quantitative research methodology; consequently, we adopted a two step approach that consisted of both expert and consumer evaluations.

2.1. Participants

In-depth interviews were held with people having expertise in the automobile industry such as auto professionals, car owners, editors of automotive magazines and veteran car mechanics. Participants were asked to provide their preferences for the crossover B-car interior design and functionality, listing the details of, and reasoning behind, their preferences. In order to understand the appeal of car interiors, the interviews were conducted using the Evaluation Grid Method (EGM). Five male experts with ages between 37 and 55 years old were interviewed. In addition, 12 crossover B-car owners were interviewed: including six male and six female car owners with ages ranging between 29 and 48. A comprehensive list of the appeal factors of a crossover B-car interior was provided for the 17 interviews and the saturation point was attained.

A questionnaire was then used, out of a total 1100 questionnaires, 1003 were returned, producing a 91.1% response rate. After eliminating the questionnaires that contained incomplete or invalid answers, 931 valid questionnaires were taken into account, resulting in a 92.8% rate of effective returns. Among these valid respondents, there were 520 males and 411 females, with the ages ranging from 31 to 55.

2.2. Measures

Preparation for interviews involved the initial gathering of data for collecting information related to the interior design and variations in functionality for crossover B-car in Taiwan. We collected data from all types of crossover B-car in the market in Taiwanese market and then focused on the information regarding interior space and design functionality. In compiling the questionnaire, we gathered 521 adjectives related to interior space and design functionality design of crossover B-car through specialized media such as automotive magazines or web sites. In addition, 27 sample cards made by the car manufacturers were selected for the interviews. These sample card contained pictures and names of 27 crossover B-car interiors.

In the process of the questionnaire production, major evaluative items were generalized from content found in the EGM. The survey aimed to target vehicle consumers or people with the financial means to be considered potential vehicle consumers. In addition, the personal information of the survey participants' sex, age, education level, marital status, family, and average monthly income were collected. Moreover, the content of the questionnaire was aimed at understanding, from the const effective side, consumers' general needs and their reasoning for preferences of crossover B-car interior design and variations in functionality.

We were able to create the questionnaire using the evaluation items in relation to specific aspects of each item. The original evaluation items, chosen in accordance with the focus of this paper, were "economical and practical" and "customized for customers' needs". Hence, consumers were asked to select their inclinations with regard to aspects of car interiors under the original evaluation item. The following are examples of the questions asked in the questionnaire under the general evaluation item of "economical and practical" in relation to varying features: 1. How do you rate the importance of "economical and practical" with the following items: durability, worth more than its cost, and safety and stability? Participants were asked to evaluate the different aspects by importance, scoring the most important as a "5" and the least important as "1". 2. In the category of "economical and practical", to which trait do you feel "durability" should be applied? In this type of question, participants were asked to select one from the following list of features: leather, metal surfaces, and integrated storage.

2.3. Procedures

To make a qualitative assessment, we collected data from authoritative articles, analyzed crossover B-car interiors, and interviewed car buyers. We applied the EGM to determine the structural appeal of crossover B-car interiors, and vehicle descriptions given by consumers were used in the construction of the questionnaire. The procedure for conducting the EGM is as follows: (a) The 27 sample cards were grouped into three stacks according to the participants' preferences from high to low. (b) the original evaluation items were obtained by asking the participants about the images and their reasons for grouping them in each of the three stacks; each original evaluation was then processed to form its corresponding "upper-level" and "lower-level" concepts (see Table 2). "Upper-level" corresponded to words that were more abstract in the hierarchical structure of semantics, while "lower-level" related to the words in the evaluation that were more specific.

Table2: The best 2 original image selections from the hierarchical diagram as determined by the number of times they appeared

Classified	Original images	Reasons (upper level)

First	Economical and practical 9	Worth more than its cost 19 Safety and stability 15 Durable 9
Second	Customized for consumers' needs 6	Customized for individual preference 20 Customized for the needs of a specific population 14

For the quantitative assessment, we conducted a survey using the questionnaires and analyzed the data. In order to measure the weight of the features in the importance of crossover B-car interiors, the aspect that was most closely related to cost-effectiveness issues was chosen. The study then adopted snowball sampling, now-probability sampling technique where existing study subjects were asked to recruit future subjects from among their acquaintances who belonged to the population of interest. People who had no automotive experience were excluded from the study. Further stringency was obtained by only enrolling participants in the study, who had used crossover B-cars for at least 3 months.

The Quantification Theory Type I method was used for the analysis of the questionnaires as a tool to evaluate the importance of the appeal factors of a crossover B-Car interiors. In addition, the different weights of the original evaluation, upper-level, and lower-level items were measured and quantified. The Quantification Theory Type I method was transferred to a mathematic formula and was run through Excel Macro for statistical analysis.

3. ANALYSIS

The EGM aimed to extract consumer language with the goal of understanding the evaluation items within the interviews and the structure of the network of factors. This was also a method used to determine how consumers evaluated product value using an in-depth investigation for each individual. Through this process, consumer perception and level of economic value were analyzed. Using the structure of the semantic hierarchy, from abstract to specific, we were able to visualize and solidify the structure of consumer values through the original evaluation composed of upper-level and lower-level items. Additionally, the repertory grid method developed by Kelly (1955) was used in the interview in order to gain an understanding of each participant's ability to report on the similarities and differences between two objects. This method is standard when attempting to gauge the extent of people's understanding and recognition of their surroundings.

Hayashi's Quantification Theory Type I can statistically predict the relationship between a response value and its categorical values (Hayashi, 1950). In product design, Hayashi's Quantification Theory Type I can also be used to evaluate the weight of factors that stem from consumers' preferences (Iwabuchi et. al., 2001)(Sugiyama et al., 1996). In addition, this technique can be used to examine the relationship between quantitative and qualitative data. For example, Jindo (1997) used Quantification Theory Type I method to analyze the relationship between subjective evaluation scores and the elements of the design of car interiors. In 2008, Nagamachi introduced the idea that, using Quantification Theory Type I, it is feasible to construct the relationships between emotional images and design elements.

The current study employed Quantification Theory Type I in order to determine the different weights among appeal factors and the critical elements of the images presented of interior designs of crossover B-cars. In addition, the relationship between the appeal factors and features of the interior of crossover B-cars were also explored. The most meaningful responses

were found to be dependent on image composition. The partial correlation coefficients indicate the extent to which each design element contributes as an explanation of the evaluation adjective. (Jindo, 1997)

4. RESULTS

Appeal factors of crossover B-car interiors were determined according to the preferences obtained from the 17 experts interviewed using the EGM. Figure 1 shows the hierarchical diagram of the crossover B-car interior preference of one participant. In Figure 2, numbers to the right of the letters indicate the frequency with which the same opinion appeared more than once. For example, “economical and practical 9” indicates that “economical and practical” was listed 9 times from the 17 participants. Table 1 also shows the statistical results of the rankings from the hierarchical diagram as measured by the number of times the descriptions appeared.

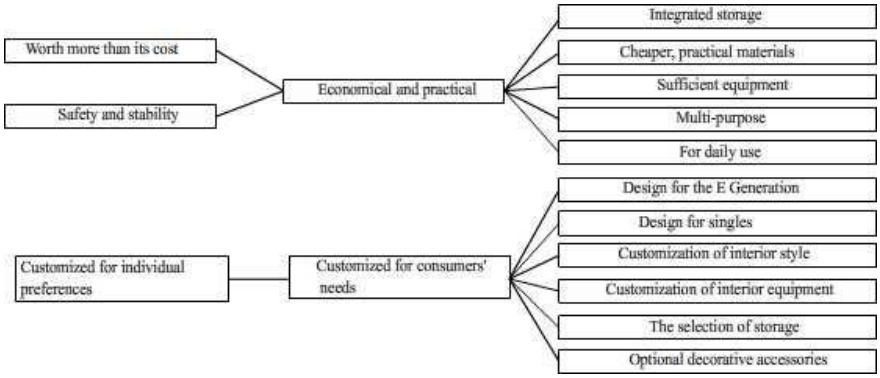

Figure 1: The hierarchical diagram of Crossover B-Car interior preference of one participant by means of the EGM

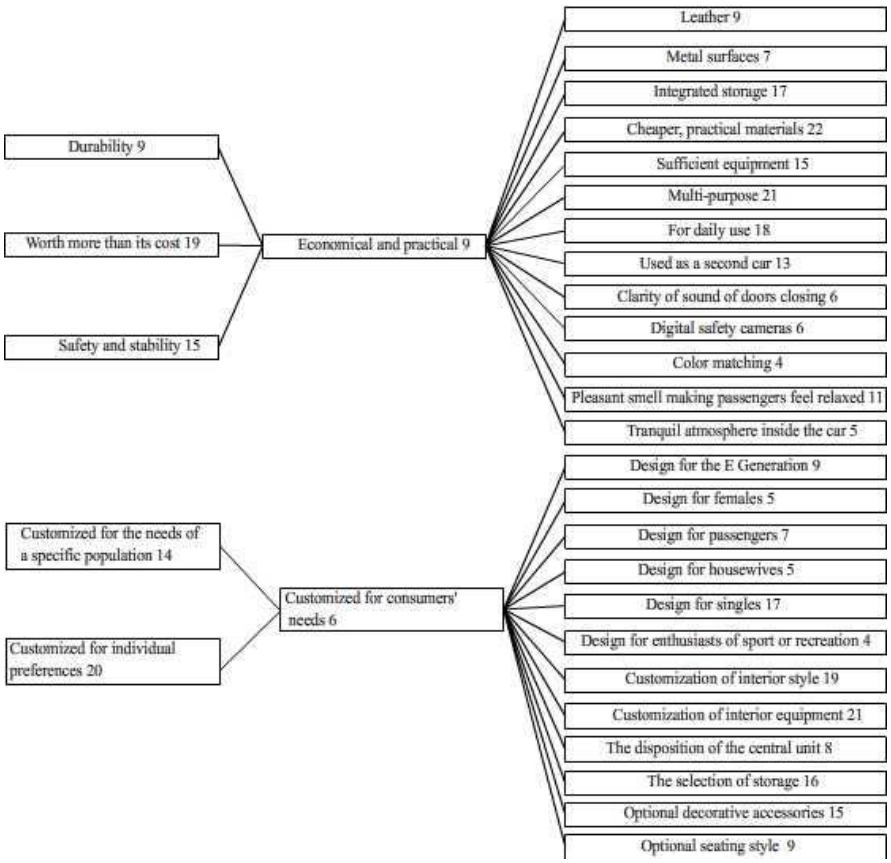

Figure 2: The hierarchical diagram of Crossover B-Car interior preference by the EGM

Table 1: Title of the table

Original images	**Upper Level (reasons)**	**Lower Level (specific attributes)**
Economical and practical 9	Customized for individual preference 20	Cheaper, practical material 22
Customized for consumers' needs 6	Worth more than its const 19	Multi-purpose 21

The first evaluation factor was "customized for consumers' needs", which included sub-classifications of "customized for the needs of a specific population" and "customized for individual preference" in the upper-level assessment. In this study, the coefficient of determination, R2=0.617, which was determined based on the results of the Quantification Theory Type I method, indicated that our surveys were reliable. The highest partial correlation coefficient was "customized for the needs of a specific population" (see Table 3), which contributed most to the "customized for consumers' needs" evaluation factor. The specific aspects included under this sub-classification of the general evaluation factor were the designs for E Generation, females, passengers, housewives, singles, and enthusiasts of sport or recreation vehicle.

Table 3: The category scores for the general item of "customized for consumers' needs"

Items	Categories	Category Scores	Partial Correlation Coefficients
Customized for the needs of a specific population	Design for E Generation	0.141	
	Design for females	0.019	
	Design for passengers	-0.141	
	Design for housewives	-0.282	
	Design for singles	-0.181	
	Design for enthusiasts of sport or recreation vehicle	*0.230	*0.816
Customized for individual preference	Customization of interior style	-0.007	
	Customization of interior equipment	0.037	
	The disposition of the central unit	0.036	
	The selection of storage	-0.099	
	Optional decorative accessories	0.047	
	Optional seating style	0.158	0.519
C		0.625	
R = 0.848			
R Square = 0.720			

As shown in the category scores in Table 3, "changeable interior style" (See Figure 3) had a stronger effect on "design for enthusiasts of sport or recreation" than the others. In addition, "design for singles" had a stronger negative effect on this factor than the others did.



Figure 3: "Changeable interior style"

The second evaluation factor classified was "economical and practical", which included sub-features related to durability, worth more than its cost, and safety and stability" in the upper-level assessment. A crossover B-car interior was classified as "economical and practical" if it gave the consumers this impression because one of the three above-mentioned descriptors. The coefficient of determination, R2=0.601, which was determined based on the results of the Quantification Theory Type I method, indicated standard reliability for our survey instrument.

The highest partial correlation coefficient was for the feature “safety and stability” (see Table 4), which contributed the most to the evaluation factor of “economical and practical”. The specific items included under this sub-classification of the general evaluation factor were the designs for the following: clarity of sound of doors closing, digital safety cameras, color matching, pleasant smell inside the car leading to the relaxation of passengers, and a tranquil atmosphere inside the car.

Table 4: Category scores for the general “economical and practical” evaluation item

Items	Categories	Category Scores	Partial Correlation Coefficients
Durability	Leather	0.011	0.137
	Metal surfaces	0.010	
	Integrated storage	-0.011	
Worth more than its cost	Cheaper, practical materials	0.129	0.652
	Enough equipment	0.022	
	Multi-purposes	-0.052	
	For daily use	*0.174	
	Used as a second car	0.084	
Safety and stability	Clarity of sound of doors closing	-0.004	*0.781
	Digital safety cameras	-0.015	
	Color matching	-0.295	
	Pleasant smell making passengers feel relaxed	-0.127	
	Tranquil atmosphere inside the car	0.103	
C		0.823	
R = 0.839			
R Square = 0.703			

As shown in the category scores in Table 4, “daily use” had a stronger effect on “cost-effectiveness” than the other items. In addition, “color matching” had a stronger negative effect on “safety and stability” than the other design features.

5. DISCUSSION

The current study probed consumers’ cost-effective needs for the interior of a vehicle. The results of the study, shown in a hierarchical diagram of crossover B-car interiors, were determined using the Evaluation Grid Method (EGM) (see Figure 2). When questions related to automobile interior design, were examined, evaluation items determined that greatest cost-effective appeal of car interiors included factors to “customization for consumers’ needs” and “economic and practical”. More specifically, the current study suggests that consumers choose car interiors because of one or more of the following characteristics: customized for the

needs of a specific population, customized for individual preference, durability, worth more than it cost, and/or safety and stability.

In addition, the weights of the varying features of car interiors were analyzed using Quantification Theory Type I, and the appeal of car interiors was determined for the following two appeal factors: “economical and practical” and “customized for consumers’ needs”. Among these factors, “customized for consumers’ needs” had the highest R square value (0.720). In addition, the results demonstrated that participants in the current study tended to identify more with the “customized for consumers’ needs” than they did with other factors.

Typically, consumers attempt to decrease unit cost by increasing the rate of the use of crossover B-car interiors. This also reflects consumers’ decision making while in the purchasing process. Furthermore, consumers are inclined to pay lower costs for the maximum functionality and usability that the crossover B-car interior has to offer. Based on these points, “economical and practical” has become a marketing strategy aimed to appeal to the cost-effective psychology of consumers who select crossover B-Car interiors. The “economical and practical” quality can be broken down into three aspects. The first of these is “durability”, including specific design features such as leather, metal surfaces, and integrated storage (Figure 4). The second characteristic is “worth more than its cost”, and includes specific factors such as the use of relatively cheat but practical materials” (Figure 5), being sufficiently equipped, having equipment with multi-purpose functions, and being a vehicle interior that is optimal for daily use, and one that is suitable for a second car (Figure 5). The third aspect is “safety and stability”. There is often concern shown for the safety of small cars, which is a consumer basic need. Therefore, the question of how to deliver the idea of “safety and stability” through a car’s interior design should not be overlooked. This has been accomplished through inclusion of several design features such as clarity of sound of doors closing, digital safety cameras, color matching, a pleasant-smelling interior to put passengers at ease, and a tranquil environment inside the car.



Figure 4: “Leather” and “integrated storage”



Figure 5: “Cheaper, practical materials”

Mass customization, i.e., catering to consumers’ needs, can be used as a way to achieve the cost-effective goal of purchasing. More specifically, the ability of consumers to choose which design elements should be implemented for targeted products without spending money for

unnecessary features could be an invaluable marketing tool. In fact, the current study, showing the preference for “customization for consumers’ needs” indicates that the functionality and usability of crossover B-car interiors reflect not only consumers’ preferences but also their motive to save money. “Customized for consumers’ needs” can be further broken down into two aspects: the first aspect is “customization for the needs of a specific population”, meaning that interior equipment should be designed according to a specific populations’ needs. Thus, specific items include designs for the E Generation (Figure 6), females, housewives, passengers, singles, and designs for consumers that show a preference for sport or recreation vehicles. The second “customized for consumers’ needs aspect is “customization for individual preference”. Therefore, specific design aspects should include customization of interior style, interior equipment, the disposition of the central unit, and the selection of storage. In addition, optional decorative accessories and seating styles of should also be included.



Figure 6: “Customized for the needs of the E Generation”

6. CONCLUSIONS

The design of the crossover vehicle, allows a small car to have a maximum interior space and functionality, and no longer offers just a style of body but also constitutes a new generation of type. In fact, consumers choose crossover B-car interiors because of cost-effective considerations relating to their social and cultural backgrounds, as discussed in the beginning of this study. Hence, social and cultural factors have a big influence on consumers’ decision-making preferences when choosing crossover B-car interiors. These factors indicate a consumer’s financial behaviour, which is greatly affected by culture and society. Based on this study, the semantic structure of the cost-effective appeal derived from interviews of experts showed hierarchical relationships between the type of appeal factors, reasons for consumers’ preferences, and specific desirable characteristics of crossover B-car interiors. In addition, overall statistical analysis on the cost-effective appeal of crossover B-car interiors was performed through consumer evaluations.

From the perspective of consumer psychology, the average prices of cars are higher than other marketable good; therefore, purchasing automobiles involve a high level of decision-making. This means that a consumer has to weigh the risks while he or she decides to purchase a car; thus, the cognitive process of purchasing a car is more complicated than the process of buying general goods manufactured for basic living. It also means that a consumer will exert a higher degree of mental and physical effort to gather information on the intended vehicle for purchase, and will consult with friends or relatives and consider comprehensive comparisons of vehicles before actually making a definitive purchase decision.

The design of car interiors is a potential area for academic research because a person’s emotional response to, and perception of, car interiors is a complicated and significant factor,

one that requires more research and further exploration. In the current study, we investigated the design of car interiors using a preference-based approach, as it was appropriate to reveal the appeal of car interiors, as articulated by the experts used in qualitative aspect of the study. In addition, it has been shown that product design integrated with marketing considerations is necessary in the current market because consumers can be motivated to change their consumption behavior. Since consumer behavior is deeply influenced both by consumer preference and motivation research, the findings of the current study should add to the literature in these two fields.

One limitation of, the current study could be that the samples collected from the specific institutions in Taiwan might not be representative of wider populations in other countries or areas, due to differences in culture and custom; therefore, a future research study could be focused on personal motivations with regard to financial considerations of other types of car interiors. To this goal, we will accumulate impression data on important factors constituting other types of car interiors, as was attempted by Jindo (1997).

ACKNOWLEDGMENTS

I wish to express my serious gratitude to my major advisor, Prof. Kuo-Hsiang Chen for his diligence and scholarly guidance of this study. I also have to acknowledge the professional instruction of my co-advisor, Prof. Min-Yuan Ma. I also wish to acknowledge my friends, Miss Wei-Ping Pu and Mr. Ching-Chien Liang who participated in this study with all their hearts. In addition, I also treasure all those who contributed to this study.

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BIOGRAPHY

Short biography of author 1 (100 words max) (leave blank for reviewing)

Kai-Shuan taught in the Department of Digital Fashion Design in TOKO University. During the period of teaching, he was enthusiastically engaged in teaching and research relative to multimedia and industrial design. From 2009-2010, he served as Project Co-Manager for Green-Technology Interdisciplinary Value-Added Innovation (98-2218-E-006-246-) and Sub-Project Manager for Green Dockers, which is elected for the award of feasibility evaluation prospectus. Kai-Shuan Shen is the corresponding author and can be contacted at: creativekevin2001@hotmail.com

Kuo-Hsiang Chen also enthusiastically participated in the Kansei Engineering research group and co-instructed graduate students to proceed to relative study of the application of Kansei Engineering Design. From 2001 to present, he has published critical papers relative to Kansei Engineering. Due to approved academic and research achievements, he was elected as the President of the Taiwan Institute of Kansei.

1C - Architecture and Urbanism

Proposal for Urban Environment Using Icons with Fifth Year Elementary Students

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Abstract: This paper presents discussion of environmental proposals by children related to the change of the expression of map from the third to the fifth year students, based on the fieldwork and the workshop on “Good Place”. According to the analysis of data, a child passing from the third to the fifth year estimates urban spaces more objectively. However, for iconic expression, the place diversity and the five senses are more closely interrelated.

Keywords: Proposal, Urban space, Icon, Five senses

1. INTRODUCTION

From the 1970s, Image Map Investigation by Lynch (1977) has been practiced along with children’s participation in city planning (Hart, 1997; Teramoto, 1999). For a better child environment, their cognition about urban spaces should be fundamentally understood to establish a method to develop a capacity for urban proposals.

The author has practiced the methodology of environmental mapping using “Icons (fives senses’ icons)” to consider urban space through the activities of "Hiroshima Eco-Peace Map" that has been conducted since 2002. Moreover, the author drilled the program for improving the proposition capability with the themes of estimation, proposal, and criticism from 2009. This was conducted with third year students of Hiroshima University’s attached elementary school (39 children). The same program was conducted with the children the following year when they had become fifth year students in 2011.

Based on activity during 2009–2010, the author analyzed the relation between the estimation and the proposal for the living environment by third-year elementary students. Results showed that the changes in their proposal capabilities were attributable to the constant activity of their five senses, irrespective of the living environment or urban environment, and also discussed the relation between their egocentricity and consideration toward others within it (Ichikawa & Sendai, 2012; Sendai & Mitsuhata, 2012): the children’s proposal is not only the moralistic concept which

they learn in the school. They also learn concepts based on the body sense, which brings egocentricity and consideration toward others simultaneously. Will we ever identify such a characteristic in the case of the fifth year children? Alternatively, will a moralistic concept produce advantages in the children in later years, as it does in adults?

This paper compares and analyzes the estimations and proposals related to the urban space by the children when they become fifth year elementary school students. Furthermore, the paper presents an examination of the change of proposal capability for the urban space using icons by children from the viewpoint of Kansei philosophy as a qualitative study (Kuwako, 2001). In other words, this study is an attempt to reveal the diversity of sensibility of the place rather than the universality of sensibility by quantification.

Previous studies of child proposals have examined pedagogic themes (Teramoto, 1999) or administrative methods related to child participation with city planning (Driskell, 2002). In contrast, this study highlights child sensitivity itself with the urban space through a series of processes from the estimation to the proposal, using five sense icons. Additionally, it must be emphasized that this study targets the same children for three years in the same area. Because sensitivity itself is not constant. Therefore, it changes dynamically and diversifies in answer to others or places.

2. METHOD

2.1. General activities

Research sources are based on the activities of our fieldwork and workshop.

In principle, because the paper is done with the same children from the third year passing to the fifth year, the process is included into the Integrated Study Curriculum in Japan. We encourage the children to make groups (5–6 children) from A to G by themselves. The university students, including both undergraduate and postgraduate students of Hiroshima University, were allocated to the respective groups as facilitators.

The target of the fieldwork for the “Good Place” in the urban environment is the central district of Hiroshima city. Nakajima district, where the Peace Memorial Park located, was designated as the "South Area". Motomachi district, which has cultural facilities, was designated as the "North Area" (Fig. 1).

As a method to obtain proposals from the estimation, we set up (1) "attempt to research", (2) "attempt to select signs", (3) "attempt to select icons", (4) "attempt to propose", and (5) "attempt to criticize" (Tables 1, 3). We operated (1) and (2) using fieldwork simultaneously, and (3)–(5) at a workshop in the elementary school classroom.

For fieldwork, we use simple signs consisting of spatial indexes (Good Place, Bad Place and Good/Bad Place) and time indexes (Lost Place and Future Place). The estimation place and the route were sufficient to cover main buildings and monuments, returning to the starting point within 3 hours. The safety for the children was examined. The same conditions were applied to all years.

In the workshop, we instructed children to select from the five senses’ icons (See, Hear, Smell, Taste and Touch) (Table 2) corresponding to the signs expressed in the estimation of the fieldwork. Additionally, we asked the children to express their ideas using colours (Green means affirmation, Red means negation, and Yellow means neutrality or affirmation/negation). To guide the children's estimation and help them make proposals based on body feelings, we use the "five senses". However, the problem of the effects of the icon forms is one of future research themes, the paper does not discuss it.

Table 1: Contents of activities in the fifth year

Fieldwork		
Date	November 22th and 23th, 2011	
Place	Nakajima area (the South Area) and Motomchi area (the North Area) in Hiroshima city	
Participant	Children : 39 persons Parents : 5 persons	
The contents of practice	(1) attempt to reseach (2) attempt to select signs	
	1st day	The South Area : the resarch and estimation Select the signs (○ / × / △ / ■ / □)
	2nd day	The North Area : the resarch and estimation Select the signs (○ / × / △ / ■ / □)
Workshop		
Date	February 27th, and 28rd, 2012	
Place	Hiroshima University attached elementary school	
Participant	Children :39 persons	
Practice	(3) attempt to select icons (4) attempt to propose	
	1st day	The South Area : Select the type of icons for the signs (see/ hear/ smell/ taste/ touch) Select the color of icons for the signs (Green / Red/ Yellow) Change the color of icons (Green) Draw the original icon
		Presentation and discussion
	(3) attempt to select icons (4) attempt to propose	
	2nd day	The Nouth Area : Select the type of icons for the signs (see/ hear/ smell/ taste/ touch) Select the color of icons for the signs (Green / Red/ Yellow) Change the color of icons (Green) Draw the original icon
		Presentation by parents and discussion

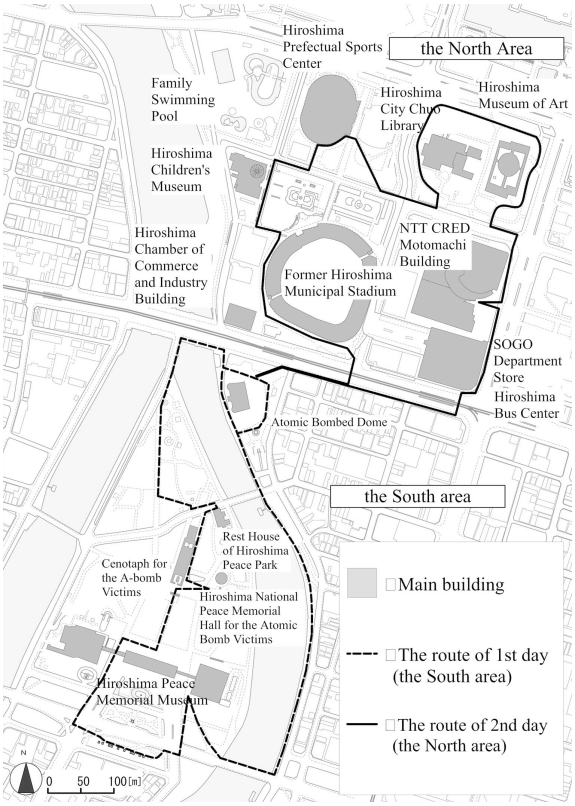


Figure 1: Fieldwork area

Table 2: Five senses' icons

meaning	See	Hear	Smell	Taste	Touch
icon					

The next stage in the workshop was to propose the urban space. We define the proposal as making the Green icon. The proposal is not only for the improvement of the Bad Place, but also the

sustainable conservation of Good Places. In addition to the icon proposal, the children write the contents of their proposal on the format seat: “actually, this is [A1] by the reason for [A2], if I try to [B1], it becomes [B2]” (Table 4).

2.2. Method of analysis

As described above, with fieldwork and the workshop for the urban environment, we introduce the simple statistic tendency of the children’s estimation and their proposal, with comparison to those of the third/fourth/fifth year students. Then we attempt a qualitative interpretation of the examples showing its tendency.

Table 3: Flow from fieldwork to the workshop

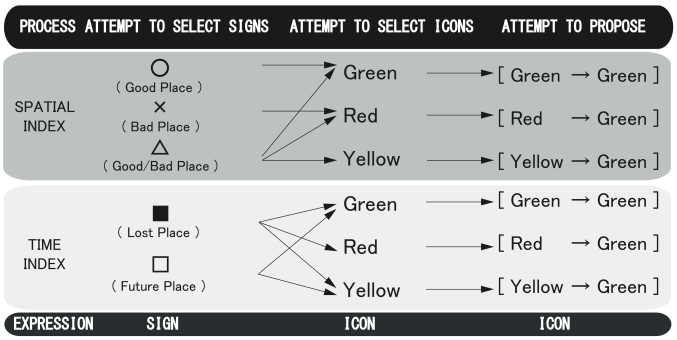


Table 4: Analysis of the contents of the children’s proposal

	tool	contents	
Investigation	sign, langage		
Estimation	language	A2 (reason)	A1(actural situation)
	Icon	type	color
Proposal	language	B1 (method of proposal)	B2 (purpose of proporsal or futur situation)
	language	Soft/Hard	Development/Reproduction/Preservation
	Icon	type	color
	language	egocentricity/consideration toward the others	

3. SIGNS

3.1 Estimation by the signs (Spatial indexes) (Table 5)

In the North area and the South area, the rate of “Good Place” is greater than 60% during the fourth and fifth years. However, the total number of signs in the fieldwork by the fifth-year students decreases nearly by half. This reduction might explain the better familiarity with the areas than before, and the shorter time to walk in the field. However, in the proposal, the total number does not decrease so much compared with that in the fourth year (Table 13 – Table 17). This demonstrates a child’s capacity for proposal).

3.2. Estimation by signs (Time indexes) (Table 6)

Total number of signs related to the time indexes in the fifth year decreases compared with that in the fourth year. In the South area, no mark signals the “Lost Place”. The rise of the rate of the “Future Place” might indicate the potential for a proposal. In contrast, the rate of the “Lost Place” in the North area increases. In fact, that indicates the local gap of the interest for a proposal.

Table 5: Rates of estimation by signs (Spatial indexes)

(left, fourth year; right, fifth year)

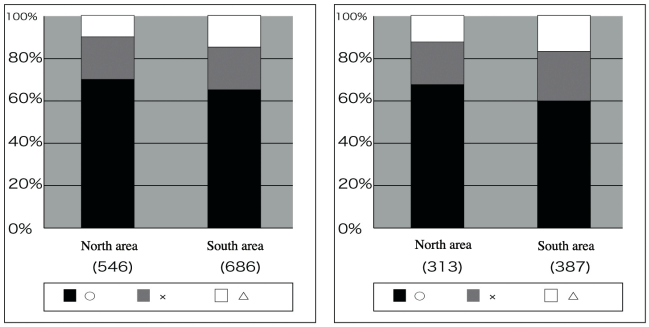
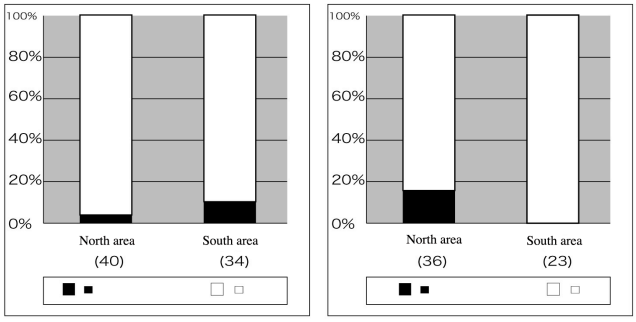


Table 6: Rates of estimation by signs (Time indexes)

(left, fourth year; right, fifth year)



3.3. Object for a sign (Table 7 and Table 8)

The rate of the signs for “Building” in the fifth year students doubles in both areas compared with that in the fourth year. However, the rates of the “Monument” and “Planting” decrease. This is the third fieldwork session for the fifth year students. They should not mark the “Monument” or the “Planting” as having a constant value, and concentrate on estimating something from which they can discover new meanings.

Table 7: Rates of objects by signs (North area)

(left, fourth year; right, fifth year)

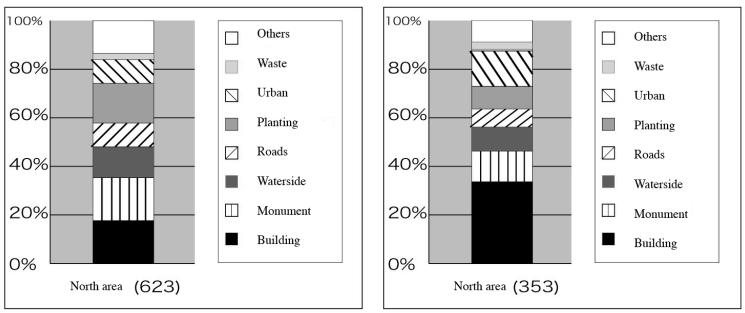
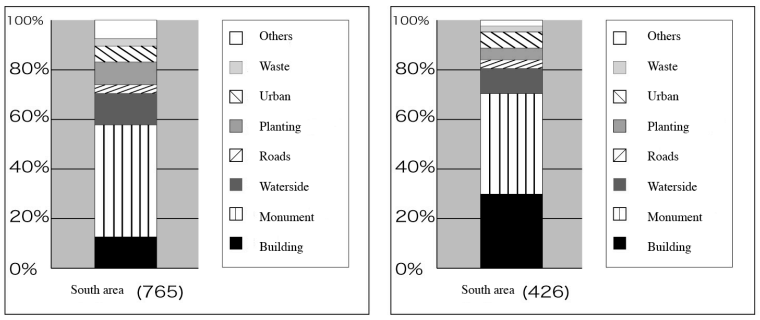


Table 8: Rates of objects by signs (South area)

(left, fourth year; right, fifth year)



4. ICONS

4.1. Colour of the icons (Spatial indexes) (Table 9)

The rates of the Green icon are highest in both years, but the rates of the Red and Yellow icons are higher in the fifth year, which indicates that the fifth-year students obtain a more objective and critical viewpoint.

4.2. Type of icon (Spatial indexes) (Table 10)

At both years, the rate of the See icon and the Touch icon is the highest and more than 70%. Nevertheless, the rate of the See icon in the South area increases, and the rate of the Touch icon decreases compared with that in the fourth year. In contrast, the rate of the Touch icon in the North area increases, which indicates the local gap of the type of icon as well.

4.3. Colour of the icons (Time indexes) (Table 11)

The rate of the Red icon increases. However, in general, the fifth year students use Green, Red, and Yellow icons equally compared with the fourth year students. That is the same tendency as that using the colour of icon by the spatial indexes.

4.4. Type of the icons (Time indexes) (Table 12)

In both years, the rate of the See icon increases, taking nearly 50% in the fifth year. In the North area, there is no Smell icon or Taste icon. However, in the South area, the See icon and the Touch icon are greater than 80%. The result is the same as that obtained using the type of icon by the spatial indexes.

Table 9: Rates of the colours of the icons (Spatial indexes)

(left, fourth year; right, fifth year)

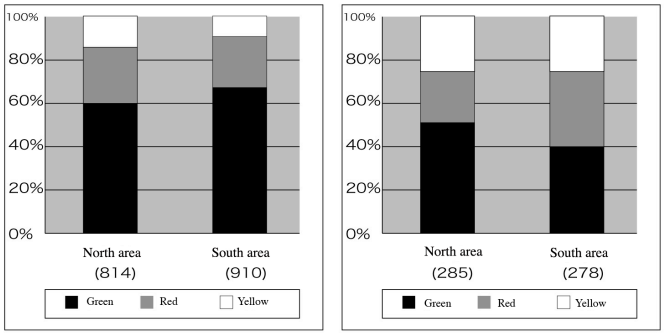


Table 10: Rates of the types of the icons (Spatial indexes)

(left, fourth year; right, fifth year)

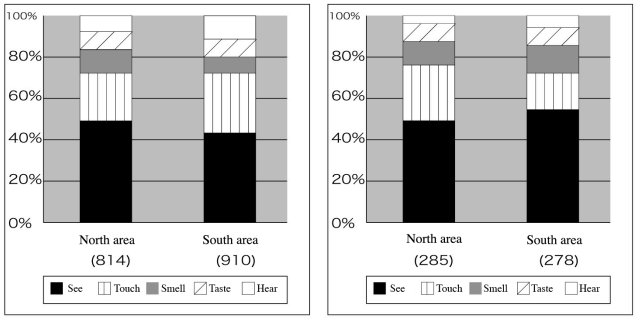


Table 11: Rates of the colours of the icons (Time indexes)

(left, fourth year; right, fifth year)

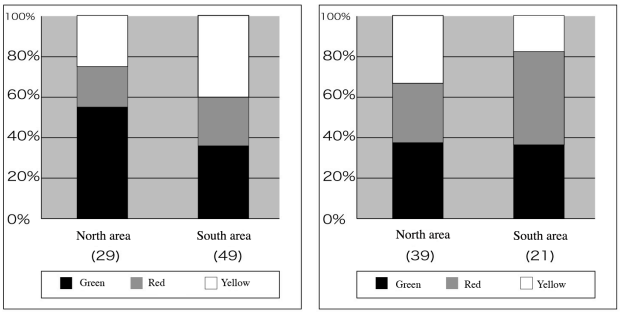
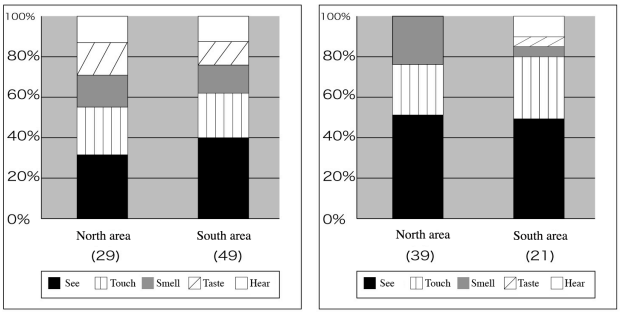


Table 12: Rates of the types of the icons (Time indexes)

(left, fourth year; right, fifth year)



5. PROPOSALS BY ICONS

5.1. Object for a proposal (Tables 13 and 14)

The rate of the proposal for the “Building” increases in both areas in the fifth year compared with that in the fourth year. Corresponding to this tendency, the rate of the other objects for a proposal decreases. Particularly the use of the “Planting” in the North area and the “Monument” in the South area decreases significantly, which reflects the tendency of the use of the objects for the sign (Table 7 and Table 8).

5.2. Method of proposal by Writings (Table 15)

We classify the method of proposal by written languages into a Hard method and a Soft method, according to the artificiality (Ichikawa & Sendai, 2012; Sendai & Mitsuhata, 2012).

For both years, in both areas, the rate of Hard is higher than that of Soft. However, the rate of

Soft in the North area increased more than 10% in the fifth year, which demonstrates the increased capacity for multilateral proposal by the Hard method and the Soft method.

Table 13: Rates of objects for proposal (North area)

(left, fourth year; right, fifth year)

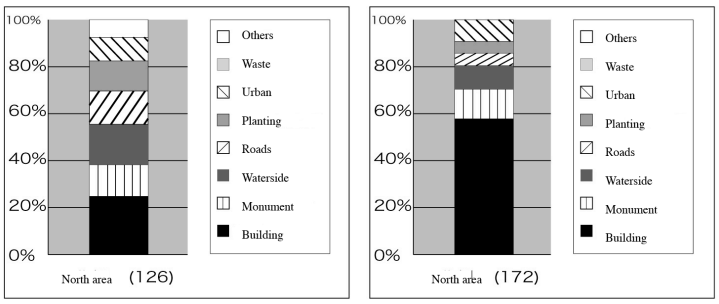


Table 14: Rates of objects for proposal (South area)

(left, fourth year; right, fifth year)

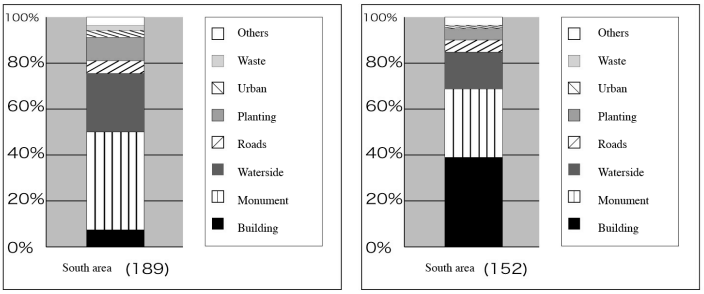
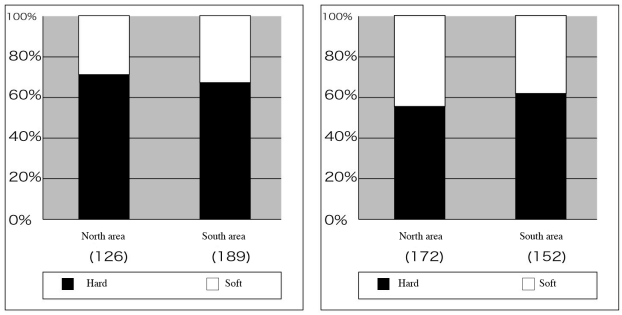


Table 15: Rates of the method of proposal (writing)

(left, fourth year; right, fifth year)



5.3. Purpose of proposal by writing (Table 16)

We classify the purposes of proposals expressed in written language into Development, Reproduction and Preservation, according to the degree of development (Ichikawa & Sendai, 2012; Sendai & Mitsuhata, 2012).

During both years, in both areas, the rate of Development, which is higher than 60%, is higher than that of either Reproduction or the Preservation, which demonstrates the positive will of children to participate in urban space improvement.

5.4. Contents of proposal by writing (Table 17)

We classify the contents of proposal by written language into Egocentricity and Consideration for others, according to the degree of egocentricity.

In the fourth year, Consideration for others is superior in both areas, but in the fifth year, the rate of the Egocentric proposal is higher, which might explain the positivity or the strong will of the children, or a regression to the feelings of third-year students.

5.5. Purpose of proposal by icon colour (Table 18)

Regarding comparison with the fourth year students, for fifth year students, the rate of the Green icon changed from the Yellow icon increased in both areas. In general, that change reflects the raised capacity for multilateral proposals.

5.6. Method of proposal by the type of icon (Table 19)

Compared to those of the fourth year, the See icon rates increase in both areas in the fifth year. However, comparison with the increase of the See icon for the estimation, uses five senses' icons equally, which indicates that the icon expression enables children to propose a future urban space by the freer use of the five senses than by the written expression.

Table 16: Rates of the purpose of proposals (writing)

(left, fourth year; right, fifth year)

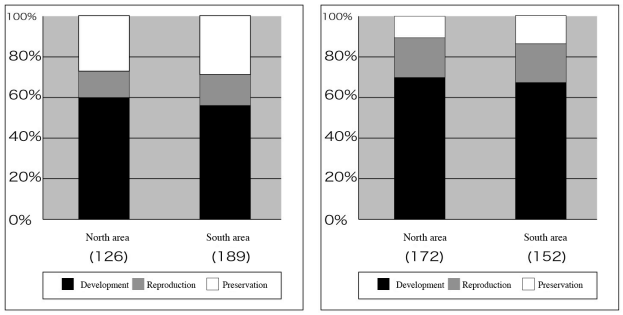


Table 17: Rates of the contents of proposals (writing)

(left, fourth year; right, fifth year)

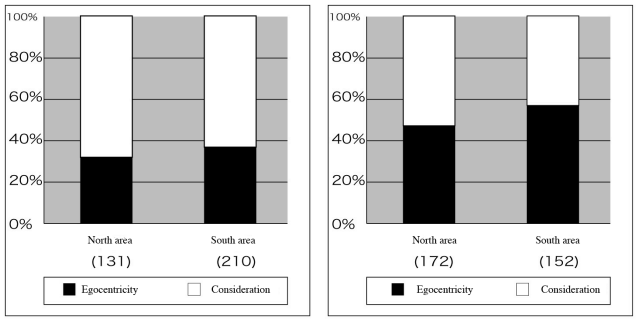


Table 18: Rates of the purpose of proposals (colour of icon)

(left, fourth year; right, fifth year)

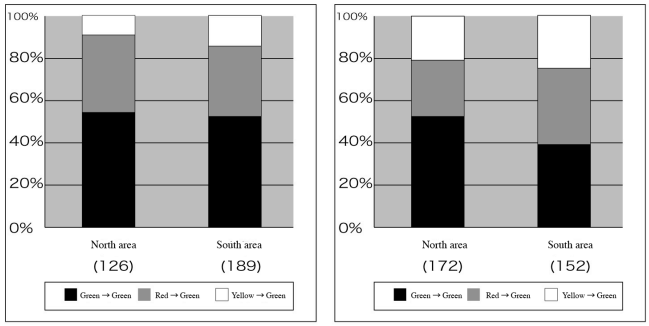
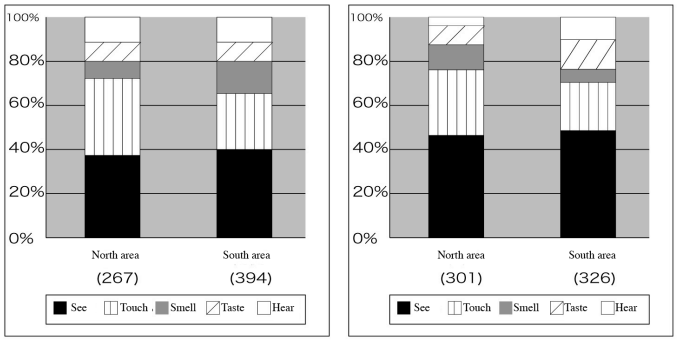


Table 19: Rates of the purpose of proposals (type of icon)

(left, fourth year; right, fifth year)



6. RESULT

Table 20: Characteristics in the process of the proposal by the third, fourth and fifth year students

Grade			3rd grade		4th grade		5th grade	
Enviroment			North Area	South Area	North Area	South Area	North Area	South Area
Estimation by signs		Spatial Index	○(Good Place)	○(Good Place)	○(Good Place) ×(Bad Place)	○(Good Place) ×(Bad place)	○(Good Place) ×(Bad Place)	○(Good Place) ×(Bad place)
		Time Index	□(Future Place)	□(Future Place)	□(Future Place)	□(Future Place)	□(Future Place)	□(Future Place)
		Object	Building	Monument	Building	Monument	Building	Building/Monument
Estimation by icons	Color	Spatial Index	Green	Green	Green and Red	Green and Red	Green, Red and Yellow	Green, Red and Yellow
		Time Index	Green	Green	Yellow	Yellow	Green, Red and Yellow	Green and Red
	Kind	Spatial Index	View / Touch	View	View / Touch	View / Touch	View / Touch	View
		Time Index	View	View	View / Touch	View / Touch	View / Touch / Hear	View / Touch
Proposal by icons		Object	Architecture (Building)	Architecture (Building) / Waterside	Architecture (Building)	Architecture (Building) / Waterside	Architecture (Building)	Architecture (Building/Monument)
		The Method of Proposal (Writings)	Hard	Hard	Hard	Hard	Hard=Soft	Hard
		The Purpose of Proposal (Writings)	Development > Reproduction	Development > Reproduction	Development > Preservation	Development > Preservation	Development >Reproduction> Preservation	Development >Reproduction=Preservation
		The Contects of Proposal (Writings)	Ego = Consideration	Ego ≦ Consideration	Ego < Consideration	Ego < Consideration	Ego < Consideration	Ego > Consideration
		The Purpose of Proposal (Icons)	Green → Green	Green → Green	Green → Green Green → Red	Green → Green Green → Red	Green → Green Green → Red	Green → Green Red →Green Yellow →Green
		The Method of Proposal (Icons)	View / Touch Using the five senses	View / Touch Using the five senses	View / Touch Using the five senses	View / Touch Using the five senses	View / Touch Using the five senses	View / Touch Using the five senses

According to the analysis, the characteristics at the third, fourth and fifth year are summarized in the following Table 20. Grey-coloured parts show the important transition from the third year or the fourth year. Based on this table, when the children passed from the third to the fifth year, the transition of the estimation and the proposition for the urban environment is the following:

(1) Estimation

In the fifth year, no marked change exists in the estimation by the signs compared within the former year. However, they use the yellow icon, which means that their estimation is more objective. In fact, the See icon, which leads to a good observation, increases at the fifth year in both areas.

(2) Proposition

In the fifth year, in spite of their objective estimations, the proposal of the new development increases in the verbal level. It contrasts with the general attitude of the fifth year students who understand the social morals better than the year before and become more conservative for the innovative development of the urban space. We interpret this tendency as positive participation in the urban space because their proposals by icons become more diverse. They show a constant use of the five senses.

7. DISCUSSION

Results show that the children's estimation of the urban environment becomes more objective. Acquisition of such objectivity itself often brings superficial estimation. However, the expression of the five senses in the proposal level is constant from the third year: cognitive development from the third year to the fifth year does not lead to the dullness of sensibility. The egocentric proposal by the fifth year students is not only selfish. It also reflects a positive attitude. Such a proposal suggests that fifth year students have acquired measures to propose through their own five senses.

However, typical proposals of the Development type corresponding to the result show that the intensities of egocentricity in the North area and in the South area have a gap.

We can find the following description of the proposal in the North area.

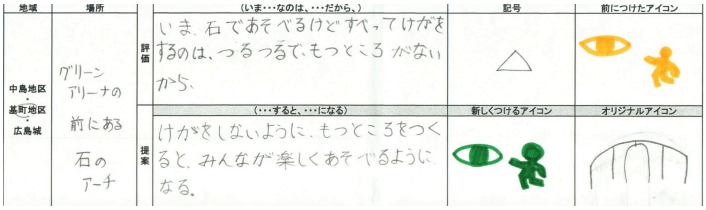


Figure 2: Description of the proposal in the North area (fifth-year students 1).

"Now, we can play with the small stones. However, we might be injured because of the very smooth stones without railings. If we install railings, we can play pleasantly." (Fig. 2).

Sculptural work is presented as a stone circle in front of the Sports Centre, providing a place for children to sit and climb, and inducing the children to play freely. Nevertheless, this child assigns this space a Yellow icon. He proposes improvement from the perspective of publicity and safety.

Another child presents the following typical proposal for the North area.

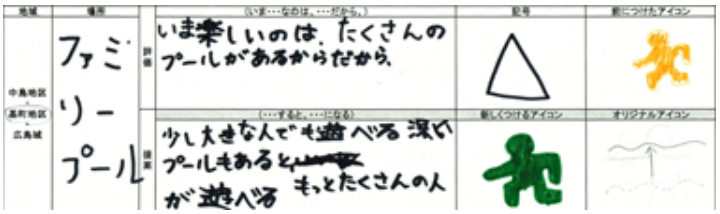


Figure 3: Description of the proposal in the North area (fifth year students 2)

"Now, we are entertained with pools of several sorts. If a pool for adults were to exist, more people could enjoy them." (Fig. 3).

This proposal is intended for improvement of the Family Swimming Pool for many users just as it has been made for children. The image of "a pool for adults" is not so clear, but the expression of "more people" includes consideration for others.

These typical proposals for the North area include consideration of others to a greater or lesser degree. We can find a Touch icon in such a proposal. However, we can find the following description on the proposal in the South area.

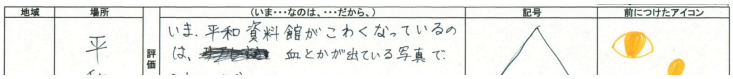


Figure 4: Description of the proposal in the South area (fifth year students 3).

“Now, the Peace Memorial Museum is terrible because the arranged photographs represent people who spill blood. Certainly, the present terrible space is important, but we need photographs like a picture book for children to understand it more easily. It is better to divide important images with some degree of fearfulness.” (Fig. 4).

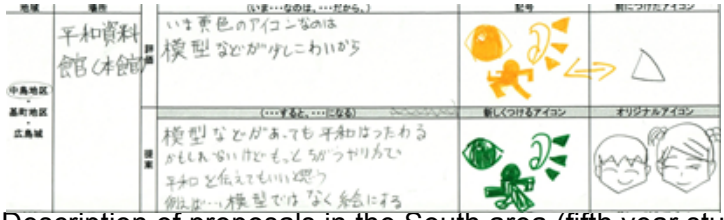


Figure 5: Description of proposals in the South area (fifth year students 4).

“Now, I estimate this model with the Yellow icon because the model is a little bit scary. Certainly, the model lets us know of peace, but I can also think of another way of giving a message. For example, a style of picture, not of a model.” (Fig. 5).

Both proposals are related to the display to transmit the misery of damage caused by the atomic bomb. However, they want to replace the present display because children cannot be patient with their “terrible” feelings. Furthermore, such an egocentric proposal is expressed through the See icon.

The proposals above reflect that the proposal contents depend on the North area and the South area characteristics: for the South area, the proposals are more egocentric with the See icons, for the North area, the typical proposal is more considerate of others with icons of more types. The uses of colour and the types of icons differ between the two areas. The sensibility aspect depends on the place for the fifth year students.

Regarding local characteristics, the North area has diverse building types (Children’s Museum, Department store, Bus centre, former Municipal Stadium under destruction, etc.). In this field, the children try to make a proposal from the perspective of consideration of others. However, in the South area, this field consists of the similar facilities with the theme of peace (Atomic Bomb Dome, Peace Memorial Museum, etc.). This area is often held up for use as teaching materials of school. Children must understand the moralistic sympathy with the others. Nevertheless, their proposals are more egocentric.

The use of the See icon in the South area represents egocentricity of a proposal. Conversely, the Touch icon as fundamental skin feeling in the North area is the starting point of the consideration of others.

8. CONCLUSIONS

From results and discussion, we conclude that the activities of five senses is durable and that it depends upon the characteristics of the place in the fifth year students. The consistent place as the South area tends to lead the egocentric proposal with the See icon. However, the more diverse

place as the North area brings consideration of others with the fundamental feeling as a Touch icon. Such a contrastive aspect of the sensibility suggests the affinity between the place where the senses awaken and the place where the others interact.

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BIOGRAPHY

1968, Born in Kyoto. 1998, Doctor Course Graduate School, Division of Engineering, Kyoto University. Associate Professor, Doctor Eng., Graduate School of Engineering (Division of Social Environment and Space) Hiroshima University. Major Publications: *Kansei Field* (Toshindo, 2012), *Fudo in City* (Minerva, 2009), *Technique and Body* (Minerva, 2006), *The Creation and "the Architectural landscape": The religious architecture of Le Corbusier* (Chuokoron-bijutsusyuppan, 2004) (Award of Japanese Society of Kansei Engineering, 2004), etc. Main works: The modern architectural landscape of Le Corbusier, the history of peace in Hiroshima and the children's environment.

KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

The Roof Garden in Japanese Modern Architecture

From the End of World War II until 1966

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Abstract: The purpose of this paper is to clarify the architectural Kansei (sensibility) in Japan since World War II until 1966. Therefore, the authors discuss how the “roof garden,” which did not exist in Japan before then, was transplanted from European Modern to Japanese Modern architecture and how it was applied. In this paper, we adopt the following five indexes: “use,” “building type,” “material,” “structure,” and “location,” using several architectural journals. We have concentrated on the great change in roof gardens in Japanese Modern since 1954 due to the economic growth caused by exceptional procurement during the Korean War, We divided the 1945-1966 period into two parts and analyzed the change in roof gardens by comparing the gardens of each period. As a result, the transitions in the five indexes have become apparent. The roof garden after World War II has been expanding to a range from an international-style architecture seeking the universal rationality to architecture that exceeds rationality and the utilitarian. Moreover, diminishing of the “view,” which had been the subject of roof gardens in the pre-war period due to the high economic growth, has led to fumbling for new functions of the roof garden. In other words, a roof garden in Japan after World War II has been changing in various ways while being involved in the attenuation of architectural kansei (sensibility) of “view.”

Keywords: Architectural Kansei, Japanese Modern Architecture, Roof Garden, Economic Growth.

1. INTRODUCTION

1.1. Purpose

The purpose of this paper is to clarify the architectural Kansei (sensibility) in Japan since World War II until 1966. Therefore, we discuss how the “roof garden,” which did not exist in Japan until then, was transplanted from European Modern to Japanese Modern architecture and applied.

A "roof garden" is created when the ground garden that is considered to be "the external space associated with the architecture" is transferred to the uppermost part of the architecture. By providing the facility on top of the building, the roof garden is perceived in this paper as a place where a function other than maintenance is added to the roof.

We have already analyzed the Japanese roof gardens that were designed since the beginning of Meiji period (Tsukano & Sendai, 2014), the earliest stage, until the end of World War II, to clarify the transition of the roof garden before the war. In those years, the roof garden was transferred from a public purpose to a private purpose that satisfies a personal physical desire. This occurred because of the spread of RC (reinforced concrete) and the control of materials due to the Sino-Japanese war over external factors. Also, the subject of a "view", which is a look at the landscape, was revealed to be immutable.

In this paper, we will analyze comprehensively the roof gardens that were designed after World War II by focusing on all of the roof gardens that were designed during the period of 1945 to 1966.

1.2. Method

For primary documents about roof gardens in Japanese Modern architecture, we refer to the three architectural journals: *Shinkenchiku* (Shinkenchiku-sha, 1945-1966), *Journal of Architecture and Building Science* (Architectural Institute of Japan, 1946-1966) and *The international Architecture* (International Architectural Association, 1950-1966), which have been published for many years throughout the pre and post WWII periods. From these documents, we have adopted the following five indexes: “use,” “building type,” “material,” “structure,” and “location” that were relied on in the previous study. In addition, focusing the great change in roof gardens in Japanese Modern since 1954 due to the economic growth caused by the exceptional procurement during the Korean War, we divide that period into two parts and analyze the change in roof gardens by comparing those of each period. Incidentally, one of the references, *Kokusai Kenchiku,* terminated publication in mid-1967. Thus, only works completed by 1966 and which can be compared in the same generation, are examined as objects of the research for this paper.

1.3. Reviews

There are few studies that thematically analyzed roof gardens from an architectural history point of view. Perhaps, the principal contributing factor was that “architecture” and “garden” had been the main focus. The "roof garden," which was considered to be an intermediate field between “architecture” and “garden,” was covered only from the viewpoint of garden history. The term “roof garden” was first used in *Meiji Engeikai Magazine* (Japan Engeikai, 1896). From then on, it referred to the non-ground garden that was accompanied by architecture in garden history. In addition, while investigating the origin of the Japanese roof garden, documents emerged that clarify how the roof garden was introduced from Europe to Japan (Hioki, 1942)(Kondo, 2007). However, these studies do not discuss the transfiguration of the roof garden that was accompanied by modernization. Also, in conducting an historical analysis of Japanese Modern architecture, some studies have mentioned roof garden (Kondo, 2009). However, these are fragmentary discussions that focus on the specific architects who are associated with Japanese Modern architecture. Further to these studies, this paper provides a comprehensive analysis that concentrates on the evolution of the roof garden.

2. TRANSFIGURATION OF THE ROOF GARDEN

2.1. Use

Table 1: "Use" The number of works

	1945 - 1954	1955 - 1966
Rest	5	51
View	3	4
Play, Sport	4	11
Drying clothe	2	5
Theater	0	4
Arts exhibition	0	5
Other	0	8

2.1.1. Rest

The roof garden at *Shima Kanko Hotel* (Kintetsu Corporation, 1951) was provided with chairs, tables and benches for resting. As represented by *Shima Kanko Hotel*, the planning of the roof garden that was intended to be a place to rest was begun during the early 1950s, and continued thereafter. In addition, roof gardens have been expanding since 1955 as a place not only where one can rest, but also as a place to eat and drink.

"Beer tastes much better when it is drunk during nightfall on the terrace on the second floor" (Shinkenchiku, vol.2, 1959, p.65).

Furthermore, after 1960, roof gardens changed to accommodate longer rests by increasing the comfort they provided by the use of canopies and pergolas as represented by *Asama Motor Lodge* (Ebihara Architects, 1964).

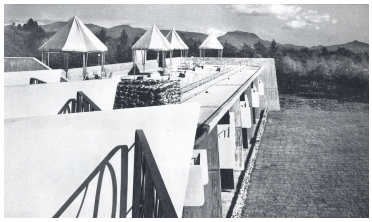

Figure 1: Asama Motor Lodge (Ebihara Architects, 1964)

2.1.2. View

Roof gardens that provide a view were first planned shortly after WWII and have been used continuously ever since. The view from the garden also was considered, such as the variety of urban scenery or of rural scenery. For example, working with a view of the city landscape from the watchtower on the roof garden was suggested for the *Tokyo KoseiNenkin Hospital* (Yamada Mamoru Architects, 1954). The view of the variety of visual objects was considered to be urban scenery and to provide the equivalent of rural scenery.

"The view from the watchtower also was the subject of a tentative proposal from the architectural aspect" (Shinkenchiku, vol.2, 1954, p.12)

However, although the roof garden that was intended as scenery continued to be planed after 1956, what was viewed from it was limited to rural scenery. There were no views of urban scenery planned

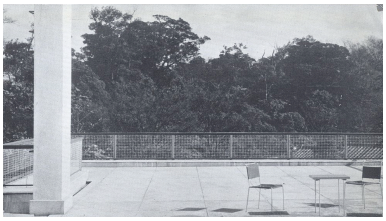

Figure 2: Iwanami House (Sutemi Horiguchi, 1958)

2.1.3. Play, Sports

The roof garden at *M Residence* (Kume Sekkei, 1951) was connected to a child's room on the top floor as a place for children to play.

"The bedroom on the second floor is quiet and bright. The balcony is large and is a place where it is fun to play" (Shinkenchiku, vol.10, 1952, p.24)

An example is *M Residence*, Planning the roof garden that was intended for play and sports began in the early 1950s. Additionally, Roof gardens intended for use as a playground and for sports continued to be planned after 1955. For example, the roof garden of *Meiji University Hall 6-7* (Sutemi Horiguchi, 1958) was used as a substitute for a sports area on the ground's surface.

"They required a roof garden for use as a sporting ground and resting area for students that is difficult to achieve at ground surface" (Shinkenchiku, vol.10, 1958, pp.27-28)

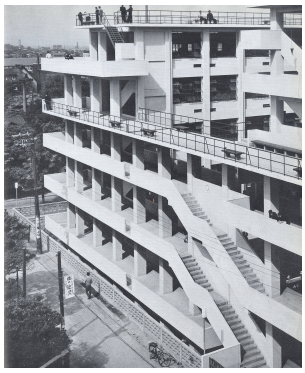

Figure 3: Meiji University Hall 6-7 (Sutemi Horiguchi, 1958)

2.1.4. Drying clothes

It may be inappropriate to bring up "drying clothes" as a theme for "use." However, an area in which to dry clothes is a new place for workers and housewives and creates an extraordinary space. Therefore, we mention it as one of the subjects.

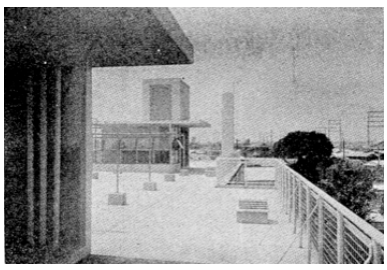

Figure 4: Inflammable Collective Houses of the Bank of Tokyo (MHD Planners, 1952)

Inflammable Collective Houses of the Bank of Tokyo (MHD Planners, 1952) is representative of places in which to dry clothes in roof gardens. They had been planned since the early 1950s. In those years and since, the number of such roof gardens that actually were established is small, although the planning of such works continued after 1956. Also, the majority of roof garden spaces

for drying clothes were planned for collective housing, where washing table, washing tanks and the frames for hanging the clothes were set up.

“We set up six common washing spaces for use as convenient spaces in which to dry clothes in the roof garden” (Journal of Architecture and Building Science, vol.1, 1952, p.36)

2.1.5. Theater

Roof garden theaters were not planned before 1954. The only exceptions is that of *Maruei Department Store* (Togo Murano, 1954), which was created for use as a rooftop playing ground that could be changed to an outdoor theater.

“Planning to create an outdoor theater in the roof garden in the future” (Shinkenchiku, vol.4, 1954, p.14)

Also, *Kaurashiki City Hall* (Kenzo Tange, 1960) created a stage setting on their roof garden with tiered bleachers and stage scenery. In this way, roof gardens that function as theaters have been constructed occasionally since 1955.

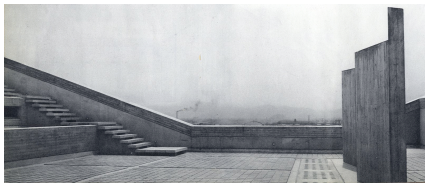

Figure 5: Kaurashiki City Hall (Kenzo Tange, 1960)

2.1.6. Art exhibitions

Roof gardens for use in art exhibitions were not planned before 1954 and used only intermittently after 1957, as was the roof garden at *Chuo Koron Building* (Yoshinobu Ashihara, 1957). In addition, roof gardens for an art exhibition represented by *Otaki town office* (Kenji Imai, 1960) and *Okayama Cultural Center* (Kunio Mayekawa, 1962) have varied gradually from simple hardens that featured only sculptures to others that have additional decorations such as benches and water towers.

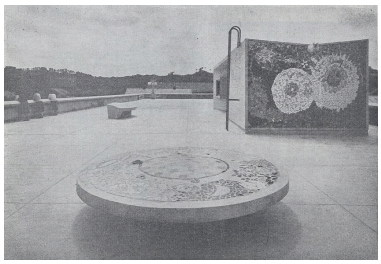

Figure 6: Otaki town office (Kenji Imai, 1960)

Furthermore, the roof garden was often created by involving a prominent artist, as was the Masayuki Nagare in T*okyo Tenri Kyokan,* which was named “garden of the sleep” (Takenaka Corporation, 1962).

2.1.7. Other

Roof gardens before 1954 were intended for either of the purposes that appear in the articles above. However, after 1955, some gardens were envisioned for transitory purposes. In a typical example, *Hisatsune Residence* (Obayashi Corporation, 1958), it was intended that the roof garden would be used until he building was extended. Consequently, only the frame was built.

“Two rooms could be extended easily” (Shinkenchiku, vol.11, 1958, p.57)

2.2. Building type

Table 2: "Building type" The number of works

	1945 - 1954	1955 - 1966
House	9	37
Collective house	8	12
School	7	19
Store, Office	8	23
Hospital	2	5
Accommodation	0	16
City hall	1	18
Other	2	38

2.2.1. House

The roof gardens on residential houses that are represented by the *Hilltop House* (MHD Planners, 1950) have become widespread since the early 1950s. Most Roof gardens on residential houses were planned as gardens that were associated the room of a one- or two-story house. Also, they were planned to be used as the buffer area between the outdoors and the indoors of an architectural structure or between rooms.

"There was a small roof garden covered with grasses and gravel utilizing a space on the second floor to soften the feeling coming of the apartment like elevation and providing a buffering gap between the bedroom and the living room on the second floor" (Shinkenchiku, vol.5, 1958, p.51)



Figure 7: Koshiro Matsumoto Residence (Junzo Sakakura, 1958)

2.2.2. Collective house

As represented by *Tokio Marine Sendagaya Apartment* (Mitsubishi Jisho, 1951) and *Yawata Iron Kouchi Apartment* (Mitsubishi Jisho, 1958), roof gardens on collective houses were begun in the early 1950s. Since then, they have become widespread. Many of the roof gardens are planned for the upper part of a three- to five-story building. In addition, extra space is created when a room that is assigned to the building's machinery, water tank, and equipment for the machinery and electricity, which are required in the collective house, is opened up as a garden that is dedicated to the residents of the house.

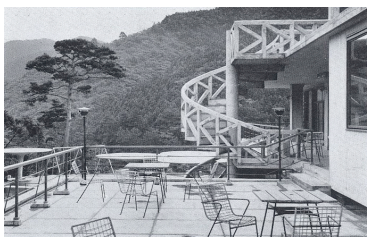

Figure 8: Yawata Iron Kouchi Apartment (Mitsubishi Jisho, 1958)

2.2.3. School

Like the example of *Joshigakuin* (Nikken Sekkei, 1951), the creation of roof gardens on schools has become widespread since the early 1950s. Before 1954, a primary task in Japan was to build a post-war society and to construct facilities that corresponded to the 6-3 system of education under the New School Education Law. Thus, many schools were constructed and roof gardens planned for use by the students and teachers. Roof gardens, as exemplified by the *Meiji University Izumi campus* (Sutemi Horiguchi, 1961) and *Futabagakuen Shizuoka* (Sutemi Horiguchi, 1964), were created mainly on top of two- to four-story buildings, with their area increasing in size as time passed.

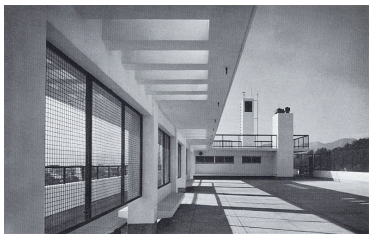

Figure 9: Futabagakuen Shizuoka (Sutemi Horiguchi, 1964)

2.2.4. Store, Office

The roof garden that is set on the upper part of the 6th floor of *Tokio Marine Building* (Mitsubishi Jisho, 1950) and the “walking roof garden” that is planned for the upper part of the third floor of *Kobe Bankers Association Building* (Nikken Sekkei, 1951) are examples of the widespread use of gardens on stores and offices. Such roof gardens have become larger and higher since 1955. The one with a flat deck above the ninth floor of the *Palace Side Building* (Nikken Sekkei, 1966) is a typical example.

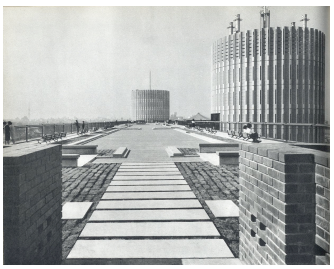

Figure 10: Palace Side Building (Nikken Sekkei, 1966)

2.2.5. Hospital

Roof gardens that have been created on hospitals have been planned since 1954. *Kanto Teishin Hospital* (Nippon Telegraph and Telephone Public Corporation, 1954) and *Tokyo KoseiNenkin Hospital* (Yamada Mamoru Architects, 1954) are examples of hospital roof gardens. Such roof gardens are set mainly in the upper part of the fourth- or fifth-story. There have been fewer, new examples since 1955. However, as represented by *Nagasaki prefectural Umabara Onsen Hospital* (Takeo Sato, 1966), the concept has found expression continuously in various heights and styles.



Figure 11: Nagasaki prefectural Umabara Onsen Hospital (Takeo Sato, 1966)

2.2.6. Accommodation

There were no plans before 1954 for a roof garden as accommodation. On the other hand, a lot of such roof gardens were planned in the 1960s, as represented by *Manraikaku* (Shindo Akashi, 1956). Many of the roof gardens planned for use as accommodations were planned as gardens for residents who lived on the upper floors from the third- to fifth-story, as represented by *Tawaraya* (Junzo Yoshimura, 1966).

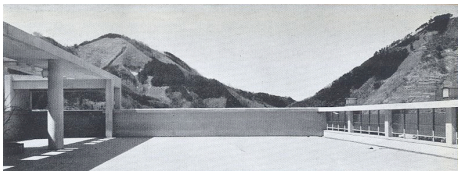

Figure 12: Manraikaku (Shindo Akashi, 1956)

2.2.7. City Hall

There were no plans before 1954 for a roof garden on a city hall. On the other hand, the public's interest in roof gardens was recognized after 1955. Consequently, planning for a roof garden at City Hall was undertaken for a full year after 1955. As represented by *Itami City Hall* (Kume Sekkei, 1955) and *Kurayoshi City Hall* (Kenzo Tange, 1957), composite roof gardens were planned at different elevations in public places so that they could be used by the citizens.

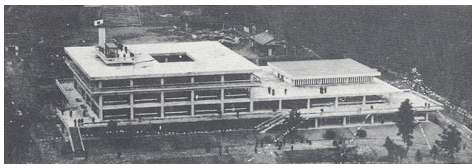

Figure 13: Kurayoshi City Hall (Kenzo Tange, 1957)

2.2.8. Other

The roof garden appear on a variety of other building types, including "community buildings," "department stores," "club houses," "libraries," and "religious facilities." However, roof gardens on other building types were not built before 1954. Planning for them took place in 1955 and later years.

2.3. Material

Table 3: "Material" The number of works

	1945 - 1954	1955 - 1966
Artificial material	37	130
Natural material	1	37

2.3.1. Artificial material

Roof gardens that use artificial materials were built throughout the period of 1945-1966. They were built in a very simple form of construction using tiles and mortar for joint finishing due mainly to material shortages. A typical example is the *Gakushuin University* (Kunio Maekawa, 1960) where the floor materials, the parapet and even the benches are made of concrete as the base material.

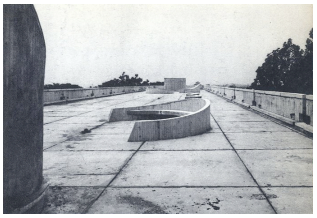

Figure 14: Gakushuin University (Kunio Maekawa, 1960)

2.3.2. Natural material

The roof gardens that use natural materials for finishing were not planned before 1954. On the other hand, from 1955 onward, we have examples that involve flowerbeds and shrubbery in a corner of the roof garden, and the planting of shrubs. *Y Residence* (Ebihara Architects, 1955) serves as an example. *Silk center* (Junzo Sakakura, 1959) and *Sakuragaoka Country Club* (Antonin Raymond, 1960) reproduce earthbound gardens on the roof that have been covered with soil and use a great deal of stone, plants and water. In addition, the roof garden of *Sumai* (Tadayoshi Fujiki, 1965) features an entire garden with wild plants. In this way, roof gardens that use natural materials have been built with increasing diversity as time has passed.



Figure 15: Sumai (Tadayoshi Fujiki, 1965)

2.4. Structure

Table 4: "Structure" The number of works

	1945 - 1954	1955 - 1966
Reinforced Concrete, Steel Reinforced Concrete, Steel	33	165
Wooden	5	2

2.4.1. Reinforced Concrete, Steel Reinforced Concrete, Steel

Given that people who experienced the terrible devastation caused by air raids were anxious to have noncombustible architecture, RC (reinforced concrete) was used immediately following the end of the war and has been used since on an ongoing basis.

"This is the first full-scale RC structure after the war" (Shinkenchiku, vol.4, 1950, p.99)

In addition, the architect made possible further verticalization of the roof garden, as represented by *Nippon Sogo Bank* (Kunio Mayekawa, 1953), by adopting SRC (steel-reinforced concrete) and an S (Steel) structure. Since 1953, almost all roof gardens have been designed with a reinforced concrete construction or the use of steel-reinforced concrete.

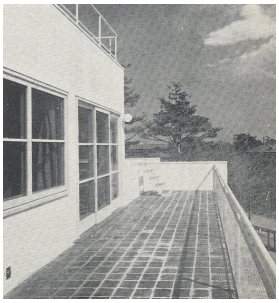

Figure 16: Hilltop House (MHD Planners, 1950)

2.4.2. Wooden

Compared to RC, it is clear that wood has less durability and resistance to moisture. However, as represented by *Sherman Residence* (Takashi Matsumoto, 1951), it can be seen that the roof gardens before 1954 were constructed of wood. Instances of roof gardens that were made of wood are mainly on houses. Why it was decided to make the house from wood may have been because of a shortage of other building materials during the period of reconstruction that followed the war. Because conventional building materials were easy to obtain after 1955, the use of wood for roof gardens was not included in the plans. In case of a *Mixed Structure House* (Masako Hayashi, 1962) that used a mixture of wood and concrete block construction, the planning of roof gardens have relied on the concrete block, but not on wood.

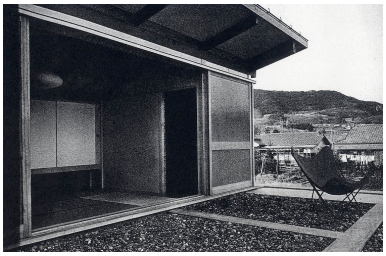

Figure 17: Mixed Structure House (Masako Hayashi, 1962)

2.5. Location

Table 5: "Location" The number of works

	1945 - 1954	1955 - 1966
Urban area	29	100
Suburb	10	69

Through the years, the roof garden has continued to be built, regardless of the urban-area/suburb. In addition, it should be noted that during the post-war reconstruction period prior to 1954, there was a relatively lower number of roof gardens constructed in the suburbs since the reconstruction of the urban areas was given priority. Roof gardens in the urban areas were planned mainly for effective utilization of the land. With the increasing number of cars due to economic growth, it is assumed that all available land will be taken by gardens and open space parking areas. On the other hand, many of the roof gardens that were built in the suburbs were built in the hope of attracting customer for commercial purposes.

3. RESULT

After analyzing the primary sources, it is clear that the number of roof gardens since 1955 is greater than the number in 1954 and the preceding years. For each of the following subjects, a trend can be seen.

Use: Roof gardens were used for practical purposes, such as "Rest," "View," "Play, Sports" and "Drying clothes" throughout the year. However, except for “view”, the uses have become more diverse since 1955, and other purposes are contemplated, such as "art exhibitions" and "theater".

Building type: Prior to 1954, the priorities for roof gardens plans were "Houses", "Collective houses," "Schools," "Stores,” and “Offices" to address the urgent need for postwar restoration, following which, there was a prominent increase in roof gardens for "Accommodation", "City hall" and "others."

Material: Prior to 1954, roof gardens were constructed with simple artificial materials. However, after 1955, natural materials, such as water, stone and various plants in soil laid underneath, were used in various forms.

Structure: As materials for reinforced concrete were prioritized for use in schools and condominiums, it was inevitable that before 1954, roof gardens on private residences and smaller offices had to be constructed on wooden roofs about which there was still concern for durability and water resistance. On the other hand, as steel and concrete became easily accessible after 1955, almost all roof gardens since have been constructed with RC or SRC.

Location: Since their invention, roof gardens have been planned without consideration to site conditions. Roof gardens in the urban areas were mainly planned to make use of the limited availability of land and to replace open squares at ground level. On the other hand, roof gardens in the suburban areas were planned to attract visitors for commercial purposes.

Table 6: Transitions of the roof garden

	1946～1954	1955～1966
Use	Rest, View, Play, Sport, Drying clothe	Rest, (View), Play, Sport, Drying clothe, Theater, Art exhibition, Other
Building Type	House, Collective house, School, Store, Office	House, Collective house, School, Store, Office, Hospital, Accommodation, City hall, Other
Material	Artificial material	Artificial material, Natural material
Structure	Reinforced Concrete, Steel Reinforced Concrete, Steel, Wooden	Reinforced Concrete, Steel Reinforced Concrete
Location	Urban area, Suburb	Urban area, Suburb

4. DISCUSSION

A direct cause of the surprising increase in the number of roof gardens after 1955 was the rapid economic growth caused by the Korean War’s special procurement that started during the end of 1954. In fact, after 1955, roof gardens architecture was often planned as a privilege for the wealthy classes in association with golf course developments, such as clubhouses, and accommodations.

The architectural effects that are absent in ground gardens are being explored for roof gardens. In short, roof gardens were planned in simple and rational forms, regardless of “location” and “structure,” since building materials were in short supply before 1954. On the other hand, roof gardens after 1955 were designed without the restrictions of “structure,” although business benefits, artistic factors and “use” were considered. As a result, “building types” and “materials” became more diverse.

Exceptionally, only the “view” on the “use” is not increased, and the case is limited to the suburbs. Because there was high economic growth, the space in the urban area became crowded with uniform buildings. Not surprisingly, the subject of urban area "view" disappeared. As a result, there were probably various requests, depending on the location. The suburban "roof garden" continues to be discussed in support for the emotion-invoking scenery in front of it. On the other hand, because the roof garden in the city has lost the battle over landscape, it has added a variety of artistic and natural materials within it.

5. CONCLUSION

The roof garden after World War II has been expanding to a range from an international-style architecture seeking the universal rationality to architecture that exceeds rationality and the utilitarian. Moreover, diminishing of the “view,” which had been the subject of roof gardens in the pre-war period due to the high economic growth, has led to fumbling for new functions of the roof garden. In other words, a roof garden in Japan after World War II has been changing in various ways while being involved in the attenuation of architectural kansei (sensibility) of “view.”

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Design urban area toward aging successfully; based on Kansei methodology

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Abstract: As globally demographic changes because of increasing life expectancy, concern about prompting greater health in old age is becoming more important. Trend shows by next three decades about 25 percent of living people are age 65 or older. Different researches has tried to define healthy aging factors objectively like 'successful aging' which divided aging well into three different components; physical health, social engagement and psychological health but when we look at this criteria subjectively there is no specific method to discover elder's psychological desires. In this paper we used Kansei theory as method to define elder's psychological needs to design built-in urban environment. As with the case for this study we choose a group of old male and female Iranian elders as participant in to understand their aesthetic, emotional, and other experiential factors which leads to design facilities and surrounding toward aging successfully and offer a framework about our target group needs, based on Kansei methodology.

Keywords: Kansei methodology, Successful aging, urban design, Iranian elders

1. INTRODUTION

Since demographic shifts internationally because of dynamics of an aging population, decreasing fertility rates, shrinking household size and growth in developed countries resulting from net immigration, more and more attention has been paid toward people who step in old age and different studies and questions addressed by gerontologist and researchers to deal with this problem to find solutions that result more respect to older adults and their environment (Colangeli, 2010). Elderly-friendly environments and equipment's toward successful aging are those designed with the elderly's physical and psychological characteristics in mind of the elderly (nakayama & morimoto, 2007). Different methods of design process have been conducted to discover real users' needs and desires especially in psychological background and Kansei engineering is one of the most successful ones. Kansei Engineering is a technology that translates user's psychological feeling into design specifications (Nagamachi, 2008). In design based on Kansei, qualitative information which is gained by interview and observation will be translated to quantitative information.

The purpose of this paper is to explore criteria of successful aging in urban public spaces base on

Kansei engineering methodology. First three aspects of physical, psychological and social defined and detailed then to address the importance characteristic of each mentioned context, Kansei engineering methodology applied.

2. DEFINITION OF SUCCESSFUL AGING

2.1. Objective and subjective definition of successful aging

The term 'success' in gerontology has generally been tied to the ability of health care providers to treat illness and disease and restore functioning that is developed by Rowe and Kahn (1997) into the most popular model in aging studies which titled was as 'successful aging'. They define idea of successful aging as a low probability of disease and disease-related disability, high cognitive and physical functioning and active engagement with life (Figure1). They belief "successful aging is more than absence of disease, important though that is, and more than the maintenance of functional capacities, important as it is. Both are important components of successful aging, but it is their combination with active engagement with life that represents the concept of successful aging most fully". Additional meanings emerging from the concept of 'success' includes; positive functioning or psychological well-being (Morgan, et al., 1991; Sullivan & Fisher, 1994), physical and mental health (Meeks & Murrell, 2001), cognitive growth potential (Stern & Cartensen, 2000), high quality of life (Yoon, 1996), high life satisfaction (Meeks & Murrell, 2001), adaptation to life changes(Abraham & Hansson, 1995), and social integration (Seeman et al, 1995).

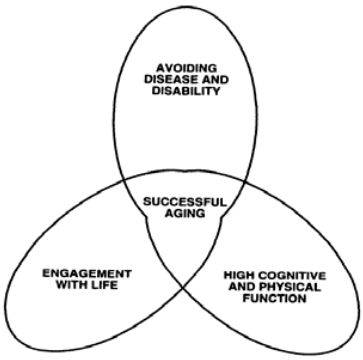


Figure 1: A model of successful aging (Row & Kahn. 1997)

Existing models of successful aging have each received criticism for not fully recognizing the multidimensionality of the concept and not considering the influence of broader social structures including the allocation of resources and opportunities, cultural contexts, and norms and behavioral expectations (Ryff & Singer, 2009). Jordan (2010) believes; "the current successful aging model of Row and Kahn(1987) was developed by non-elders and non-minorities, but it has been applied to the elderly population as well as minority elders; as a result, this model does not take into consideration the unique characteristics and circumstances of ethnic minority elders"(Jordan,2010). Strawbridge and Wallhagen (2003) have criticized current conceptualizations for their failure to acknowledge and incorporate layperson perceptions and experiences of successful aging. For example, In a study by von Faber and colleagues (2001), 81.5% of the subset of participants who took part in the qualitative interview felt they were aging successfully however, only 10% met the researcher's criteria of successful aging defined as a state of optimal overall functioning (physical, social, psycho-cognitive) and well-being. Participants generally viewed success as a process of

adaptation, valuing well-being and social functioning more than physical and psycho-cognitive functioning (von Faber et al, 2001). Subjective measures of successful ageing are lay views, or those which are defined by older individuals themselves (Farina, 2009). Advocates of subjective measures argue that objective criteria fail to incorporate older individual's views of how successful ageing should be classified (Hilton, Kopera-Frye, & Krave, 2009). A subjective rating was most commonly obtained using a ten-point Likert scale ranging from least successful to most successful (Vahia et al., 2010). Most important elements that have been identified subjectively by older adults themselves include: longevity, absence of disease, freedom from disability, independent functioning, good cognitive functioning, life satisfaction/well-being, mastery/growth, positive adaptation, personality traits, social/productive engagement and environmental factors (Phelan & Larson, 2002).

2.2. Aging successfully and environment

2.2.1 Ecological model of aging

The outdoor environment offers great opportunities for older people to be physically active, to have contact with nature and to meet with friends and neighbors (Sugiyama, W. Thompson. 2005). To expand the importance of perspectives in the field of the ecological and environmental factors on successful aging and well-being Lawton and Nahemow's (1973) suggested the Ecological Model or competence-press model that is based on three concepts dealing with persons, environments, and the relationship of the two (figure 2).

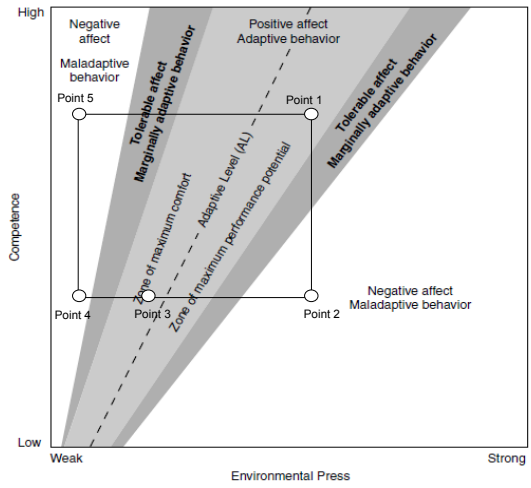


Figure 2: Lawton and Nahemow's Press-Competence Model

In competence-press model the ability of a person to function independently is represented by the vertical axis (competence) which includes physical, mental weakness and includes physical and emotional qualities. The degree of difficulty associated with the built environment (Environmental Press) is represented by the horizontal axis. As a person deals with changes he or she can take different positions in the ecological model. Point1 shows a position of satisfying the match between the press of environment and personal competency. Point 2 shows a position of a less satisfying match between the same environment and personal competency (less independence due to illness or some accidents). Point 3 shows a position with lower press from the environment (which is a different place where more assistance is provided). Point 4 shows a position where the environment

is providing too much care (nursery, hospital, etc.). Back to the level of functional competence (convalescence from an accident or an illness), a person can pass to point 5, providing low environmental press. When this low press becomes unsatisfactory, the person can move back to point 1 (Regnier and O. Byerts, 1983).

Further studies by considering the ecological model, emphasize the important role of urban environments on older people overall health. Bowling et al. beliefs elder's engage with outdoor environments from three different types of process; (1) participation in outdoor Physical activity, (2) exposure to outdoor natural elements and (3) social interaction with friends and neighbors in outdoor places (Bowling et al, 2003). In the dimension of social environment, the urban area furnished the elderly with abundant activities and brought a positive influence on their mental and cognitive health. In the dimension of physical environment, urban areas supplied distinct types of leisure facilities and equipment, which influenced the elderly's physical, mental and cognitive health, and their social relationships. Finally, in terms of the natural environment, the surroundings improve the relationship and coherence between peers (Lin and sakiuno, 2012).

3. KANSEI ENGINEERING

Different methodologies have been developed to integrate emotional/intangible/inexplicit needs into product concept design among these methodologies; *Kansei Engineering* (KE) is that using a strong-structured process for analyzing unexpressed and unconscious needs of consumers and for translating such needs into the design domain (Nagamachi, 2008). According to Nagamachi, "*Kansei is the impression somebody gets from a certain artefact, environment or situation using all her/his senses of sight, hearing, feeling, smell, taste as well as their recognition*" (Nagamachi and Matsubara 1997).

3.1. Overview of definitions of Kansei

Akira Harada who was firstly tried to define concept of Kansei in 1998 (Harada 1998). Looking for a comprehensive definition of *Kansei*, Harada collected definition of the word *Kansei* provided by about60 researchers involved in the research related to *Kansei*, and analyzed the responses statistically. Figure 3 shows the resulting graph of the cluster analysis made on the keywords output from researchers' answers.

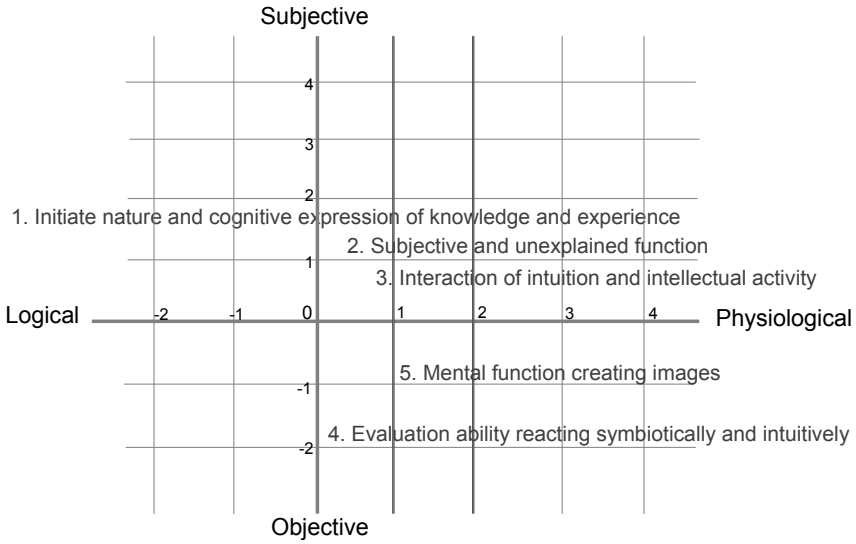


Figure 3: Scatter Graph of Keywords of *Kansei* definition (Harada 1998)

The axis X (axis 1) is interpreted as a logical-psychological axis and the axis Y (axis 2) as a subjective-objective axis. This proposition shows a multi-dimensionality of *Kansei* and is composed of multiple elements such as 'subjectivity', 'expression of the inner (knowledge and experience)', 'intuition and intelligent activity', 'reacting toward external stimuli', 'reflective images'. According to Harada, *Kansei is an internal process (a high function) of the brain, involved in the construct ion of intuitive react ion to external stimuli* (Lévy, Lee and Yamanaka, 2007). Harada (2003); proposed to describe kansei as "an internal process (a high function) of the brain, involved in the construction of intuitive reaction to external stimuli." During the same period, Nagamachi (2006) describes kansei as an "individual's subjective impression from a certain artifact, environment, or situation using all the senses of sight, hearing, feeling, smell, taste as well as recognition." While Harada describes kansei as a process, Nagamachi describes kansei as a result of this process. *Harada* goes further to list three major characteristics of *Kansei* as; 1) human expression based on added knowledge and experience to inborn dispositions; 2) the ability to react to and evaluate external stimuli intuitively; and 3) the interaction of intuition and intelligent activity (Harada, 1998).

4.METHODOLOGY

The research method has been designed in order to provide environmental paradigm which governs the value of public space from the perspective of elderly people in Tehran for participation, being active and social interaction. The population for this study included all residence aged 65 and older who participated in public places in Tehran.

To collecting require data Totally 20 elders were asked to participate in questionnaire to evaluate the importance of each kansei words in the process of design urban environments and inside equipment's. The experiment was conducted in three central parks of Tehran (Laleh, daneshjo and Honarmadan Park) where the population of elderlies is noticeable.Data for this research was collected during 1month, from middle of December 2013 until January 2014.

The procedure to assess environmental emotional quality by KE in this research schematized into five different phases; (1) Exploration of the physical, psychological and social properties dimensions of urban environment to identify appropriate kansei words; after few filtering in this research, 30 kansei words are collected toward define cognitive and emotional bond between users and the environment under study, (2) Construct of five-point SD (semantic differentials) scale is constructed to evaluation the importance of each word, (3) Collection of users' impression according to the identified words in first phase, (4) Analysis of the collected data for predicting how strong the different environmental elements are related to the users' emotional response; and (5) Definition of the new outdoor environment development strategy according to the results of the analysis made in phase4.

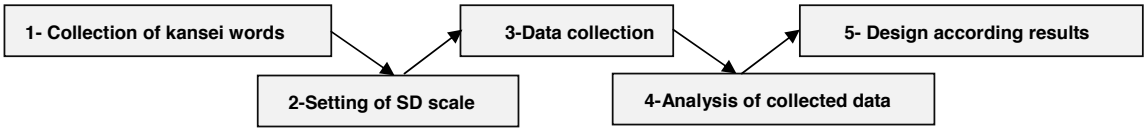


Figure 3: Flow of kansei methodology used in research

The 5-point constructed SD Scale was included 30 kansei words in total as shown in Table 1, which divided into 3 aspects of physical, psychological and social dimensions. Selection of these

words was according to importance and repetition of them in earlier research in the field of design and successful aging.

Table 1: List of Kansei words for SD scale

Physical dimensions	Psychological dimensions	Social dimensions
Barrier-free	Pleasure	Collaborative
Flexibility	Understandable	Encouraging
Accessibility	Natural	Democratic
Dynamic	Informal	Friendly
Supportive	Attraction	Competitive
Simplicity	Modern	Respectfully
Functional	Security	Unity
Masculine	Lively	Inviting
Fun objects	Relaxation	Controlled
Curved	Symbolic	Arranged

In exploring these words behaviors and activities of elderly in urban public spaces have been affected. These words were explained in such a way that firstly the elderly be familiar with them secondly in elder mind, significant mental image of these words exist.

5.RESULTS AND DISSCUSION

Demographic characteristics of participant in this study were evaluated with the Microsoft office excel 2010 software. In this study 35% of participants were women and 65% were men. Also 45% of sample were aged lower than 65 years, 40% between 65 – 75 years and 15% were 75 years and older.

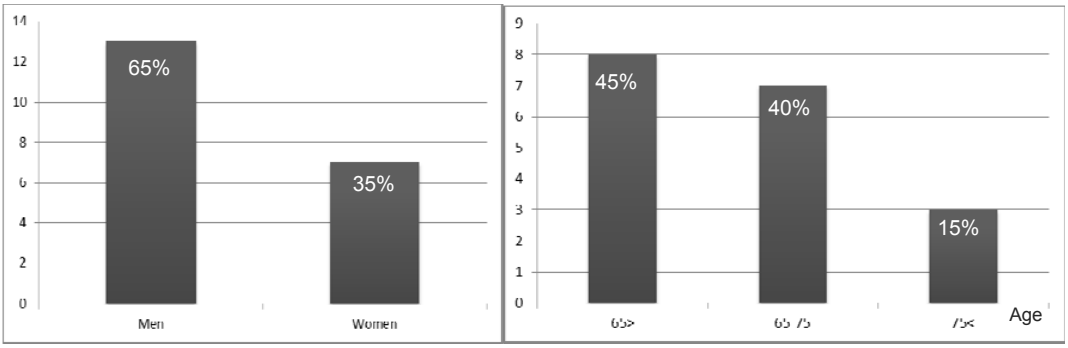
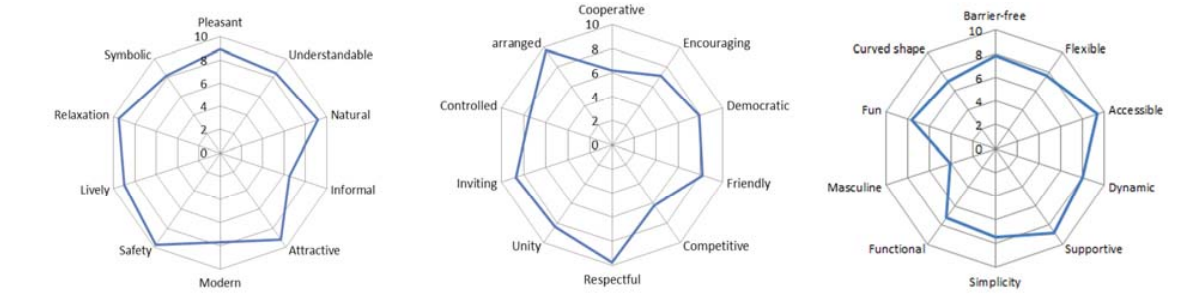


Figure 3: Demographic evaluation of Elders participant in research

The success of KE is mainly due to its systematic procedure by which it is possible to determine the “quantitative” relationships between users’ emotions and feelings of and product elements (Nagamachi, 1995). In this research by categorize the quantitative expression of elder’s feeling about urban environment in three columns of physical, psychological and social we aimed to

understand importance of components of each group. After collecting data from interviews all data were entered in Excel and then scoring and weighting of each factor which showed in the final result. Due to analysis of social keywords related to success of elders respectful treating, arranged and inviting environments are most important. For physical dimension we found several factors in same level of importance but factors like accessibility in use, being supportive were more bold and finally most relative dimension toward psychological dimension were feeling relaxation, safety and natural. In figure 4 the importance of each factor toward participation rate of elderly in urban green places of Tehran have been shown.



Psychological KE words toward successful aging | Social KE words toward successful aging | Physical KE words toward successful aging

Figure 4: Kansei words related toward aging successfully in urban area

According to the results of research from mentioned 30 Kansei words toward aging successfully we arranged 16 of them from all categories as the most important factors that received point 8 from total number of 10 (table 2).

Table 2: List of 16 selected Kansei words for aging successfully in urban green places

Selected Kansei words	Value	Description
1- Safety	9.8	Urban spaces should have the condition of freedom from danger, risk, or injury
2- Respectful	9.7	Environments should characterize by or showing politeness or deference
3- Arranged	9.7	facilities in parks should planned toward specific order
4- Relaxation	9.5	Details should design for Refreshment of body or mind
5- Accessible	9.4	Urban space should be easy to approach, enter, use, or understand
6- Natural	9.2	Facilities should being related in, or produced by nature
7- Attractive	9.2	spaces should appeal to the senses or mind through beauty, form, character
8- Lively	9	Public space should be full of life or vigor
9- Pleasant	8.9	Environments should be toward elders enjoyment and agreeable
10- Supportive	8.8	Equipment's should Furnished to support or assistance
11- Inviting	8.7	The Attractiveness of the urban place should be significant
12- Understandable	8.5	Spaces should be Expected or accepted under the circumstances
13- Unity	8.4	harmony or concord between different details of urban area
14- Friendly	8.2	Urban environments should be warm and comfort
15- Symbolic	8.2	Using symbolism in design urban details

16- Dynamic	8	Urban places should concerned with energy or forces that produce motion

7.CONCLUSION

Aging is a phenomena in new days and make a lot of challenges for society. For increasing quality of life in the society, we have to work on successful aging. One of the best ways to understanding about users' feelings is kansei methodology. In this study Kansei Engineering was used to recognize elder users' needs toward successful aging in public urban spaces and applying these needs to environmental properties. According to the study and findings seems, recognition and understanding of elders needs in urban places and trying to response these needs and respecting their preferences in the design and optimization of urban public space can be improve the quality of life and life expectancy of elders which contributes successful aging for them. The result of the study showed that from the elders people viewpoint totally 16 characteristics of urban public places were most important to experience successful aging from 30KE words that firstly were selected.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Desire, Space and Technology:

Communications Technologies as Articulators of Design for Urban Space

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Abstract: The current paper presents design of urban public space as a problem framed by experience affordance. We proceed analytically. First, we note that people harbor and approach desires. Next, we observe that people inhabit space and their desires are enacted in space. We claim that urban public spaces are sites that afford realization of desires. Urban spaces, however, do present their own contradictions. In particular, we identify walls as capable of fragmenting space and the experience of space. We partially deconstruct walls and look for points of rupture, penetration and transcendence. Then we seek strategies for exploiting these in affordances of transcendence prompted by communications technologies. Our objective is to contribute to discourses surrounding human inhabitation of urban spaces and those concerned with adding value to the experience of inhabitation.

Keywords: Desire, boundaries/limits[1], communications technologies, public space, urban space.

1. INTRODUCTION

1.1. A phenomenology of leisure

The narrative of urban experience can be framed in terms of the concept of leisure. There is instrumentality[2] in conceptualizing urban experience as a leisure experience. To those not invested in the subject, this might seem extraordinary (or mystifying). So we begin by way of explanation.

[1] In the case of this paper, we will use "limit" in a mundane sense (as equivalent to boundary) and not as in the more intricate conceptualization presented by Cilliers (2002): as knowable from one side.

[2] This, of course, is instrumentality of the act of conceptualizing. True leisure itself is largely considered, in one school of thought, as autotelic.

Leisure is to be conceptualized as a phenomenon that catalyzes, structures and qualifies a way of dwelling[3]--including actualizing personal dimensions of self, enacting relations with others and taking possession of the way space is inhabited. In the first instance, it is about an "intrinsic state" (Cohen, 2008, p. 2) as the modulator of daily experience. This perspective is grounded upon a long, stable tradition of leisure--the *classical ideal*--as a state of being ([de] Grazia, 1962). In the Aristotelian perspective, the route to happiness courses through leisure. The ideal life has leisure as a defining characteristic at its centre. Self-exploration and fulfilment, among other things--in personal or social contexts--become *dimension-able* under the leisure construct. With realization of self-in-the-world tied to an internal state, the ideal is readily deployable to examining all facets of life in which personal experience is involved (Cohen, 2008). Indeed, it has been argued that it is not an activity (form or context, per se) that is as defining as quality of the experience (Kelly, 1981).

In terms of the social dimension, Kelly (1981) has argued for some measure of intrinsic meaning that is socially-sourced in leisure experience. Leisure is a social space within which a dialectical balance of social interaction emerges: "In a social ecology characterized by considerable fragmentation and dispersion," wrote Kelly, "leisure becomes a necessary social space for the location, development, and enrichment of primary relationships" (p. 307).

It is this state of being while *dwelling* in the city that informs our perspective in this paper. In the following pages, having established leisure as an underlying construct and articulator of desire, we will next present a critique of the urban context and finally propose a mediative mechanism (in form of affordances patent in peripatetic technologies) for contouring the problem of space design.

1.2. Leisure and its desires

In order to investigate leisure, it is useful to identify some of its defining dimensions (or, here, desires).[4]

Harris (2009) has presented leisure as a set of *arguments*. These arguments situate the discourse of leisure in contemporary dialogues, are interdisciplinary in nature and bracket experience and cultural parameters as articulators of leisure. The arguments range from pleasure and escape to narratives and values. Harris essentially enables the argument that city planners, builders and institutions are creating affordances for experiences of city inhabitation such as shopping, going to “fast foods” or visiting theme parks and these latter represent “meaning-oriented [activities] with pleasures of [their] own” (Harris, 2009, p. 237).

Shaw (1985), by way of a time-diary study, established perceptual dimensions of leisure that include, among others, enjoyment, relaxation, freedom (of choice), motivation, self-evaluation[5] and satisfaction, but also personal development/growth/creativity, spontaneity and social interaction. All these were associated with activities or events.

Thus, experience, desire, self and social context collide complementarily in living a leisure-mediated life in the metropolis. Urban space, argued Stevens (2007), is a product of instrumental function, social reproduction and a "diverse scope of...desires that comprise everyday

[3] In a Heideggerian sense

[4] Its long history of definitions includes, to name a relevant few, a state of being, state of mind, an existential condition and a qualitative form of experience (Goodale & Godbey, 1988, (de) Grazia, 1962; Iso-Ahola, 1976; Kelly, 1981; Kleiber, 1999; Neulinger, 1974; Witt & Ellis, 1985).

[5] This is to be understood as the *absence* of inhibitive self-evaluation. It could imply easier space for creativity.

urban life" (p. 217).

1.3. Spatialization of desire

When we observe people in action, wrote Stevens (2007), we recognize desire, needs, personal growth, freedom are "not just abstract ideals...[but] social experiences constituted through practices" and to which shapes are given by public spaces (p.197). There is a dialectical relationship between human psychic drives and space. People develop/desire and produce meanings; spaces provide affordances to reify those meanings (p. 206). Public spaces enable "integration of...desire into rational everyday practices" (p. 75) and humans harness "the environment to [explore/satisfy] their desires" (p. 193).

It can be concluded, then, that "human desires [are] collected together in...public spaces" (Stevens, 2007, p. 193): personal development, relaxation, escape from normal bodily experience, engaging strangers, risk, thrill, testing bodily limits, destruction, disorder, creativity, ecstasy, freedom, etc. The city is "a site for multiplicitous practices of desire" (p.9). Those desires are awakened and pursued within spaces granted by the city (Stevens, 2007).

1.4. Paper task

The current paper will reconsider experience in the metropolis within a geography of a phenomenology of leisure. As has been made clear above, this is not anymore simply about leisure as residual engagement or amusement, but of an excursion into a more substantial, pervading *constituting* of human experience. "What leisure offers is the charm of fulfilment which the density of everyday life negates," wrote Rojek (1995, p. 124).[6] We consider what we might term, to borrow from Stavrides (2010)--but in a dimensionally less-monumental way--an "emancipatory potential of existing, emergent or possible" urban space (p. 11). We see all this as not contained, however, only by person-delimited engagements, but constituted through multiple social intercourses as well. It is essential, wrote Stavrides, to conceptualize spatialities that have potential to facilitate social relations.

In this project, we view design of the physical environment not necessarily as *creating* the leisure experience for individuals, but as a critical supplementary system: supporting/facilitating, awaking, instigating, highlighting, enhancing. The task is to map a path which connects ideal and form via a mediating mechanism. It will be less about spaces-as-finished, but more about recognizing performative dimensions that give rise to or constitute their evolution into experience actuators.

We will re-engage the metropolis through a lens of leisure as a structure which is quiet in mediation but eminent in goal. We will present the frame (desire in urban space), provide a critical view of the context (metropolis), isolate one of the environmental problems, deconstruct that problem and provide a mediative mechanism that links deconstructed problem with goal. As an additional step, we shall end with illustration of an evolving design language notebook. It is possible for a designer to create different design language scripts based on a chosen trope, frame, design concept, or any other inaugurator of design. In this paper, we have used communications technologies. All the foregoing will be carried out relatively briefly, in the interest of space.

A delimitation is essential. Some parts of this investigation of the urban context are deliberately scaled at the unit level of the inhabited urban, public building and/or small space. The urban

[6] Rojek (1995) added: "That this charm is actually symbolically connotated rather than directly experienced" does not disaffirm this dimension of the phenomenology of leisure (p. 124).

context is constituted of repetitions of such units[7] and it is pragmatic to include investigation at that relevant level as well.

2. VISIONS OF THE METROPOLIS

2.1. Visions of pleasure, displeasure, transcendence

2.1.1. City as ideal problem: Visions of beauty

The city is a beautiful place. In it can be found opportunities for constitutives or ideals of what may be considered beautiful. Vitruvius proposed *venustas* ("visual quality...that would arouse the emotion of love")--alongside *firmitas* and *utilitas*--as a desirable dimension of building (Britannica, n.d.).[8] Alberti (1988) found beauty--a "most noble" goal (p. 155)--revealed through *concinnitas* (archetypally, proportion--Tavernor, 1998). Moralists such as Pugin (Taylor, 2000), Ruskin (1961) and Scott (1974) have linked aesthetics and ethics, connected building with function and evocation of feelings. Sitte (Collins & Collins, 2006) signified a beautiful city in meticulously-created relationships between parts. Rossi (1982) found the soul of the city in memory and artifact/monument. In these and many other ways, what is beautiful about the city has been *thickly* codified. The built environment of the city, affording all these ideals, promises richness of human experience.

2.1.2. City as pragmatic problem

The city, however, is not all beautiful. It harbors/embeds such ills as alienation, individualism, congestion, and injustice--which, de-Shalit (2003) claimed, might partly be sourced in architecture of the city. Simmel (1969/1950) expounded on "the threatening currents" of the environment of the metropolis (p. 48). Such discontent has led to a social history of critical analyses and pragmatic intentions about the city. The range of thinkers--not necessarily always all in agreement--have advocated for cities that are planned not just on how they look, to borrow from Jane Jacobs (1961), but much on how they work. The city is said to work through existence of ordinary urban places where a “complex weave of meanings” is generated (Curtis, 1996, p. 562). Significant groups weighed in. The influential 20th century alliance, CIAM (*Congrès Internationaux d’Architecture Moderne*), advocated creation of “a physical environment that will satisfy [the human’s] emotional and material needs” (Frampton, 1992, pp. 269-270). Its *Charter of Athens* stated that it is the function of cities to shelter humans well (Conrads, 1997).

These visions may well be summed up in insights offered by Lewis Mumford. Fundamentally, Mumford saw the city as an organic concretization of culture and how people express their aspirations through living collectively (Donskis, 1996; Lybeck, 2010). According to Donskis, Mumford’s solution to the city is reflected in Candide’s call to “cultivate our garden”: a pragmatic call to do right with the things we have, rather than lust after what might be hard to justify in terms of attainability.[9] For Mumford, a holistic consideration of the person in the city mattered. An “architectural embodiment of the modern city" is not possible until, among others, "biological, social, and personal needs have been canvassed" and all of the activities of humans in the city have been

[7] As is to be expected, a constellation of units, which forms the metropolis, does possess its own emergent characteristics beyond mere addition of those units. Inhabitation of space in the urban context, however, is localized and is necessarily investigatable at different degrees of molecularity.

[8] Also see Vitruvius, 1960

[9] Mumford, rather than aim for utopia (the impossible), aimed for eutopia, or “the good place,” even though the solution offered by the latter might be just partial (Donskis, 1996).

integrated with the context into a balanced whole (Donskis, 1996, paragraph 55).

2.1.3. On utopian, innovative and deconstructive insights

The same social history has also offered solutions that have been, in different ways, described as Utopian: from the land-avowing (e.g. Wright and Broadacre [Dehaene, 2002; Ganjavie, 2012], Corbusier and Ville Radieuse [(Le) Corbusier, 1964, 1971; Ganjavie, 2012; Hatuka & D'Hooghe, 2007) to the unabashedly machine-informed and futuristic (e.g. Archigram [Vidler, 2003], Metabolists [Lin, 2007, 2011]). While utopian visions have been criticized by some, others have argued against pure practicality as the sole driving force behind conceptualization of cities or urban settings.

Hatuka and D'Hooghe (2007) argued that the focus of planning today (i.e. after post-modern critical discourses of the 1960s and 70s silenced the ideal visions of modernism) is near-entirely based on the concrete and pragmatic and that has dissociated planning professions from important universal questions. While holding that there is distinction (following Ernst Bloch) between abstract utopias which are not embedded in reality and concrete utopias that are framed around the possible, they advanced the side of the argument among theorists who see utopian promise as a prerequisite for change in society, that ideal visions constitute an "essential catalyst" for social development (p. 21). We accept the viewpoint that visionary and ideal-driven conceptualizations are useful for extending formulations of our solutions to problems of the inhabited environment.

In the interest of space, we move quickly past utopian projects and identify a critical lesson sourced in late 20th/early 21st century criticism, in deconstruction. We draw upon the work of one of its exponents.

In *The Manhattan Transcripts* Tschumi (1994) conceived of city space as a stage where events are witnessed in a complex space-use relationship. Architecture is judged, not by functional standards, but by a narrative of inhabitation. *Possibility* becomes a lesson as experience is granted potential through interactive affordances. In the *Transcripts*, new "relations and structures" (p. 11) are revealed, physical dimensions change, "reality is made malleable" and all these enable "emotive, dramatic, or poetic attributes" of space, use and experience to unfold (p. 12).

Tschumi (2000) continued the project in *Parc de la Villette*. He suggested that a program which traverses the landscape (e.g. as is a city) can be realized in design as a distribution of intensity points deployed across that landscape. Instead of conceiving only of forms, one could think about forces, instead of places, flows that occur there; voids can become in-betweens (p. 12). In designing, one makes efforts to "uncover potentialities" that are hidden in program, site and circumstances (p. 11). Such contexting and conceptualizing go hand-in-hand (Tschumi, 2004). Each can be used to define the other. Thus context (as potential) is not a given or a fact, but "a matter of interpretation" (p. 12). Tschumi (2004) saw architecture as not necessarily about forms, but about interrogation of concepts "and their subsequent materialization" (p. 15).

Hatuka and D'Hooghe (2007) have written that visionary thinking adds value by providing us with an opportunity to invent new ideas and formal expressions for structuring our cities. We are able to create an alternative awareness, a critique of how we inhabit our spaces, a revision of our spatial constructs and configurations. We bring the foregoing background thinking into our evaluation of walls within the city.

3. THE [MUNDANE] PROBLEM OF WALLS

One central lesson that emerges from the deconstructive standpoint may be deployed diagramatically:

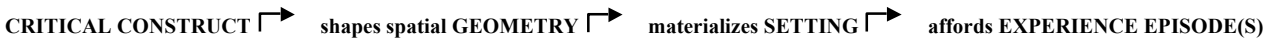

Figure 1: Construct-experience determination path

The last facet of the profile above, *episodes of experience*, symbolizes actualization of a social contract about (facilitating) people's experience in (or of) city space.

Critical thinking, as noted, instigates an alternative awareness and critique of our spatial constructs/configurations and inhabitation. In our own particular deconstruction, we recognized space inhabitation in the urban context as fragmented by pervasiveness of *walls*. Elegance of spatial harmony and nobleness of its continuity are shattered in the city by *walls*, many walls. In the city, walls constitute one of the classic and most ubiquitous delimiters of space and, consequently, "fragmenters" of experience. Often taken for granted, we interrogate walls in the city.

3.1. Critique of walls

In order to slow down or partially counter erosion and impoverishment of human experience in the metropolis, the designer must take on some challenges. One of them is the challenge of the wall.

Walls, Brighenti (2009b) observed, are known as "symbols of segregation, containment [and] division" (p. 63).[10] Walls fragment space, experience, social relations and harmoniousness of urban dwelling. Stavrides (2010) has noted about partitioned space[11] that, experienced from one side (the outside), what is on the other side is seen as an exception; from the obverse (the inside), it is experienced as a secluded world. Thus our fabricated enclaves within the metropolis, while "spatially embedded" in the city, are also "contractually outside" (p. 35). Walls, wrote Brighenti (2009a) possess an "exclusionist attitude" (p. 18). As much as--metaphorically--one is unaware of what is behind them, they have potential of insinuating such *cancers* as dangerisation (perception of threat potential) and periopticity (autonomously-induced resistance of the other), among other things (Brighenti, 2009b, pp. 67-68).

Walls do more. Beyond being an element of the "optic organisation of the city," (Brighenti, 2009a, p. 17), walls resist experience by resisting bodies. Walls "define flows of circulation, set paths and trajectories for people and, consequently, determine the possibilities and impossibilities of encounters" (Brighenti, 2009b, p. 65)--and in that, their potential impact on emotion sourced in social encounter cannot be completely disregarded. The "undeniable" repercussion of walls, wrote Brighenti, is that "they impact directly on bodies" and "on the materiality of the social" (p. 64). The fragmentation they institute, the "mobility fluxes" they mangle (2009b, p. 69), may be argued to create, to adapt Brighenti (2009a), a *triage* of experience.

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[10] It should be noted that Brighenti (and in other sections of the cited volume) made note that walls could also, in instances, "connect the separate" (p. 63). Those instances, however, do not nearly erase fragmentation effects.

[11] Enclaves

The indomitable materiality and pervasiveness[12] of walls grants them the power to "deliver a sort of constant 'public address'" (Iveson in Brighenti, 2009b, p. 65)--one about separation. Unfortunately, a partitioned city, wrote Stavrides (2010) destroys "the public character of public space" (p. 26). So, in defiance of walls, we minded Simmel's observation that the human is not only a bordering creature, but also "[a] creature who has no border" (in Stavrides, 2010, p. 14).[13]

3.2. Deconstructing walls

Consequently, we deconstructed walls. We searched for points of weakness. We probed for points of rupture, penetration and transcendence of their materiality. In Table 1, we present some of these.

Table 1: Basic descriptions of wall systems

Element of physical environment	**Basic description**
A. Wall: material systems	
Solid envelope/ divider	Substantive wall system; this is what is ruptured by the systems that follow below
Transparent envelope /divider	System here includes glazed and some partially porous walls
Hybridized envelope	Wall of a unit integrated with that of another [phenomenally-blurred boundaries]
B. Wall breach systems	
Entry/door	Wall opening for access
Aisle	A spatial element which separates or divides entities [Supplementary note: As a system that separates, it is a dematerialized wall. Due to its higher order capacity to subvert the defiant wall, however, we place it under the wall breach system.]
Ambulatory	A system to be considered as a peripheral aisle
Foyer/lobby	Classified as an extended breach in the wall [Supplementary note: The traveler has not yet completed traversing the wall, has yet to cross into the sanctum.]
Vestibule	Special case of foyer/lobby
Bridge	A system which enables interconnections between two other systems. [Supplementary note: We identify this as a system of which one of its primary functions is circulation.]

[12] Proliferation of walls may be even greater. Brighenti (2009b) suggested that movable surfaces such as trains also constitute walls.

[13] For creation of a border, expounded Simmel, also contains the "possibility...of stepping out of [the] limitation into freedom" (in Stavrides, 2010, p. 14).

Table 1: Basic descriptions of wall systems (continued)

Element of physical environment	Basic description
Court/cloister	[Interior court]: categorized as a system in wall which, if it were removed, what would be left would be a wall separating two spaces; so, it could be seen as a void inside a massive wall
Telescoped skin	Distal satellite unit(s) of a central body; as with interior court, a hyper-extended void--and that extended void could be considered notionally as ignorable if the primary program that spans it was seen as un-fragmented [Supplementary note: Programmatically strongly linked to the nucleus campus, it is just a distal envelope.]
C. Wall auratic systems	
Porch/patio/terrace	Spatial system adjoining a wall [Supplementary note: One way to visualize porch would be, in symmetry with foyer, a wall breach on the outside. An alternative interpretation, however--and the one chosen here--is as a wall-induced/dependent space. Unlike a foyer/lobby whose function is likely to be related to the inner spatial program, the porch does not have to be, directly--as when it is construed as a *patio/terrace* serving a complementary function (e.g. a cafe).]
Ascribed skin	A phenomenally-read extension of boundary which surrounds or defines presence of a system
Threshold	A spatial *value* which delineates or encompasses another spatial element [Accessory note: This is a pervasive spatial system and one of eminent complexity. It is discussed in a different paper]

4. A METAPHOR FOR LIMIT TRANSCENDENCE

4.1. Generative lessons of communications technologies

In a program of transcendence of limits, we look at an *other* paradigm. A metaphor encourages us. Communications and mobile technologies, for instance, offer *counsel* that we can penetrate and extend beyond boundaries. Kim (2009) observed that "spatial divisions of urban life are overcome by...boundary-crossing, mobile communication technologies." Consequently, our "organizing principles of social spaces are moving from enclosure and containment to connection and distribution" (p. 353). There is a sense of unboundedness (Schwartz, 2000). We have unlocked a code that grants crossing borders; we have entered a *passageway* (Schwartz, 2000). Space (postmodern) in the age of communicative technology is mobile and flexible (Rojek, 1995). Some constructs of transcendence are presented below.

1. *Location awareness*. Mobile technologies enable location awareness (Licoppe & Inada, 2009). We extend location awareness to include functionalities of locative media. According to Bleecker, locative media can delve into "the historical surface of a space to reveal past events or stories" (Locative media, n.d.). Location aware technologies enable "a new type of relationship between experiences of place and space" (Licoppe & Inada, 2008, pp. 6-7). They engender hybrid ecologies, presenting an opportunity to enrich life in the urban context (Licoppe & Inada, 2008). Metaphorically, location awareness as we have used it signals that a person is spatially located, but also transcends that point in the time-space compact. We include

capacity to engage current location in a mesh of relations and other flows in the city. The result is an interactive city, one which "[augments] personal territories" (Licoppe & Inada, 2009, p. 7),

2. *Mobility*. Mobile technologies foster relocation within space. Mobility is about movement and also about continuity of one's engagement across different spaces. It involves "fluid transitions" (Dery & MacCormick, 2012).

3. *Connectivity*. Connectivity is about tapping into a network or resources. Through connectivity, there is access to data, people, discourses, and so on, noted Dery and MacCormick (2012). A designer of the urban environment can provide facility for the city dweller to "connect" to events in the environment, but the former can also aim to put in place affordances that enable that city dweller to find varying degrees of "refuge" from those events. For our purposes, related to the idea of connectivity is *ubiquity of access* (Squire, 2009). This suggests ease of access from different locations.

4. *Permeability*. This is an idea of *passing through* boundaries. A related concept is *porosity*. We shall employ porosity to represent permeability infused through an entire body or system. Goodwin (2003-2005a, 2003-2005b) has employed the concept to explore the urban physical environment. The "functional boundaries ascribed to the physical dimensions of public space in the city" were tested through "interconnecting and adapting existing architectural bodies." The set of interventions exploiting the porosity of urban architecture aimed to acknowledge producing "a richer social fabric" and "existing cities [that] expand in symbiotic metamorphosis." (Goodwin, 2003-2005a; 2003-2005b). In Goodwin's vision, inhabitation of a space generates pressures of desire to connect to other spaces. We are reminded of La Varra's (2000) description that we punctuate urban spaces.

5. *Collaboration*. Facilitation of collaboration is a functionality of communications technologies (Naismith, Lonsdale, Vavoula, & Sharples, 2004). Collaboration involves capacity of systems to work together (as partners). In terms of urban dynamics, we see this as existence of "pathways" which connect spaces and events. Thus elements of the urban fabric extend into one another spatially, electronically, temporally, programmatically and so on.

6. *Conversations between systems.* This can be seen as a collaboration function, where connection or exchange is carried out with minimal difficulty (Naismith, Lonsdale, Vavoula, & Sharples, 2004). It represents the capacity of people and/or technologies to exchange information and experiences seamlessly.

7. *Venturing and opportunity seeking.* The idea derives from the practice of scouting for wi-fi connectivity (at hot spots). Connectivity is not very rare in an age of extensively increased accessibility, but we draw upon the idea--a search-and-find process which we characterize as venturing.

8. *Distal engagement*. This describes the act of engaging an *other* (person, thing, event, etc.) from a "safe" distance. Communications technologies enable the user to stand apart from a phenomenon while having opportunity to engage it.

9. *Framing private space in public space*. One's control over space can be used to frame own space. Control, wrote Deleuze (1992), modulates space. Armed with power of modulation, the individual could carve private out of public space. As Kim (2009) wrote, "the social space of the public and the private with their related dispositions of publicity and privacy, seclusion and connectedness" are about modulation of one's engagement with space (p. 355). Space can be constructed out of "conditions of interaction and control" (Allon, in Kim, 2009, p. 355).

Squire (2009) framed the concept in terms of *remediation of place*. *Cocooning* and *camping*, for instance, describe, respectively, how some urban dwellers use mobile systems to frame personalized micro-spaces "attached to the person and not the physical space" (p. 76) and others carve out and inhabit a work space with the same devices. We could also apply Martijn de Waal's (2008) notion of "centring devices" (paragraph 63).

What all these strategies offer are opportunities to either transcend the wall directly or transcend its way of disrupting how the individual might wish to create flows in urban space. In his "MySpace urbanism," de Waal (2008) has explored the ongoing dialogue between humans inhabiting the city and communications technologies. The latter allow individuals to be engaged socially, "perform identities" (paragraph 19), turn presence into a hybrid experience (virtually in more than one place at one time) (paragraph 89), but also to "personalize the city" (paragraph 19).

4.2. A mediated relationship

In the foregoing pages, we have established three main structural components of this paper: desire (human experience), space (wall systems) and counseling concepts of communications technologies. We now present a diagram which illustrates the mediative role of the third between the initial two components.

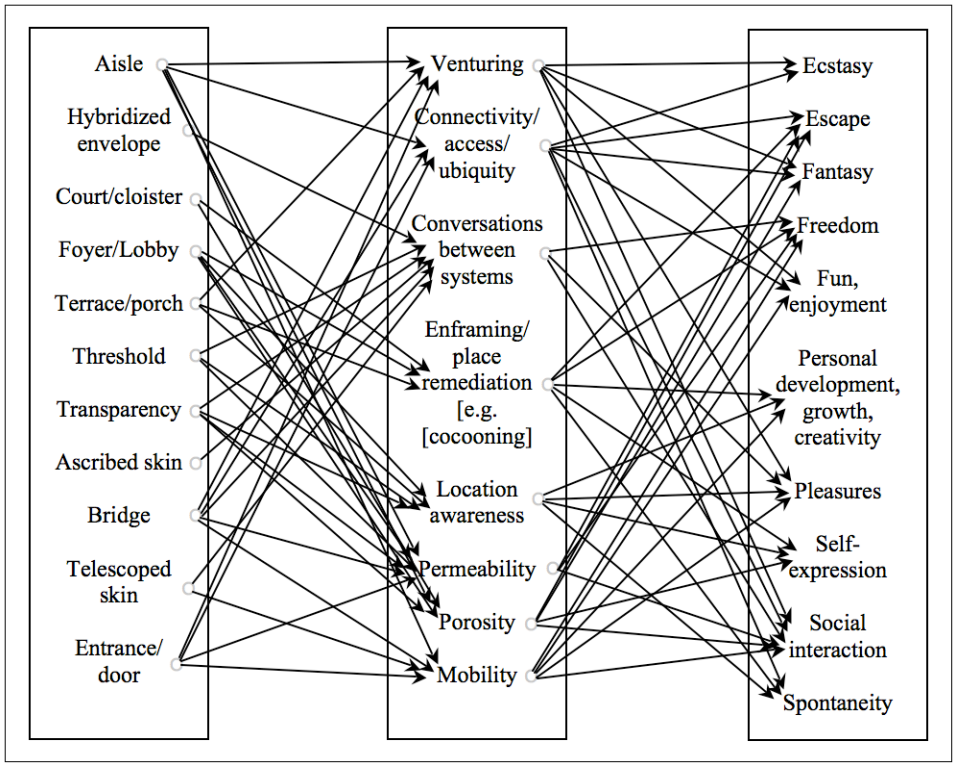


Figure 2: Mediation of space experience via lessons of communications technologies (partial representation)[14]

Another way to consider interrelationship among the three variables--in terms of human experience--is through what we might term a quasi-causal diagram[15] as shown in figure 3. In the figure, grey arrows are primarily locative, indicating where the mediating mechanism might be anchored in environmental space. Red arrows are the active "causal" ones mapping how desires

[14] All models illustrated from here to end of paper will not necessarily contain all possible sub-elements and/or connections. This is done in order to reduce visual complexity.

[15] Three notes: (1) This form of the model contains or makes apparent greater conceptual information (as in current paragraph--above). (2) "Causal" should be understood, as often usual, in the conceptual and not real sense. (3) Quasi-causal is in the sense that what is observed (experienced, in our case) is sourced in something else--elements of farthest column to right, which are, technically, unanalyzed. (In a more proper causal model, our grey arrows would not be featured as here.)

are sourced in the mediating system.

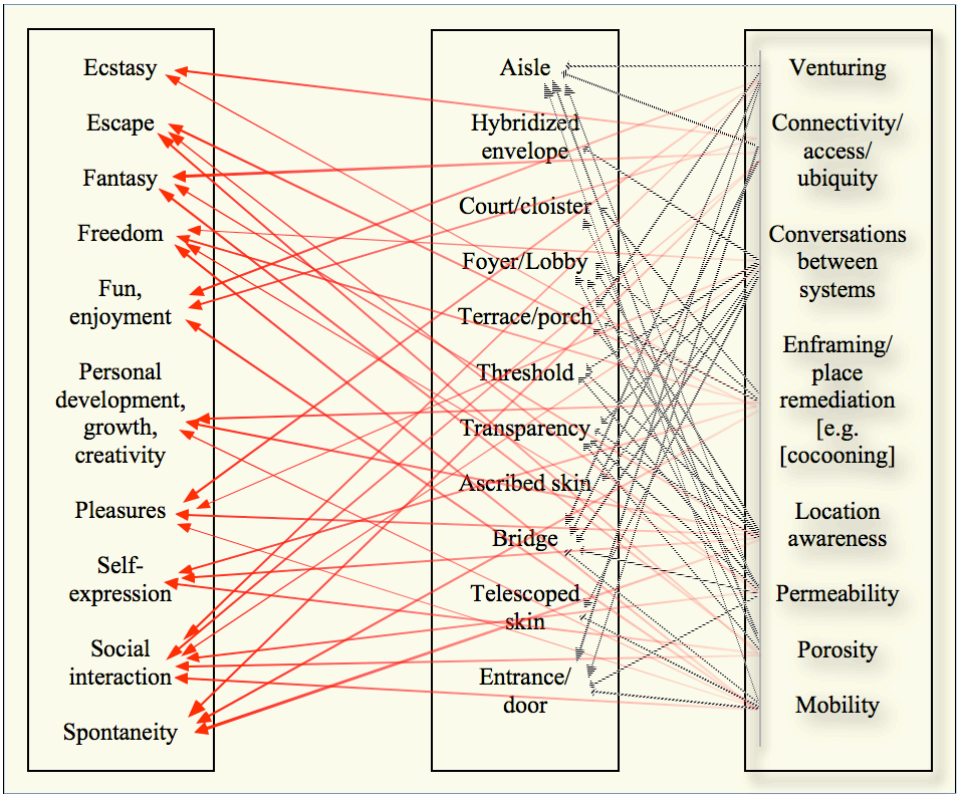


Figure 3: Variation on Figure 2: Experience facilitated by latent affordances of communications technologies

4.2.1. Affective Filter

As the model in figure 2 is considered, it becomes apparent that the question of an affective[16] filter (see next sub-section) through which the user registers experience in space is another useful mediator that ought to be shown (see figure 4). People develop emotionally-structured mental images of the city they inhabit, suggested Luo (in Schut, Hettige & Nas, 2008). These personalized formulations clarify how they feel about the city, its spaces and its affordances.

[16] Affect as trigger before emotion (see Nathanson, 1992)

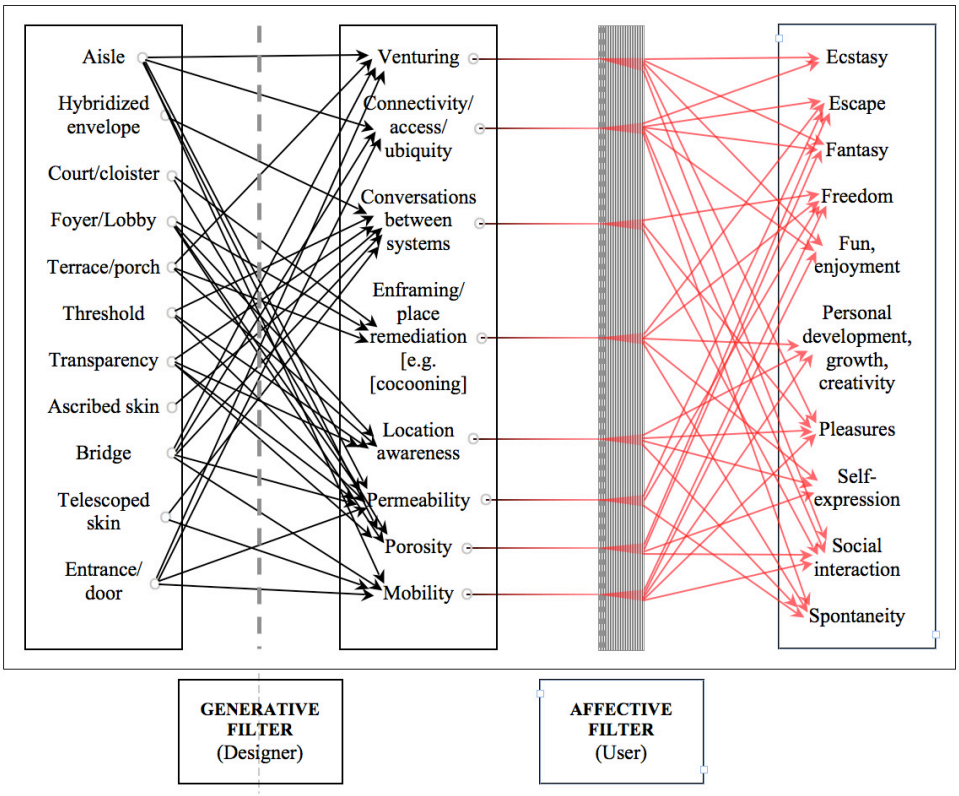


Figure 4: Co-assembly enlarged: affect + cognition gathered with performance and experience[17]

4.2.2. Recognition of personal experience

We are informed by insights articulated by Tomkins (2008). We have mapped a path which links environmental components as loci of experience-triggering with ensuing experiences, these latter mediated by affects (as mechanisms of amplification) (figure 4). Our cognitions, wrote Tomkins, become "hot and urgent" when coassembled with affects (pg. xxv). The combination provides the poetry of the script of living in or engaging the environment. It becomes part of the goal of the designer to intentionally instigate that coassembly. The metropolis is social, but experience is also ultimately personal. A lesson may be drawn from Fewell's (2003) study of colonies that, although multiple levels of organization/aggregation might exist in a collective, it is useful to recognize and examine functionality at an individual level as well.

5. CONCLUSION

We have addressed the question of facilitating or adding value to the experience of inhabitation of the city. We noted that desire is inscribed in human inhabitation and some of those desires could be represented within the construct of leisure if the script of inhabitation were written performatively as living--and living was seen as aspiration towards ideals of leisure. We presented the city as, potentially, beautiful, beauty understood figuratively. We also observed, however, presence of potential impediments to a fulfilling experience in the metropolis. Among others, we isolated one pervasive element of the physical environment which might obstruct fluid experience: the wall. We undertook the business of probing it for points of rupture and

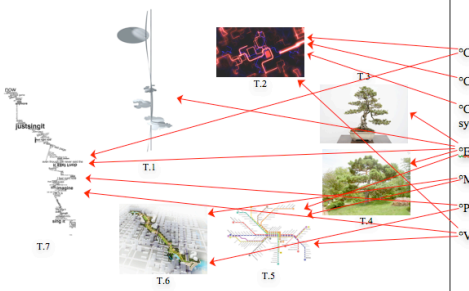
[17] We recognize that "enjoyment" might be considered as an affect, hence, belonging in the affective filter. Nevertheless, it is also recognized as an outcome in other models--e.g. models of leisure.

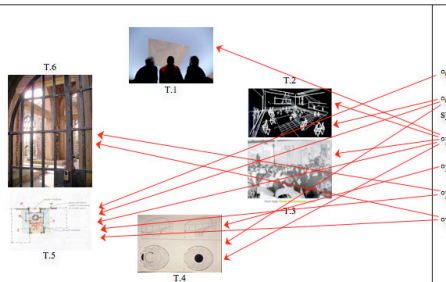
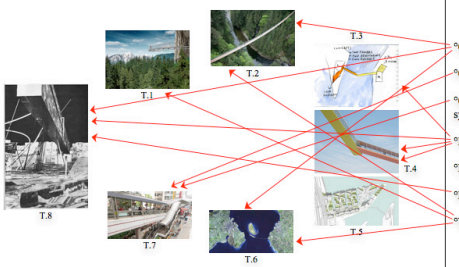
exploiting those potentialities through metaphors of transcendence borrowed from communications technologies. In a set of illustrations, we illustrated mediating dynamics through which desires might be consummated. In all, our objective is to contribute to the practice of (and support designers in the search for) deconstructive analysis in the project of solving design problems which add value to day-to-day living.

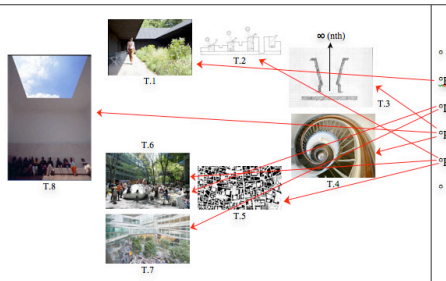
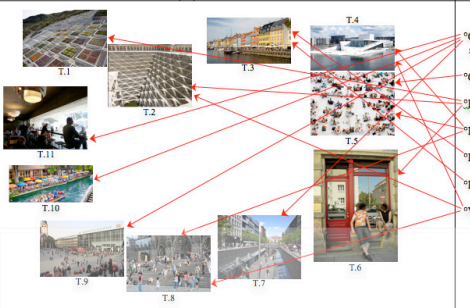
It is important to add in closing that this paper is not intended to serve glorification of communications technologies. These technologies present as much potential for harming social and personal life as they present opportunities. Numerous critiques are extant, auguries of consequences.

6. POSTSCRIPT: NOTES ON PROBLEM RECONSTRUCTION

In this section, we provide an example of an analysis process based on the model above, using several elements of the physical environment listed in table 1 above.

Element of physical environment		Illustrative notes, deconstructions, precedents	Mediation concept	Notes on mediations and user experience
A. Wall: material systems				NOTE: All possible connections are not indicated in order to simplify diagrams.
1. Solid envelope/divider				
2. Transparent envelope/divider				
3. Hybridized envelope				
B. Wall breach systems				
1. Entry/door				
2. Aisle			°Collaboration °Connectivity °Conversations between systems °Enframing/place rem. °Mobility °Porosity °Venturing	° T.1: Inspired by ant colonies 1. T.2: Circuit **connectivity** 2. T.6: Threads through built fabric, rendering **porous** 3. T.6: **Mobility** eased through fabric 4. T.2: Enables communication with other connected parts of system 5. T.1, T.3, T.4, T.5, T.7: Enable pods of space connected, **place remediation** 6. T.2, T.7: Intricate **collaborations** between connected systems 7. T.7: Multiple connected pods render space **porous** 8. T.2, &.5, T.7: Intricate linked spaces and multiple routes and passageways encourage **venturing** OTHER generative notes: 1. Aisles punctuate landscape, fabric (La Varra, 2000) 2. Though sometimes a separator, it is also a wall breach system. Affordance of movement/circulation--which further dematerializes the resistive wall, is an instability that can be exploited. 3. Network = alternative routes (between two or more points) 4. You make encounters of all sorts on the way (adventuring) 5. Crossings exist along paths, but also nodes/pods that serve as places or "points of pause" (e.g. along metro line, ant colony, Scots pine) 6. Network of lines offers multiple points of contact (Fewell, 2003) 7. Network of lines offers distributed local control points and parallel operations 8. Redundancy in connections offer not just mobility, but ease of moving across as well
3. Ambulatory				

Element of physical environment		Illustrative notes, deconstructions, precedents	Mediation concept	Notes on mediations and user experience
4. Foyer/lobby/vestibule			°Connectivity °Conversations between systems °Location awareness °Mobility °Permeability °Venturing	° T.5: Diagram of T.6 (vestibule) 1. T.2, T.3, T.4, T.5: **Location awareness** as multiple stories, multiple histories--complex visibility in multiple directions and multiple depths; 2. T.2 & T.3: Sees all around (Theatre in Counterpoint, Agam); multiple narratives as **location awareness** 3. T.5: Sightlines to multiple locations; **connectivity** 4. Skyspace (Turrell) frames and shows or feeds changing environmental conditions in-time, as RSS feed; **location awareness** 5. T.2, T.3, T.4, T.5: Unspoken, silent **conversations between systems** or spaces and between multiple spaces and humans 6. T.5: Visual and physical **permeability** 7. T.5, T.6: Any kind of permeability instigates **venturing** 8. T.4: Delimited space (stage) is location/context-indeterminate (moves); ephemerality & changing conditions); movement signifies change (Bomfim & Urrutia,2005)); **mobility** is reified in change OTHER generative notes: 1. Koolhaas (1994): Lobby reveals life inside as it presents in a hostile relationship with life outside; lobby "competes with the street," he wrote, "presenting a linear display of the building's pretensions and seductions" (p. 88). 3. As transient spaces, lobbies can also deliver quick peripheral information (see peripheral information in communications technology: Emotipix--Cowan, L., W. G. Griswold, Barkhuus, L., & Hollan, J. D., 2010)
5. Bridge			°Collaboration °Connectivity °Conversations between systems °Location awareness °Mobility °Permeability °Venturing	1. T.1, T. 2: Ad**venture** 2. T.6: Crossing partway above land to island, then underwater; **venturing** 3. T.7: Longest outdoor escalator; **conversations** between different levels 4. T.8: Bridge tilted over wall "sees" the other side; **location awareness** as creating awareness of context beyond "here" 5. T.8: **Permeability** in breaching the wall 6. T.3, T.4, T.5: Change in bridge direction is response to different site conditions; **location awareness** 7. T.2, T.6, T.8: **Collaboration** fostered between two separate ends/sides OTHER generative notes: 1. Bridge can traverse monumental obstacles 2. Drama can be created in traversing 3. Can make dramatic use of 3rd (z)-dimension (e.g. T.8)

Element of physical environment		Illustrative notes, deconstructions, precedents	Mediation concept	Notes on mediations and user experience
6. Court/cloister			° °Enframing/place rem. °Location awareness °Permeability °Porosity °	1. T.1: Cloister is carved-out solitary space, but also individual can carve out solitary space alone in it; **enframing** 2. T.2: Hollowness created by court(s) generates **porosity** 3. T.3, T.8: **Permeability** in breaking through barrier(s) 4. T.5: Voids make city fabric **porous** 5. T.6, T.7: Some specific courts could contain specific dynamic histories and current narratives, continually unfolding and made known to participants; **location awareness** 6. T.3, T.4: Ultimate **permeable** space up into infinity
7. Telescoped skin				
C. Wall auratic systems				
1. Terrace/porch/patio			°Conversations between systems °Collaboration °Enframing/place rem. °Location awareness °Permeability °Porosity °Venturing	1. T.1 & T. 2: Metaphors to be integrated and adapted Personal space **enframed**/delimited in public space. 2. T.3: Wall of bars/restaurants **permeated** by choice of user to spill outside 3. T3: Penetration extended and done easily into other/outside space, making space **porous** 4. T.1, T.2, T.4, T.5, T.8, T.9: Awareness of self in place, but also **awareness** of context and events unfolding 5. T.7: Steps connecting levels publicly; enabling inhabitation **conversations bet. systems** 6. T.8 & T.9: From popular, public steps of cathedral to Hauptbahnhof/station; enabling inhabitation **conversations bet. systems** 7. T.6: Personal space carved along sidewalk 8. T.4, T.2, T.1, T.8, T.9: Positioned to reach-out, engage in events of interest as participant or observer, serendipitous discoveries, **adventure** 9. T.11: Inside-outside --> phenomenal **conversation between systems** 10. T.10: Terrace along river *gathers* all businesses along it together OTHER generative notes: 1. Versatility in *negotiating* inside & outside transition 2. Capacity for drama (display)--e.g. large vertical structural gestures (not workable in interior, but possible on terrace)--e.g. Jubilee Church (Meier); JVC Center (Himmelblau) 3. Capacity for exploiting dramatic roof overhangs--Lucerne Concert Hall 4. Terrace allows criss-crossing paths = connectivity

Element of physical environment		Illustrative notes, deconstructions, precedents	Mediation concept	Notes on mediations and user experience
2. Ascribed skin				
References	Aragaki, Sayako. (2007). Agam: Beyond the visible (3rd ed.). Jerusalem: Gefen. Bomfim, Z. C. B., & Urrutia, E. P. (2005). Affective dimension in cognitive maps of Barcelona and São Paulo. International Journal of Psychology, 40(1), 37-50. Retrieved December 30, 2013, from http://ehis.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=4&sid=f3900663-0315-4f84-a340-937c5a9892cb%40sessionmgr4004&hid=4111 Cowan, L., W. G. Griswold, Barkhuus, L., & Hollan, J. D. (2010). Engaging the periphery for visual communications on mobile phones. In Proceedings of the 43rd Hawaii International Conference on Systems Sciences (pp. 1-10). Retrieved December 23, 2013 from http://www.computer.org/csdl/proceedings/hicss/2010/3869/00/index.html Fewell, J. H. (2003). Social insect networks. Science, 301, 1867-1870. Retrieved January 1, 2014 from http://www.sciencemag.org/content/301/5641/1867.full.pdf Koolhaas, R. (1994). Delirious New York. New York: Monacelli. Libeskind, D. (1988). Daniel Libeskind (City Edge). In P. Johnson & M. Wigley (Eds.), Deconstructivist architecture (pp. 34-45). New York: Museum of Modern Art.		
Image sources				
Aisle				
T1	Model based on ant colony	> Author		
T2	Electronic circuit	> http://overheadproductions.files.wordpress.com/2013/05/sequence-01-still00312.jpg		
T3	Bonsai tree	> http://bonsaiexperience.com/images/exposedrootform439.jpg		
T4	Scots pine	> http://davesgarden.com/community/forums/fp.php?pid=8766540		
T5	Metro map	> http://www.skyscrapercity.com/showthread.php?t=541977		
T6	Ring-River Park System, LRS Architects	> http://www.lrsarchitects.com/market-sectors/china/ring-river-park/		
T7	Deconstructed text	> http://www.typographic.nicolewilliams.info/deconstruction.html		
Foyer				
T1	Skyspace (Turrell)	> http://www.arcspace.com/exhibitions/unsorted/james-turrells-skyscape/		
T2	Theatre in Counterpoint (Agam)	> http://books.google.com/books?id=JyKOTnw4m4wC&pg=PA92&lpg=PA92&dq=%22theater+in+counterpoint%22&source=bl&ots=ir9Rgk1G2h&sig=w_9 9HfYWgqdKhvoeaBiN57CsfAIA&hl=en&sa=X&ei=F9_IUoGlLun52wXss4Bo&ved=0CCkQ6AEwAA#v=onepage&q=%22theater%20in%20counterpoint%22&f=false		
T3	Theatre in Counterpoint (Agam)	> (as above)		
T4	Total Theatre (Gropius)	> http://rosswolfe.wordpress.com/2013/07/20/theater-buhne/#jp-carousel-10542		
T5	Analytical sketch of St. Peter's, Bristol	> Author		
T6	Entry section, St. Peter's, Bristol	> Author		
Bridge				
T1	Cliffwalk, Capilano Suspension Bridge Park, North Vancouver, Canada	> http://beauty-places.com/capilano-suspension-bridge/		
T2	Capilano suspension bridge, Capilano Suspension Bridge Park, North Vancouver, Canada	> http://www.capbridge.com/gallery/suspension-bridge/		
T3	LM Harbor Gateway, Copenhagen (Holl)	> http://www.bustler.net/index.php/article/steven_holl_architects_receives_2010_p_a_award_for_lm_harbor_gateway		
T4	LM Harbor Gateway, Copenhagen (Holl)	> http://www.bustler.net/index.php/article/steven_holl_architects_receives_2010_p_a_award_for_lm_harbor_gateway		
T5	LM Harbor Gateway, Copenhagen (Holl)	> http://www.byoghavn.dk/byudvikling/bydele/nordhavnen/marmor-front/marmormolen.aspx		
T6	Oresund Bridge, Denmark/Sweden	> NASA/GSFC/METI/Japan Space Systems and U.S./Japan ASTER Science Team, http://asterweb.jpl.nasa.gov/gallery-detail.asp?name=oresund		
T7	Hong Kong Central Mid-Levels Escalator	> http://evanchakroff.com/category/blog/		
T8	City Edge (project, Libeskind)	> Libeskind, D. (1988). Daniel Libeskind (City Edge). In P. Johnson & M. Wigley (Eds.), *Deconstructivist architecture* (pp. 34-45). New York: Museum of Modern Art.		
Court				
T1	Hortus Conclusus (Zumthor)	> http://www.morfae.com/1043-peter-zumthor/		
T2	Futureplex proposal	> http://dudye.com/the-futureplex-was-supposed-to-represent-the-design-of-future-offices		
T3	Nth degree/infinity	> Author		
T4	Spiral staircase	> http://www.trekearth.com/gallery/Europe/Denmark/West/Ringkobing/Holmlands_Klit/photo484756.htm		
T5	Nolli map	> http://cityeu.wordpress.com/category/maps/		
T6	International Forum, Tokyo	> http://userdisk.webry.biglobe.ne.jp/004/514/93/N000/000/014/133622102681213228885.jpg		
T7	International Forum, Tokyo	> http://www.t-i-forum.co.jp/en/facilities/square/		
T8	Skyspace (Turrell)	> http://www.pinterest.com/pin/263882859389133788/		
Terrace				
T1	Awaji Hyakudanen, Japan	> http://www.amazingplacesonearth.com/awaji-hyakudanen-japan/		
T2	Chand Baori, India	> http://imgur.com/gallery/JzmHw		
T3	Nyhavn, Copenhagen	> http://upload.wikimedia.org/wikipedia/commons/3/39/Nyhavn_MichaD.jpg		
T4	Oslo Opera (Snohetta)	> http://thesuperslice.com/2011/11/14/oslo-cooking-spacegroup-jds-snohetta/		
T5	Oslo Opera (Snohetta)	> http://travel.nationalgeographic.com/travel/365-photos/opera-house-oslo/		
T6	Sidewalk cafe seating	> Author		
T7	Mall, Hannover	> http://www.niedersachsen-tourism.com/shopping-in-hannover		
T8	Steps, Cologne Cathedral	> http://www.agefotostock.com/en/Stock-Images/Rights-Managed/IBR-1379894		
T9	Colone Cathedral + Hauptbahnhof	> http://explorenorth.com/wordpress/exploring-cologne-germany/		
T10	Riverwalk, San Antonio, Texas, U.S.A.	> http://www.mightytravels.com/13232755/hottest_san_antonio_texas_hotel_deals_and_seaworld_tickets.php		
T11	Cafe window	> http://www.dailycal.org/2013/10/18/top-4-local-coffee-shops-bay/		

Figure 5: Notebook of design language: Communications technologies as articulators

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User Experience in the Threshold Matrix of Public Space

Design Intervention in a Complex Environment

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Abstract: Designers seek to create environments that offer their inhabitants comfortable, desirable, meaningful or other qualified positive forms of experience. In some successful models, solutions involve a synthesis of space and person, such that they are mutually constitutive. Often as well, models involve an understanding of space, person and their union as dynamic. Models of space design which recognize such a dynamic relationship are said to view space as *relational*. In this paper, we claim space as relational. We also present the case that emergent in actualizing the relational idiom is the idea of *threshold*. Threshold is many things and complex. It symbolizes crossing but also pause, end but also beginning, a brief moment but also extended duration. In the paper, we explore the concept of threshold within physical, perceptual and rational frames. We attempt to foster a rich awareness of threshold, link it to a fertile, generative picture of public space, connect it to enrichment of inhabitants' experience of the city and articulate roles for the designer. City and cultural spaces have pleasures embedded in the idea of threshold. Through analysis and intervention the designer can tap into those pleasures for the benefit of the user.

Keywords: Threshold, affect, complexity, public space

1. INTRODUCTION

Designers consistently explore models and concepts for facilitating human experience in urban public space. In this critical-analytical paper, we will hold that public space is relational, human-centered and performed, that performed space is dynamic (or indeterminate) and that performed space is networked (or *mesh-worked*, as we shall point out). In these re-framings, we transcend a "sedentary metaphysics" of space (Anderson, 2012).

Somewhat containing all these structural dimensions is *threshold*. Threshold is an in-between--a place, a duration, an experience. Thresholds are physical and psychic locales of human performance. Thresholds can be sojourned-in or crossed. As sojourn, they are temporary pauses in an experiential journey across time-space (Anderson, 2012). As places of movement (Stevens, 2007), they "regulate and give meaning to the act of crossing" (Stavrides, 2010, p. 13). That thresholds symbolize non-finality, however, means they also entail possibility. They "present distinctive perceptual, behavioral, social and symbolic affordances" (Stevens, 2007, p. 152).

If there is one pre-eminent observation at this point, it is that threshold is a complex idea. It is exceedingly rich and thereby presents a range of opportunities for the designer to exploit it. It is a construct that is of value to designers interested in questions surrounding designing space for human inhabitation and those interested in exploring the interface between space and human. Through analysis and intervention, the designer can tap into the *possibilities* it offers in order to facilitate user experience. This paper purposes to frame that generative picture of possibilities in public space.

2. CITY AS THRESHOLD

2.1. City experience as dynamic

The city, according to Wirth (1969/1938), may be defined[1] as "a relatively large, dense, and permanent settlement of socially heterogeneous individuals" (p. 148). The gathering of human bodies, all active in performance, is core to the urban condition. The city is also space which harbors these embodied agents. Coupling these two dimensions, Stavrides (2010) urged us not to consider urban space as merely a container, but as a "formative element of social practices" (p. 13). Camponeschi (2010) echoed that view and also highlighted the salient idea of experience in urban space: "Public space is better understood not as a predetermined physical place, but as an experience created by the interaction between people" (p. 11).

Brighenti (2009) extended the conceptualization. She noted that "territories are better imagined as processes than objects" (p. 64). Spaces or places in the city are first demarcated, but they become what they are through a combination of their past, present and intentional histories/trajectories of inhabitation. Threshold, as we saw above, is such a territory that is defined by a synthesis of space, human and performance.

Extending yet one step, Stavrides (2010) re-enlisted the now-prominent idea that the city is not simply an aggregation of static points, but a "network of flows" (p. 28). It is possible, then, to conceive of the city as a constellation of points/places being continuously traversed by humans and in which a vast range of dynamic engagements occur. The city can be conceptualized as a network of thresholds.

In an argument about boundaries (which we are unable to discuss extensively here due to space limitations), Cilliers (2001) proposed that in a complex system, its components are richly interconnected such that there is a short route from inside to outside and "everything is always interacting and interfacing with [other components] and the environment." It would be as if the boundary was folded in or "perhaps, the system consist[ed] of boundaries only" (p. 142). If one considered thresholds (in one of their idealizations) as "boundary breachers" (in the sense that

[1] For sociological purposes

[2] These are grouped by category here, not ordered according to any other criterion--e.g. Nathanson (1992)

they might span boundaries), then the city could be seen as a continuous meshwork of thresholds rendering in flux insides and outsides or melding dynamically contiguous environments that are, in one sense of actuality, neighboring systems. So, every moment or point is a charged instance surrounded by its own field of influence, but that field is made up as a configuration of other charged points, each surrounded by its own field. There is constant overlap in an unbroken dialectic across space. Describing movement across space, Ingold (2005) wrote that while on the trail (and we could say, while moving through the city), "the wayfarer [as opposed to a person transported] is always somewhere, yet every 'somewhere' is on the way to somewhere else" (p. 47).

If the city is seen as a continuous connection of thresholds, then it is easy to embrace Stavrides' (2010) point of view of understanding thresholds as "always being crossed" (p. 36). This conceptualization seems to represent the city well on the elemental, physical level, but we also intend it at a higher creative level (as did Stavrides) of inhabitants doing the crossing as engaged continuously in the simultaneous production and "consumption" of experiences. It is a useful strategy for a designer to consider city space creation from the viewpoint of a meshwork of experiential scripts. The wayfarer, Ingold (2006) continued, "*is* [her or his] own movement...instantiated in the world as a line of travel" (p. 24). The designer should not see people moving across the fabric of the city as simply connecting points, but creating a narrative as they go, each person as her own movement, instantiated in the world by a history precipitated in movement.

2.2. Dense, dynamic space

Anderson (2012) urged us to move beyond conceptualizations of site and space as fixed and static, "part of a 'sedentary metaphysics'...which seeks to 'divide the world up into clearly bounded territorial units'" (p. 572). Employing figuration of surfing, he enticed us to transcend a useful, but not *total*, portrait of assemblage ("surfers, boards, and waves are 'connected' together to form one coherent unit for the lifetime of the ride") and reach, in addition, towards the generative (even if transient) sphere of convergence ("surfed wave becomes a place whose constituent parts are not simply connected together but, rather, become blended and blurred into a converged entity/process") (p. 571).

2.2.1. Meshwork

Ingold (2005, 2006) has described movements of persons in space. In order to contemplate *meaningful* inhabitation of environments, we should consider, Ingold suggested, their movement in terms of the walk rather than the assembly. He distinguished between lines connecting points (an assembly) and the fluid line which narrates a *walk*. He discarded the term, network (of lines simply connecting points), for *meshwork*. Instead of thinking of an interconnection of points (which emaciated lines of the network suggest), we should be thinking of interconnected lines in a meshwork (since each line embeds a narrative, represents a packaged history). The lines of the meshwork, he wrote, "are the trails *along* [emphasis in original, in contrast to "across"] which life is lived." It is in "the entanglement of lines, not in the connecting of points, that the mesh is constituted" (2006, p. 26).

In movement within a meshwork, movement that is a *walk*, points or nodes take on a different significance. They are not a constellation of termini (opposed by Ingold, 2005, 2006), but places of pause. They are no longer simply geographical, but temporal, wrote Anderson (2012): "A place is now. It is permanently in the present, only temporarily 'fixed', and now something else" (p. 574). Places should be seen by the designer as in-betweens along *walks*.

The idea of meshwork points our attention to one of its superordinate paradigms, *relational thinking*.

2.2.2. The relational turn

In relational thinking, space is defined in terms of "object(s) and/or processes...considered in space and time" (Jones, 2009, p. 490). These objects and processes are deployed in a meshwork that reveals interdependencies and flows between them. The *relational turn* pivots towards understanding places as not static, but shaped by openness, conditionality and emergence (Anderson, 2012). It "not only encourages us to consider traditional (terrestrial) places in new ways (eg, towns, neighbourhoods, parks, or plazas) but also enables the consideration of new 'coming togethers' as 'places'" (p. 571). It is an "interdependent epistemology" (Anderson, 2012) that recognizes a "hybridity of subjects, identities and spaces" (Watson, 2003, p.145; also in Anderson, 2012).

Relational thinking, according to Anderson (2012), "marks a rejection of a static ontology of 'being-in-the-world'...and an embracing of a more emergent and emerging ontology of 'becoming-in-the-world'" (p. 573). Space is seen as an actor-centred becoming (Jones, 2009), created through "inhabiting practices" (Stavrides, 2010, p. 23). In this new paradigm, threshold plays an active role (in its conative association with *becoming*). Within a network topology, wrote Massey (2006), landscape is "a constellation of ongoing trajectories" (p. 92). In travelling across space, Massey continued, we are not simply travelling across landscape, but across stories.

2.3. Role of affect in stories and narratives of experience

In order to link experience of the city with affect, we draw on the work of psychologist, Silvan Tomkins. Echoing Massey above, Tomkins understood human existence as "sequences of scenes animated by emotion and linked to form stories about lives" (Nathanson, 2008, p. xi).

To the extant model of human behavior as a stimulus-response dyad, Tomkins added affect as a mediating mechanism. No stimulus, he argued, can trigger a response "unless and until it triggers an affect," which then brings the stimulus to the attention of the organism and mobilizes a response (Nathanson, 2008, p.xiii). Thus, he depicted life as stimulus-affect-response sequences organized into a series of scenes.

Tomkins presented a palette of nine innate affects: two are positive affects, six (four "negative" plus two "displeasure") are negative and one is a reset affect (Lövheim, 2012; Nathanson, 2008).

Table 1: Affect systems as proposed by Tomkins (Tomkins, 2008; also Nathanson, 1992)[2]

Positive	Interest-excitement
	Enjoyment-joy
Negative	Fear-terror
	Distress-anguish
	Anger-rage
	Shame-humiliation
Displeasures	Dissmell
	Disgust
Neutral re-set	Surprise-startle

He proposed the term, "minding system," for a combination of human cognition and affect. The special function of the minding system "is the ability to convert the raw texts of affect and cognition into the compelling poetry of scripts, which provide the rules that turn data into language with grammar, semantics, and ways of living" (Nathanson, 2008, p. xxv).

Tomkins continued his elaboration: Consciousness is a state "created by the assembly of an event (percept, cognition, scene retrieved from memory, etc.) with the affect it triggered" (Nathanson, 2008, p. xxi). When we receive stimuli, they are brought to our awareness "as colored by affect" (p. xiv). "The world we know is a dream, a series of images colored by our life experience of whatever scenes affect brought to our attention and assembled as scripts" (p. xi).

According to Tomkins, our cognitions, when coassembled with affects become hot and urgent (Nathanson, 2008, p. xxv). Amplified by affect, he noted, anything becomes important. Affect "makes good things better and bad things worse" (p. xii).

The "scenes" of day-to-day life in the metropolis could be conceptualized in terms of the ways the inhabitant encounters the city--which affect amplifies for her or him. We are motivated, proposed Tomkins, "to accept, savor, and seek out the two positive affects because they are 'inherently rewarding,' and motivated to avoid, quash, and rebel against the six negative affects because they are 'inherently punishing'" (Nathanson, 2008, p. xx). There is a lesson for the designer--that designing places and objects in order to be received well by the user should be a habitual, dedicated strategy, where the goal of positive reception becomes part of experience augmentation.

2.4. Complexity of "threshold"

Threshold is a complex idea. It is so both on account of its range being vast as well as of the intricacy of some of the internal/*interior* ideas it affords. For example, Cilliers' (2001) argument was presented above that, in a complex system, the boundary could be indeterminate, that due to the rich network, it could be as if the boundary was folded in or "perhaps, the system consist[ed] of boundaries only" (p. 142). Indeed, Cilliers (2007) chose to discriminate between boundary and

[2] These are grouped by category here, not ordered according to any other criterion--e.g. Nathanson (1992) noted that shame is the most recent affect to develop through the process of evolution (p. 136).

limit. Although boundary could be complex, so also is limit. Limit, he argued, is knowable only from one side (while boundary has two easy-to-conceptualize sides). Since one does not know the extent of what is beyond the limit, then it becomes hard to know when one has reached the limit. Boundary and limit are both threshold constructs. Another spatial example of the complexity of threshold is what this author refers to as a *telescoped skin/envelope*[3] of a system. If, say, an institution within the city had a satellite, branch or affiliate at another location within the city, where is the limit/boundary/envelope of the institution--especially considering that other independent spatial entities exist between the mother and satellite? How, then, is its threshold to be mapped?

Continuing the insight, Stavrides (2010) wrote that threshold is a "complicated social artifact" (p. 15). Stevens (2007) wrote that "threshold spaces are always, by their very nature, only partly defensible and also partly unregulated and disordered, shared with strangers, other activities and unfamiliar experiences which are always in motion." Thresholds, he said, "can be both physically and existentially slippery" (Stevens, 2007, p. 177).

The nature of threshold is that it exists in both material and intellectual domains. In figure 1, we attempt to convey the deployment of constructs of threshold on so-called continua of materiality and ideation, using a few examples. In the next section, we will lay out a range of conceptualizations of threshold.

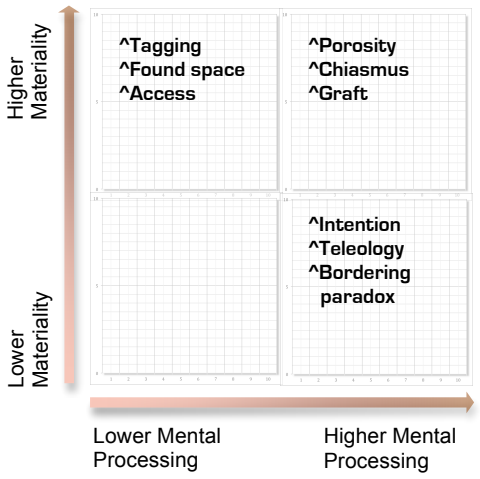

Figure 1: Reifications of threshold: Ideation, experience and materiality

2.4.1. Concepts of threshold

In this section, we present conceptualizations delineating physical, idealized or experiential forms or states of threshold. We have grouped these into three categories based on how they might be described as sourced:

Geometric (G): Threshold can be imposed via diagramming or management (e.g. time use) by a designer or other.

Intuitive-direct (ID): Threshold actualizes as a result of user current experience, recognition from prior experience or effortlessly-inferred user experience.

Intuitive-indirect (IR): Threshold actualization is mediated by rationalization (logical, poetic,

[3] It is the space between that gets compressed, hence the notion of *telescoping*.

allegoric, etc.).

Geometric can be pre-ordained by designer. Many of the *intuitive-direct* and *intuitive-indirect* require a user frame or user implant, but they are also useful for the designer because they can serve as anticipated narratives for framing design. The categories are not mutually exclusive.[4] The list is not exhaustive.

Table 2: Conceptualizations of threshold

	Category			**Conceptualization**	**Brief description**
	G	ID	IR		
1	X	X		Access	Zone through which entry is gained
2		X	X	Bordering paradox	Extending a thought from Bernardes (2010): the beach as threshold is a "border"/field that separates desire (desirable water with which to make contact) on one side and "impossible total experience" (p. 219) (total annihilation by that same water) on the other. Paradox: what is desired will also annihilate.
3			X	Boundary/limit	Aristotle: Limit is "the last point of each thing, i.e. the first not possible to find any part, and the first point within which every part is" (in Barnes, 1984, p. 1163).
4			X	Caesura	*Dis-stabling* break, pause, interruption--(idea instigated by Teyssot [2005], but used differently by Teyssot--see #17 below)
5		X	X	Chiastic space	Chiasmus, inversion, crossing; Goodwin's (2003-2005a, b) "experiments" with private-public space interpenetration
6			X	Context for elaboration, synthesis, correction/ modification/ re-adjustment	Kuhn (1970/1962) painted this picture: Emergence of scientific paradigms often follows a trajectory: multiple theories/hypotheses/ conjectures; then one theory emerges which accounts for the different observable effects; that theory unites the field and subsequent work becomes built upon it. The consequential theory represents the threshold--the intellectual (in our case, physical) space and condition that facilitates what is to follow. What was in the past is either (i) reinforced (ii) integrated or (iii) corrected. As for the future, if it is not fully seen or comprehended, at least, a vision is afforded. The physical threshold can be designed as a space in which the past that brought the current occupier/inhabitant to it is either elaborated, reintegrated or corrected. For illustration: Correction phase: An arduous trek up a hill to a temple might have been a hard experience for the pilgrim. At the summit or close to it, an opportunity to pause and cast a grand view over the landscape might afford a comprehensive review which leads to a requalification of experience; weariness yields to appreciation. Threshold is space of metamorphosis. ** Purgatory: where venial sin is eroded in preparation for entry into paradise (Radding & Clark, 1992)

[4] Groupings and integration are also not necessarily in a final state. The "matrix" is necessarily indeterminate, as interpretations can modify things. In a way, it is in a "threshold" state.

Table 2: Conceptualizations of threshold (continued)

	Category			Conceptualization	Brief description
7		X	X	Dialogue in space	Space of encountering the other and engaging in dialogue/negotiations (Stavrides, 2010)
8	X	X		Diffusion	Hybridization Zone of blending; (also Benjamin [Weber, 2003])
9	X	X		Extension	Penetration into environment or auratic zone
10			X	Fiction, whimsy	In *The City and the City*: travelling (unseen) within in-between spaces, contested or unclaimed spaces between two overlapping cities ("alterspaces," dissensi" [pp.45, 172]); membrane between cities" (p.253). As the two cities had grown together, "places, spaces had opened between them, or failed to be claimed, or been those controversial *dissensi*" (p.257). (Mieville, 2009).
11			X	Hypotheses	Time-travel/dimensional-teleportation; being here and elsewhere; worm holes
12			X	Immanence	e.g. Our transactions with buildings and their parts are rooted in not only direct perceptual encounters, but also in other significances grounded in the symbolic, spiritual, primitive/visceral, communitarian, etc. A building is a use-object and human engagement of it for use is necessarily through a point of entry. So, an entry threshold is, arguably, an *a-priori* condition; hierarchy manifested
13		X	X	Intention •User aspiration	Goals, aspirations--held in present, but consummated in future; threshold is temporal; suspension in time e.g. person in race not thinking about race, though completely involved, but thinking "I'm going to win" (Author's data)
14			X	Inversion •Boundary erased	Boundary is folded into system in networked, complex system; inside-outside blurred (Cilliers, 2001, 2007). Boundaries are sometimes not perimeters, but "functional constitutive components," and so where is boundary? (Zeleny in Cilliers, 2001, p. 141); limit: as discussed in this paper
15		X	X	Liminal space	Ritual space, transition, communitas (Turner, 1969)
16	X	X	X	Loose space •Found space •Neglected space	Spaces with less restrictions in the city; public space (Franck & Stevens, 2007); skaters and *found* city spaces (Borden, 1998); neglected space (Camponeschi, 2010)
17		X	X	Moment when phenomena are about to dissolve	e.g. Awakening as well as moment of "fading out" (of memory, into sleep or even death (Teyssot, 2005)
18			X	Narrative	A narrative, while ongoing, is *aspiring* to finality Threshold: End of a narrative or beginning of one? Do old narratives become obsolete? (Viljoen & van der Merwe, 2007)
19			X	Network	(See "N*on-linearity*" below)
20			X	Non-finality	Intermediary zone of "doubt, ambivalence, hybridity" (Stavrides, 2010, p. 18); zone of indeterminacy, emergence

Table 2: Conceptualizations of threshold (continued)

	Category			Conceptualization	Brief description
21			X	Non-linearity	Complex systems: non-linear interactions; causality not easily delimited (Cilliers, 2007)
22			X	Passageway	In threshold, "passage towards otherness" might take place (Stavrides, 2010, p. 14).
23		X	X	Peripatetic technologies	Mobile technologies that render space fluid
24			X	Poetic-prosaic medium	According to Ricoeur (Poetry, 1991), one of the functions of ordinary language should be to mediate between the univocity (one sense; precise meaning) of scientific/technological language and the richness of poetry in avoidance of "reduction to utility" (p. 449). Prose mediates between the fixed/rigid and rich; threshold mediates between the fixed/rigid, existential-brute past and possibility (richness; literally hard-to-delimit options due to contingencies) implied in future.
25	X	X	X	Porosity •Penetration •Interpenetration	Penetration of one space type into another (e.g. Goodwin, 2003-2005a, b)
26			X	Possibility	Indeterminateness, dynamism, emergence embeds possibilities; a condition of possibilities = threshold
27			X	Rhythmic in-between	Threshold as chaos period mediating between two "spaces" of order (Stavrides, 2010, p. 32); or vice versa
28			X	*Schwellen*	After Benjamin: *Schwellen*, not *Grenze*; Benjamin's threshold "indicates a crisis in the function of containment." Instead of containment, there is movement and extension (Weber, 2003, pp. 23-24).
29			X	Shiftable [elements of] form	Surfed wave as place; surf shifts, place shifts; place not static (Anderson, 2012)
30		X	X	Shifting user	User in movement; zone of influence is not static
31	X	X	X	Space in-between (punctuating urban fabric)	Spaces that "punctuate the urban territory"; "intervals" within incessant pace of urban life ([La] Varra, 2000, p. 431)
32	X	X		Space in-between (transition)	Vestibule, foyer, porch (Mugerauer, 1993)
33	X	X	X	Space re-writing •Graft •Time transparency	*Graft*: "mode of alteration of the territory" characterized by "insertions," whereby elements of the territory are replaced (Boeri, 2000). During periods of temporary disuse, "temporary rewriting of the urban space" ([La] Varra. 2000, p. 428).
34			X	Stage	Locale of performance that fronts a backstage
35		X	X	States of suspension	Pause (waiting); hope/anticipation; revelation/discovery; anonymity; metamorphosis; incredulity (not knowing what to accept); illusion; escap*ing*; in repository of the unresolved (e.g. aliens or not?)

Table 2: Conceptualizations of threshold (continued)

	Category			Conceptualization	Brief description
36	X	X		Tagging	Along strips of space--e.g persons using window ledge for sitting
37		X	X	Teleology •Event anticipation	Thinking-to "Performative threshold": threshold incipient at nascency of anticipation--e.g. of a visualized space--e.g. "home" and warmth begin to be anticipated three minutes from arriving at front door e.g. Previewed photographs present to the viewer a framework (or a system) for *beginning to experience in present* what is yet to be encountered (e.g. a building), something that can be incorporated into framing true experience during real visit; images build expectations about experience
38		X	X	Temporality: either-or	Goodwin's (2003-2005a, b) chiastic spaces: threshold is either-or: each episode ends and is repeated. Once invader discovered, the separation ends and she either becomes part of the inside or is forced outside; threshold delimited by period of invasion
39	X	X	X	Temporality: constantly there	Threshold *is constantly present*. e.g. Urilift (n.d.) toilet: shows or is not shown, but as indeterminate space, it is always there.
40			X	Time (in-between)	Threshold is an in-between *period*" (Stavrides, 2010, p. 32).
41	X	X	X	Transparency •Use transparency •Time transparency	Simultaneity, interpenetration, ambivalence; two phenomena can overlap or interpenetrate each other as long as there is no real destruction of the one by the other. Space, Kepes noted, "fluctuates" (Rowe & Slutzky, 1963, p. 45). **Use transparency**: Multiple simultaneous uses of a space can be observed, e.g. used for both dining and listening to a lecture without one destroying the other. One use penetrates the other within the same space. **Time transparency**: Different uses of space at different times; time is "seen through." Transparency enables transcendence of a single or static definition/delimitation. It also uncovers the complexity inherent in the notion of spatial limit.
42		X	X	User state	User in threshold state: dream, hallucination, flow (Csikszentmihalyi, 1975); could be sustained or/and active (e.g. flow), so different from moment of dissolution (see "*Moment when phenomena are about to dissolve*" above)
43	X	X		Virtual sidelines	Hot spots
44		X	X	Zone of blending	(See *"Liminal space"* above); social classes blurred
45		X	X	Zone of reconnaissance with otherness	Threshold allows an individual to "depart from [herself or himself] to be somebody else [and be able to show] this temporary transformation as a gesture" (Stavrides, 2010, p. 18)
46		X	X	Zone of re-constitution	Threshold as "space" of returning to the stable old order after disruption (Stavrides, 2010, p. 33)

Threshold is, indeed, complex. As Cilliers (2007) noted, "when we try to understand the world we are always dealing with ontological *and* epistemological issues simultaneously" (p. 84). Obviously, a designer cannot concurrently attend to all of the possibilities expounded or identified above, but she or he can bracket ideas for use. Therein, then, lies a bit of relief for our attempts to manage complex problems: problem boundaries, degrees of articulation, are constructions we impose (Cilliers, 2007). We can regulate that epistemological dimension of working with complexity.

3. CONCLUSION

3.1. Designer role

3.1.1. Exploitation of threshold

By its nature, the idea of threshold is rich. Accordingly, a designer might be able to exploit it inventively. The designer might, for instance, re-set a problem within framing parameters such as space, time or experience. That, in itself, has multiple possibilities. A designer might also creatively recognize and assume *instability* as a characteristic inherent in threshold and so approach some design problems as those of performance under dynamic conditions. A designer could, furthermore, create threshold to be experienced bodily (e.g. changing conditions as one moves from one space to another) or to be, in addition, constructed by the user with attendant rationalizations (e.g. crossing the threshold from profane into a sacred space).

What this means is that the idea of threshold presents a fertile solution space for exploring solutions to one of the enduring problems of the human-environment system: places hold meaning for people and the designer aspires to contribute creatively and positively to that meaning-making. This has ethical implications, but before we outline a few roles along those lines for the designer below, we first ground the argument of meaningful human-space interaction.

3.1.2. Humans, emotional[5] link to spaces they value and mutual constitution

Humans have an emotional bond with places and that has importance in qualifying the character of human existence (Giuliani, 2003). Meaningfulness of the environment emerges from a positive evaluation of the environment (Rapoport, 1982; also Tomkins on appeal of positive affects, in Nathanson, 2008). Intensity of bond is “determined by the physical and social characteristics of the environment, by individual needs and peculiarities, and by evaluation of the present situations vis-a-vis the possible alternatives and the effective possibility of making a choice” (Giuliani, 2003, p. 149). The general lessons to be observed here are that factors such as (1) ability of the environment to meet personal and social needs, (2) potential to make choices in the environment, and ability of both (1) and (2) to contribute to one’s physical and mental well-being might be valuable considerations in evaluating a desirable environment. To be attached to an environment in which one is located is to “make [it] a part of [one’s] extended self” (Belk, quoted in Giuliani, 2003, p. 151). Giuliani added that feelings we experience towards certain places "and to the communities that the places help to define and that are themselves defined by the places” certainly have a positive effect in "defining our identity, in filling our life with meaning, in enriching it with values, goals and significance” (pp. 137-138).

Following the above, the argument is tenable that the relationship between human and environment is mutually constitutive, each one affecting, shaping and re-shaping the other

[5] Emotion understood as at a stage progressed beyond the trigger of affect (see Nathanson, 1992)

(Descola & Palsson in Strang, 2005). People make objects, but those material components of material culture are also activated by their being construed as *actants*. Components of built physical space--and the quality of space defined by those components--act to frame or modulate the experience of the human. We make objects, but as Heidegger has noted, “our ‘dealings’ with things in the world in which we are immersed in everyday life" leads those things to acquire ontological significance for us (in Dant, 2005, p. 85). Realizing the power and value of objects as actants, the designer aims to employ objects which constitute the built environment as tools to accomplish ends which facilitate the inhabitation of space. Artifacts, observed Vermaas and Houkes (2006), are both products as well as means of intentional human action. Both designers and users, they claim, manipulate artifacts for attaining desired ends.

3.1.3. Moral-ethical engagement

Many theories on urban culture, wrote de Waal (2008), "are not neutral [analyses] but rather ethical stances" (paragraph 32). Employing that awareness, some designer goals which embed moral implications should be sought and constituted intentionally that way. A few examples are provided as follows:

1. In general, a designer's interventions should be aimed at creating (positive) value in the metropolis so as to advance enhancement of quality of urban experience.
2. In exploiting city-as-threshold, it should be designed to focus on encounter rather than separated identities (Stavrides, 2010).
3. Exploiting its instability/dynamism for user benefit, the threshold should be designed as an opportunity for negotiation among social actors. Goal should be opening up dialogue rather than conflict (Stavrides, 2010).
4. Threshold should, however, also not resist desire for self-exploration:

> But people unavoidably acquire a very important social dexterity: to be able to become other, to be able to be in someone else’s place. It is here that the power of inhabiting thresholds, in-between space-time, lies. To be able to experience a change in identity, to be able to rehearse, test, check and visit otherness means potentially to acquire the power, to negotiate with otherness. (Stavrides, 2010, p. 40)

5. The environment perceived by persons in the city, wrote Dewey, does not exist solely outside the perceiver. "It extends the 'inner landscape...into the world" (see Burns, 2000). A designer has a responsibility not to knowingly rupture that relationship and does better to facilitate it in the meshwork of thresholds.
6. Tomkins (2008) observed that humans are motivated to savor and seek out the positive affects. The designer can define contrasts (positive/negative affect, arousal/boredom, health/ailment), attach values to each and design the positive over or into the negative.

Norberg-Schulz (1988) wrote that architecture (and one could say building the physical environment, generally) "means the creation of meaningful places" (p. 16). Participating in making the city ought to be about making meaningful places.

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1D - Senses

The Difference of Imagery Perception between Visual and Tactile Sensation

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Abstract: Images aroused by sensory faculties, especially that of touch and vision, play a very important role in human-product interaction. Most studies tackled sensory modalities in isolation, which is somewhat insufficient, as cross-talks among sensory channels would be unduly overlooked. In this study we compared visual and tactile images at the same time, trying to reveal the correlations and distinctiveness of these two primary modalities. In the first stage of the study, we obtained 35 pieces of modern design works as the visual stimuli according to the opinion of interviewed experts. The material compositions of these works were then analyzed and 37 materials were abstracted for tactile evaluation. The vocabularies used by the experts to describe their feelings on evaluating the design works and the materials were grouped into 21 adjective pairs with KJ method. Thirty five subjects were then recruited to give semantic differential evaluation with the scale of the 21 adjective pairs on the 35 visual and 37 tactile stimuli. Through factor analysis, we found four principle factors of image for both of the two modalities. However, the components of adjective pairs in each factor of the two modalities are slightly different. This variation may imply that although tactile and visual sensation often function cooperatively to enhance the perception of each other, they sometime work competitively; the dominant modality will suppress the other one especially for some imagery perception. Finally, this study found that the tactile oriented feeling of roughness may influence visual images. The result of the investigation can help researchers to further understand the influence between multisensory images and to treat it as a useful reference for relative studies, while it can help designers to design products with demanded tactile and visual feeling.

Keywords: Kansei engineering, Imagery difference between sensations, Semantic differential method, Factor analysis

1. INTRODUCTION

People use senses to gain information when interacting with products and then integrate the all information to form whole product image and experience. In general, for most people considered the imagery may be most vivid for the case of visual images（Kosslyn, 1994）. In addition, compared to other sense organs, vision has a dominant advantage, so that the effects and influences of other senses are often neglected. Therefore, previous studies on the product image mainly focus on visual images rather than other senses, especially on the sense of touch. However, some previous studies show that when evaluating the products, the sense of touch has a function not weaker than vision, both of which are regarded as the most important sensory (Schifferstein and Cleiren, 2005).

On the other hand, each perceptual mode can be considered as an independent channel accepting corresponding energies. Due to the different forms of stimulation, messages received by different senses may not be consist; they may present different meanings, even if the stimulus is from the same product. For example, signals like colors, appearances and sizes of the product received by vision might generate relatively more subjective preferences. However, touch will generate images of actual weight and of characteristics material. Thus, most previous studies on product images only focus the image brought by a single sense.

Although the human senses functions independently, the integrated information in the mind play a more important role on perception. When encountering certain stimulus, interaction will generate between sense organs (Schultz & Petersik, 1994). Another sensory feeling may be naturally caused by the stimulation of one sense, which is known as synesthesia (Cytowic, 2002). For example, if vision receives information from a shiny object, it will produce a smooth tactile perception indirectly, and both of which may elicit the simple and delicate images.

Sensory stimulation is accepted individually, and different stimuli will carry different messages. However, synesthesia makes different sensory trigger a common image. Since 80% of information accepted by human is owing to the vision (Berger, 1989), in terms of assessing product images, will vision still be dominant? Will vision show greater contribution than sense on which specific images? Or, what images share relatively high synesthesia between vision and touch? These questions deserve to be deeply explored. Therefore, this study utilizes the comparison of images assessment results between vision and touch, to learn the differences and classify the above issues.

2. METHOD

To achieve this goal, this study conducted a semantic differential (SD) evaluation on visual image of 35 products and a SD evaluation on tactile image of 37 materials. The factor analysis then was carried on the assessment data of both SD investigations to compare the difference between visual and touch images. This study used SPSS statistics (version 19) as the statistical tool. The SD evaluations are explained as follows.

2.1. Subjects

Thirty (13 males and 17 females) were recruited for both SD evaluations. Half of them are design background, the other are not. The age range of subjects is 21-25.

2.2. Stimuli

This study firstly conducted an interview on 11 design experts who have a master or doctoral degree, and more than 5 years of teaching or practical design experience. During the interview, the design experts were required to list clearly recognized product design styles as many as possible, and also to identify the representative products for each style. Then, the design experts were asked to describe the features, such as the sensory perception, image and association of each product. At the meantime, the experts were also asked to list the common materials fabricated in products. The interview lasts for 1~2 hours. The entire interview process was recorded in video, and the interview content was transcribed, integrated and summarized based on the questions asked in the interview.

According to the result of the interview, 35 representative products, as shown in figure 1, were selected as stimuli for further SD evaluation on visual image. The full color product pictures with eliminated background were used in the evaluation. The picture with size of about15*15cm was printed on the center of an A4 paper to show the product outlook and the original colors. From the interview this study further sorted out the representative material types commonly applied by industry. The identified material types mainly include: metal, plastics, stone, wood, leather, fabrics, glass and special. To make the stimuli for SD evaluation on tactile image including as various images as possible 3~4 materials with varied physical properties then were selected from each material type to constitute a set of 37 material samples, showed in Figure 2. These material samples were presented with size of 20cm*20cm in the further SD evaluation.



Figure 1: Pictures of representative products

2.3. Rating scale:

This study sorted the description of the perceived experience for each product mentioned by the experts in the interview. It works out 109 vocabularies related to product image, including physiological sense of vision and touch, as well as psychological perception dimension. And then we integrated, classified and screened them based on the content similarity, and finally obtained a set of 21 adjective pairs representing the perception and image, showed in Table 1, as rating scale for both SD evaluations on visual image and tactile image.

Table 1. Adjective pairs of image of three dimensions

Tactile images					
Cold-Warm	Hard-Soft	Rough-Fine	Frictional-Smooth	Low tactile-High tactile	Comfortable-Uncomfortable
Visual images					
Bright-Dark	Simple-Complex	Decorative-Plain	Pure-Mixed	Geometric(Regular)-Organic (irregular)	Pretty-Ugly
Psychological perception images					
Chill-Passionate	Intimate-Distant	Fabulous-Humble	Safe-Risky	Lively-Rigid	Like-Dislike
Conflicting-Harmonious	Bold-Conservative	Natural-Artificial			

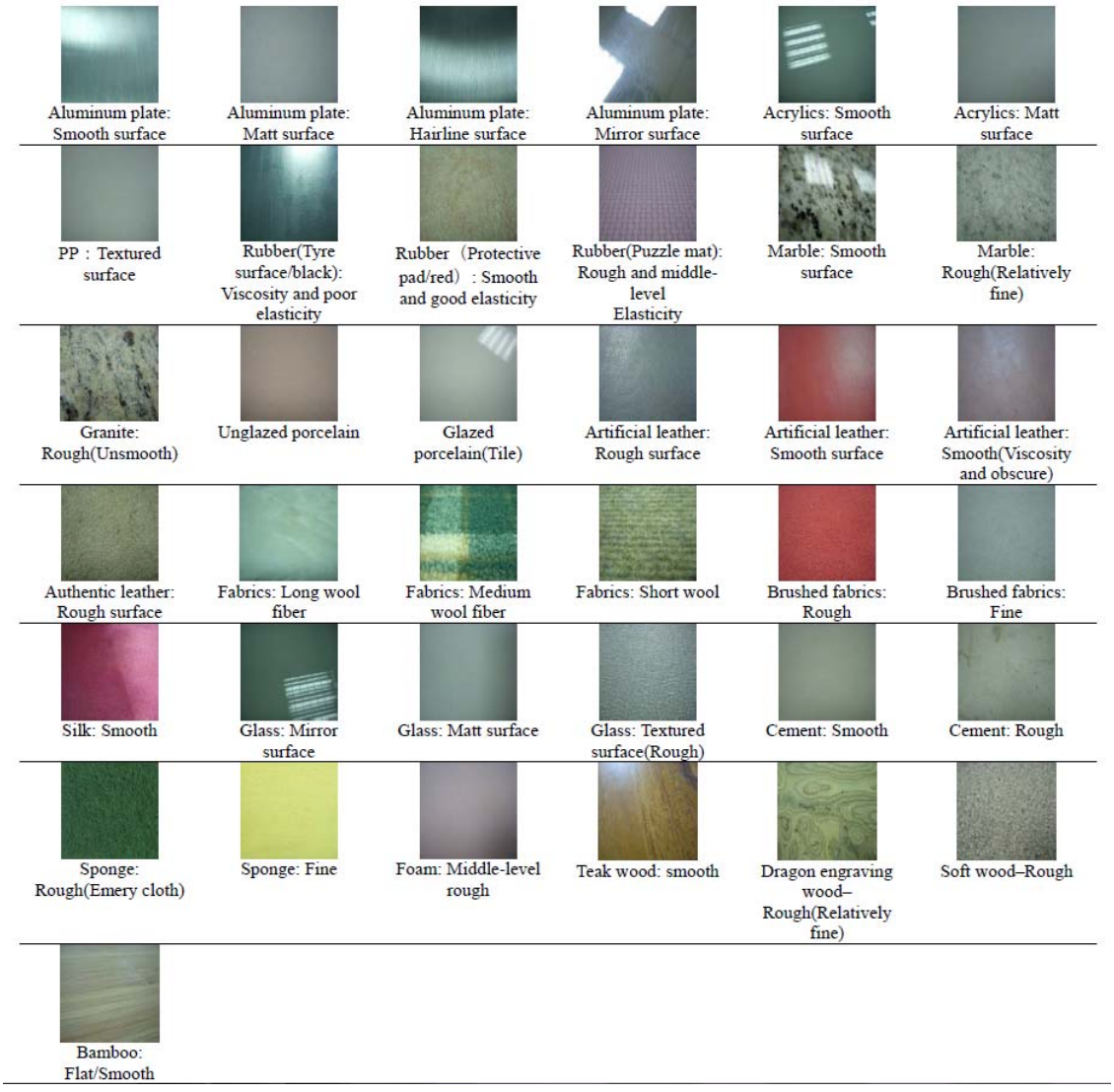

Figure 2: Material samples for tactile stimuli

2.4. Procedure:

In order to make sure all subjects would receive the same visual and tactile stimulations, we conducted the SD evaluation experiments in a room with constant lighting and temperature. At the experiment, researchers firstly explained experiment's purpose, method and steps. All subjects were asked to complete two kinds of SD evaluation experiments which including evaluating 35 product pictures by seeing and 37 material samples by touching. During the visual SD evaluation experiment, subjects were asked to conduct paper-pencil test. Here, 35 product pictures were presented to subjects one by one; subjects had to rate each product on each of the 21 image scales with the 7-point scale. During the touching SD evaluation experiment, all subjects were asked to blindfold their visual ability, and only using their hands and fingers to touch material samples. Here, 37 material samples were presented to subjects one by one; subjects had to rate each material on each of the 21 image scales, mentioned by researchers one by one, with the 7-point scale. Subjects could inquire questions and could adjust or correct their ratings in any time during the experiment. The order of stimuli and image scales presented to each subject for was randomly decided.

3. RESULT AND DISCUSSION

3.1. Factor Analysis results of the 2 experiments individually

After getting the mean value of the 30 subjects on the SD evaluations of the two kinds of stimuli, it worked out two evaluation matrixes. These two evaluation matrixes then were used to conduct factor analysis respectively. By adopting the principal component analysis method for extracting factors with the criteria of Eigenvalue larger than 1 and through the orthogonal varimax rotation, we obtained the results of factor loading of each image pairs for the two SD evaluations, as shown in Table 2 and 3 respectively.

As indicated in Table 2, four principal factors could be extracted for visual evaluation of product pictures, with explained variance of 29.64%, 26.92%, 20.21% and 9.39% respectively, as well as the total accumulated explained variance reaching 86.16%. The meaning of each factor is explained as below:

1) Factor 1: It includes 9 adjective pairs, namely, Pretty-Ugly, Like-Dislike, Rough-Fine, Pure-Mixed, Frictional-Smooth, Simple-Complex, Decorative-Plain, Comfortable-Uncomfortable, and Conflicting-Harmonious. These adjectives mainly focus on the visual shape and appearance of the object. Products with higher score in this factor may bring fine, pure and simple images to people, and may also arouse strong feeling of Pretty and Like; and vice versa.
2) Factor 2: It includes 5 adjective pairs, namely, Cold-Warm, Intimate-Distant, Hard-Soft, Chill-Passionate, and Low tactile-High tactile. These adjectives are inclined to the describing of tactile experience. Products with higher score in this factor may bring cold and hard images to people, and this kind of tactile feature may also arouse the feeling of Chill and Distant; and vice versa.
3) Factor 3: It includes 5 adjective pairs, namely, Bold-Conservative, Lively-Rigid, Fabulous–Humble, Geometric (Regular) - Organic (irregular), and Safe-Risky. These adjectives are mainly to reflect the emotional elements, such as surprising and exciting. Products with higher score in this factor may bring bold, lively and fabulous images to people, and also arouse the risky feeling; and vice versa.

4) Factor 4: It includes the last 2 adjective pairs, namely, Bright-Dark and Natural-Artificial. This factor may reflect the external glossy (shiny) of the object. Products with higher score in this factor may bring the bright and eye-catching images to people, and is also accompanied with man-made and artificial feelings; and vice versa.

Table 2. Factor analysis result of visual SD evaluation

	Factor			
	1	2	3	4
Pretty-Ugly	.903	-.161	-.074	-.204
Like-Dislike	.871	-.353	-.064	-.143
Rough-Fine	-.851	.101	.241	-.259
Pure-Mixed	.788	.325	-.334	.188
Frictional-Smooth	-.764	.018	.120	-.323
Simple-Complex	.733	.336	-.349	.211
Decorative-Plain	-.728	.059	.569	.146
Comfortable-Uncomfortable	.641	-.575	-.293	-.054
Conflicting-Harmonious	-.638	.467	.516	-.088
Cold-Warm	.035	.951	-.063	.139
Intimate-Distant	.225	-.930	.044	-.059
Hard-Soft	-.156	.870	.102	.079
Chill-Passionate	.355	.809	-.376	-.002
Low tactile-High tactile	-.109	.685	.023	.610
Bold-Conservative	-.277	.103	.925	-.001
Lively-Rigid	-.073	-.326	.903	.071
Fabulous-Humble	-.380	.052	.867	-.013
Geometric(Regular)-Organic (irregular)	.082	.529	-.596	.400
Safe-Risky	.505	-.543	-.557	.052
Bright-Dark	.317	.047	.046	.822
Natural-Artificial	.179	-.613	.061	-.619
Eigenvalue	8.624	6.161	2.057	1.251
Explained variance	29.64%	26.92%	20.21%	9.39%
Accumulated variance	29.64%	56.56%	76.77%	86.16%

Table 3 shows that four principal factors could be extracted for tactile evaluation of material samples, with the explained variance of 35.99%, 29.29%, 18.86% and 10.26% respectively, as well as the total accumulated explained variance reaching 94.39%. The meaning of each factor is explained as below:

1) Factor 1: It includes 8 adjective pairs, namely, Hard-Soft, Cold-Warm, Intimate-Distant, Safe-Risky, Chill-Passionate, Geometric (Regular)-Organic (irregular), Conflicting-Harmonious and Low tactile-High tactile. The adjectives under this factor mainly reflect the tactile feeling, which depends more on the hard and cold features among the physical properties. Products with higher score in this factor may bring strong hard and cold images, and may further arouse the corresponding psychological feelings, such as distant, risky and chill emotions; and vice versa.

2) Factor 2: It includes 8 adjective pairs, namely, Frictional-Smooth, Rough-Fine, Pure-Mixed, Pretty-Ugly, Simple-Complex, Comfortable-Uncomfortable, Like-Dislike and Bright-Dark. The adjectives under this factor mainly reflect the tactile feature as well, which focus on the roughness feature of the object surface. Products with higher score in this factor may bring obviously smooth, fine and pure images to people, and may also arouse the feeling of Pretty, Comfortable and Like; and vice versa.

3) Factor 3: It includes 4 adjective pairs, namely, Bold-Conservative, Fabulous–Humble, Decorative-Plain and Lively-Rigid. The adjectives under this factor are inclined to the psychological and emotional dimension. Products with higher score in this factor may bring bold and fabulous images to people; and vice versa.

4) Factor 4: It includes the last adjective pair, namely, Natural-Artificial. This factor clearly reflects the material composition; it is either organic or inorganic, and either highly processed or not. Products with higher score in this factor will give highly natural image to people.

Table 3. Factor analysis result of tactile SD evaluation

	Factor			
	1	2	3	4
Hard-Soft	.979	.006	.039	.060
Cold-Warm	.961	.121	.100	-.114
Intimate-Distant	-.959	.001	-.068	.227
Safe-Risky	-.958	.069	-.157	.031
Chill-Passionate	.929	.284	-.044	-.196
Geometric(Regular)-Organic (irregular)	.777	.441	-.059	-.328
Conflicting-Harmonious	.766	-.567	.246	-.074
Low tactile-High tactile	.595	.371	-.482	-.415
Frictional- Smooth	-.105	-.955	-.012	.164
Rough-Fine	.114	-.937	.041	.282
Pure-Mixed	.317	.901	-.102	-.203
Pretty-Ugly	.125	.893	.126	.317
Simple-Complex	.386	.739	-.334	-.401
Comfortable-Uncomfortable	-.594	.737	-.115	.172
Like-Dislike	-.432	.666	.008	.564
Bright-Dark	.483	.597	.525	-.256
Bold-Conservative	.145	-.119	.955	-.055
Fabulous-Humble	.202	.065	.933	.146
Decorative-Plain	.149	-.141	.886	-.219
Lively-Rigid	-.492	.118	.786	.184
Natural-Artificial	-.206	-.237	-.070	.912
Eigenvalue	8.511	6.050	3.830	1.431
Explained variance	35.99%	29.29%	18.86%	10.26%
Accumulated variance	35.99%	65.28%	84.14%	94.39%

3.2. Comparative analysis on the composition of visual and tactile factors

To compare the results of the two factor analyses this study then consolidated images (adjective pairs) in each factor shown in Table 2 and 3 to get a corresponding matrix as showed in Table 4. By reviewing these three tables we had the following comparisons:

1) The accumulated explained variance of factor analysis for visual SD evaluation is lower than that of tactile assessment（86.16%<94.39%）. In the visual SD evaluation, six images（Comfortable-Uncomfortable, Conflicting-Harmonious, Low tactile-High tactile, Geometric(Regular)-Organic (irregular)、Safe-Risky、Natural-Artificial） have related low factor loadings (less than 0.7) in their attributed factor but related high factor loadings (higher than 0.5) in some non-attributed factors On the contrary, there are only two images in tactile SD evaluation（Geometric(Regular)-Organic (irregular), Conflicting-Harmonious）under the same condition. The result shows that some visual images are relatively independent compared to tactile images.

2) Table 4 shows that the image compositions of factors in the two sensory are approximately

corresponded. The visual factor 1 is closely corresponding to tactile factor 2, with common images including: Pretty-Ugly, Like-Dislike, Rough-Fine, Pure-Mixed, Frictional-Smooth, Simple-Complex and Comfortable-Uncomfortable, which are images related to preference, style and composition. Visual factor 2 is similar to tactile factor 1 in composition with common images including: Cold-Warm, Intimate-Distant, Hard-Soft, Chill-Passionate, Low tactile-High tactile. They mainly reflect the tactile based experience and the corresponding psychological image. Both factor 3 of visual and tactile evaluations, including common images of Bold-Conservative, Lively-Rigid, Fabulous-Humble, are corresponded to mainly reflect psychological related feelings. Finally, both factor 4 of visual and tactile evaluations are corresponded containing the common image of Natural-Artificial. With these corresponding arrangements, 16 out of 21 images are shared by both visual and tactile evaluation; or we may say the corresponding rate of these two senses is about 76% (16/21).

3) The remaining five non-corresponded images include Conflicting-Harmonious （visual factor 2, tactile factor1）, Decorative-Plain（visual factor 1, tactile factor 3）, Safe-Risky and Geometric (Regular) - Organic (irregular)（visual factor 3，tactile factor 1）, Bright-Dark（visual factor 4，tactile factor 2）. Among them Conflicting-Harmonious and Geometric (Regular) - Organic (irregular) have relatively low factor loadings in the attributed factors of both factor analyses. Thus, they are somewhat incongruent with other images in the same attributed factors; they may belong to other factors not yet abstracted. Factor loadings of Safe-Risky and Decorative-Plain are low in attributed visual factors but high in attributed tactile factors. On the contrary, Bright-Dark has significantly high factor loading in attributed visual factor but low in attributed tactile factor. It shows that these three images have different meanings in visual and tactile sensory. According to the factor loadings and attributed factor of Safe-Risky in tactile sensory, this image is strongly and clearly associated with the toughness and felt temperature of the touched material. Bright-Dark is the image that can be felt clearly through vision but is not a clear feeling in tactile sense. Decorative-Plain image is clearly associated with some psychological feelings of activeness in tactile sense, while it is somewhat associated with feelings of evaluation or preference in visual sense.

4) Like-Dislike, Pretty-Ugly and Comfortable-Uncomfortable are the images related to preference used in the SD evaluations. They are closely correlated with Rough-Fine, Pure-Mixed, Frictional-Smooth and Simple-Complex images in both visual and tactile sensory. Visually or tactilely fine, pure, smooth, simple are important to make products preferred. Among these images roughness and smoothness are more tactile oriented perceptual feelings, whereas purity and simplicity are more visual oriented ones. This finding disagree with people's generally thinking that a soft and gentle (felt temperature) tactile is significantly related to the degree of comfort.

5) Through corresponding matrix of Table 4, it also shows another interesting phenomenon. In the touch-oriented images, Cold-Warm and Hard-Soft are integrated. However, integrated tactile is an important element influencing Low tactile-High tactile images. On the other hand, Rough-Fine and Frictional-Smooth can be integrated into one. As for vision, only Pure-Mixed and Simple-Complex show significant correlation and other vision-oriented images are distributed to various factors. At the same time, the tactile sense of Rough-Fine and Frictional-Smooth, and the visual sense of Pure-Mixed and Simple-Complex show high correlation with each other. The classification of these two sensory assessments is consistent. The result shows that the visual sense is significantly correlated to the roughness on material. By modifying the roughness of the materials, visual images can be affected, such as images of

simplicity and purity can be greatly enhanced.

Table 4 Corresponding matrix of factors abstracted in the two factor analyses

Visual factors / Tactile factors	Factor 1	Factor 2	Factor 3	Factor 4	Sum
Factor 1	Conflicting-Harmonious	Cold-Warm Intimate-Distant Hard-Soft Chill-Passionate Low tactile–High tactile	Safe-Risky Geometric (Regular)-Organic (irregular)		8
number	1	5	2		
Factor 2	Pretty-Ugly Like-Dislike Rough-Fine Pure-Mixed Frictional-Smooth Simple-Complex Comfortable-Uncomfortable			Bright-Dark	8
number	7				
Factor 3	Decorative-Plain		Bold-Conservative Lively-Rigid Fabulous-Humble		4
number	1		3		
Factor 4				Natural-Artificial	1
number				1	
Sum	9	5	5	2	21

4. CONCLUSION

In order to understand what images the visual or tactile sense may be dominant, as well as the association between sensory and images, the study performed visual and tactile SD evaluations with stimuli of product pictures and material samples respectively. We then conducted corresponding factor analyses on the data obtained from the two SD evaluations and compare the differences of resulted factors and factor composition. The result of this study can be summarized as below:

1) Through factor analyses, both visual and tactile SD evaluations can obtain 4 factors. Generally, the accumulated explained value of visual factor analysis is lower than that of tactile factor, which shows that some visual images are more independent and difficult to be classified than tactile images.

2) According to the significant similarity and difference in composition of factors derived from the two factor analyses, it can be found that the correlation between visual image and tactile image is high. As for the difference between these two sense organs, psychological images of the tactile sense are more closely correlated to objective perception on materials.

3) Tactilely felt roughness will affect the preference to the touched material and is closely correlated to the visual experience. This also shows that roughness is an image of complex

sensory and is equally dominated by both vision and touch.

4) As for roughness and temperature on the sense of touch, they are weakly correlated to vision, which show no strongly clear correlation to visual image. Therefore, these two images of the sense of touch also depend on the tactile assessment, without visual impact.

5) Finally, it is interesting that the results of imagery classification show a high relevance with tactile feeling and intimacy degree, which is not functioned by vision. Whether it indicates that the feeling of intimacy is generally not obtained and presented by vision. Therefore, in the process of visual assessment, the images can not be clearly classified. On the contrary, touch sense has great advantage in creating intimacy and intimate feeling. This advantage might come from the direct interaction between human and product or human and human, which is generated mainly due to physical contact.

The can be served as a reference for designer to transfer the image of tactile sense in product design. By introducing specific tactile feelings, the visual image can be strengthened to build overall characteristics of product. For future studies, the result of this study can also provide a basis of reference for investigation on the tactile image, especially on the research of synesthesia.

ACKNOWLEDGMENTS

This research was supported in part by the National Science Council, Roc under Grant no. NSC 99 - 2221 - E - 009 - 127 - MY3.

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BIOGRAPHY

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Characterizing Perceptions of Material Sustainability through Drinking Vessels

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Abstract: Our perceptions of the environmental impacts that materials have tend to be formed by vernacular knowledge and experience. We are familiar with recycling aluminum cans, so aluminum must be sustainable because it is so recyclable. We bring our own mugs to the coffee shop because we see ceramic mugs as more durable than disposable paper cups. Images of plastic bottles littering our landscapes lead us to believe that polymers are harmful because they don't degrade. Our perceptions of the sustainability characteristics of these materials – aluminum, ceramic, and polymer – are influenced by our experience with products made from these materials. To date, Kansei engineering studies to assess perceptions of the sustainabilities of materials have been conducted with materials samples. The goal of this study is to see how people perceive the sustainability of a material used to make a specific product. For the study, a series of seven drinking vessels, each made of a different material, was fabricated. Each vessel was designed to have the same environmental impact as its companions, as calculated based on the 2007 Okala single-figure Life Cycle Assessment (LCA). This paper examines how people perceived ten unique sustainability attributes of these drinking vessels, and which of these attributes may have a dominant effect on the product's overall perceived sustainability. Clarifying which attributes of sustainability influence peoples' understanding of a product's overall sustainability will help product designers and engineers select materials for products that consumers will accept, understand, and champion for their reduced environmental impacts.

Keywords: Materials Selection, Sustainability, Product Development, Life Cycle Assessment, Kansei Engineering

1. INTRODUCTION

Consumers today consider the sustainability of a product to be important. Companies know that sustainability influences consumers in their purchasing decisions. New product developers are trying to develop more environmentally friendly, sustainable products that consumers will enjoy. Qualitative strategies (Graedel, Allenby, 1995; Lewis, Gersakis, 2001) and quantitative assessment tools such as the Okala LCA and Sustainable Minds LCA, help designers create more sustainable products. However, tools do not exist that include the intuitive response that a customer has to the sustainability of an object. The visceral response a person has to an object may not correlate to the qualitative strategies chosen by the designer, nor to the calculated impact of a product determined by LCA. It would be beneficial for designers and companies to incorporate peoples' subjective responses to sustainable attributes when intentionally designing more sustainable products with tools that couple consumer perception with calculated decision-making.

Materials choice can improve the sustainability of products, and is a frequent feature-area that is used to affect sustainability and drive consumer perception of a sustainable product. However, sustainability assessment tools do not take into account the knowledge, or lack of knowledge, that consumers have regarding materials (Crabbé, et al., 2013; Hsu et al., 2013). While materials provide discreet features through their material properties, including mechanical properties, chemical properties, optical properties and thermal properties, the sustainability of the material is defined with a combination of elements from all of the material properties. The fact that a connection exists between materiality and sustainability is well documented, but very few studies have been conducted to relate the intangible characteristics of materials to the concrete materials choices designers have at their disposal (Karana et al., 2009). Whether or not a material is perceived to be – and in practice would be – recycled, bio-degradable, or natural, as examples, is dependent on the product (Karana, 2012). Full life-cycle assessments place the materials in context with the use and functions of the product (Clancy, et al., 2013), but they are not practical nor necessarily accurate during the development of a yet un-realized product.

Breaking apart the many issues of sustainability that a material embodies can clarify the discreet issues that materials address. This study was designed to test consumer perceptions of materials on ten sustainability-oriented attributes. Discovering the kinds of attributes that customers are concerned with will help fulfill their expectations of greener products (Tseng and Huang, 2013). Because the product form influences how a material may or not behave sustainably, it should also influence the consumer perception of a material's sustainability. The product used for this study is a drinking vessel, or cup, chosen for it's clear use-scenario – beverage consumption – and the great variety of consumer-accepted materials and forms possible for a functional product.

A series of seven drinking vessels, each made of a different material, was fabricated. Each vessel was designed to have the same environmental impact as its companions, as calculated based on the 2007 Okala single-figure Life Cycle Assessment (LCA). A Kansei-engineering study with word-pairs developed to address various aspects of sustainability was conducted to investigate which sustainability attributes people relate most strongly with each product and, by extension, the materials used to make the product.

2. METHODS AND MATERIALS

Seventy people participated in the Kansei cups ranking exercise, all of whom were students at the University of Oregon. Their ages ranged from 18 to 28. There were 25 female and 45 male participants. Two groups of students, each enrolled in a product design course, were given the opportunity to participate. Participation in the study was concluded prior to the introduction of course information regarding material sustainabilities. Forty-three of the participants were provided with extra credit for their course as compensation for participating in the study. For the two students who participated from both courses, only the results from their first experience with the study are included in these results.

2.1. Cups

The sample cups used in this study were designed to be fabricated specifically for this study. Each cup is a different material, and 5 different manufacturing processes were used: sand cast secondary aluminum, slip cast ceramic, blown 100% recycled glass, blown primary glass, injection molded primary polypropylene, and rotationally molded primary high-density polyethylene. They were designed for their height, opening diameter and base diameter to be as similar as possible, considering the different requirements in proportion necessary for different fabrication processes. The wall thicknesses for the cups vary. The wall thickness for a given vessel was defined by the overall ecological impact of the vessel based on the material and the fabrication process used, and calculated using the 2007 Okala LCA tool (White et al., 2007). The goal was to create a set of vessels with as close to the same ecological impact as possible. All dimensions of the vessels needed to obey the manufacturing requirements for each process, including wall thickness and draft angle. The differences in impact for the theoretical vessels ranged from 4.58 to 4.85 Okala impact factor points. (See Table 1)

Table 1: Okala Impact Factor calculations for theoretical cups

Material	Material Impact Factor	Fabrication Process	Fabrication Impact Factor	Wall Thickness	Total Impact Factor Points
Aluminum, secondary	17	Cast	18	1 mm	4.81
Ceramic, sanitary	19	Heat	0.003996	1.4 mm	4.67
Glass, 100% recycled	6.5	Heat	0.003996	7 mm	4.58
Glass, primary	9.1	Heat	0.003996	5 mm	4.82
Polypropylene, primary	13	Injection Mold	10	5 mm	4.48
High-density Polyethylene, primary	12	Rotational Mold	14	3 mm	4.85

The fabricated vessels differed from the theoretical vessels due to the ability for manufacturers to fabricate at the required wall thicknesses, and for the ability to hold tolerances for the given fabrication processes. Also, the final aluminum cup was spun rather than cast. The rotational molder also provided linear low-density polyethylene (LLDPE) cups made from the same mold that produced the HDPE cups, as the final product was a better fill with LLDPE than with HDPE. Images of the virtual and final production cups are in Figure 1.



Figure 1: Rendering of cups (left) and production cups (right). Cups are from Left to Right, spun secondary aluminum; slip cast ceramic; blown 100% recycled glass; blown primary glass; injection molded primary polypropylene; rotationally molded, primary high-density polyethylene; and rotationally molded, primary linear low-density polyethylene.

The cups were provided to the participants as a 7-member sample set, one of each cup, in a box with an identifier letter. All cups in that box were labeled with the same identifier letter to monitor potential differences in the respondents' reactions to different sample sets. The cups were not identified with either the name of the material, or the fabrication process used.

Similar to previous Kansei studies of the perceptions of materials' sustainabilities (Muenchinger, 2012; Muenchinger 2013b), the participants in this study were asked to rank each cup on 10 word pairs. The word pairs were designed to target qualitative strategies of sustainable design. The word pairs were: *Rare – Common; Delicate – Durable; Lasting – Degradable; Raw – Sophisticated; Harmless – Toxic; Inexpensive – Costly; Luxurious – Meager; Natural – Artificial; Precious – Valueless; Recyclable – Waste*. Materials selection goals outlined by Graedel and Allenby (Graedel and Allenby: 240) of choosing abundant (*Rare – Common* and *Inexpensive – Costly*), non-toxic *(Harmless – Toxic)*, natural *(Natural – Artificial),* and minimal and minimally processed *(Luxurious – Meager* and *Raw – Sophisticated)* materials were included in the word pairs. Additional design for waste minimization strategies from Lewis and Gertsakis (Lewis and Gertsakis: 86-87) including extending the product life *(Delicate – Durable* and *Precious – Valueless),* using recyclable materials *(Recyclable – Waste)* and minimizing the impacts of disposal *(Lasting – Degradable)* were also used.

3. RESULTS

During each testing session, at least 2 ceramic cups were broken by the participants. The broken cups were replaced immediately with new ceramic cups, and the participant who was working with the cup was able to finish the survey. Because the breaking was heard and seen by other people in the testing space, the breaking ceramic cups may have influenced responses from more participants than just the few who broke the cups themselves.

Average ranking results for each of the cups examined are provided in Table 2. They have been modified from the original scoring sheets to position the more environmentally friendly word of the pair at the "1" side of the ranking on the 1-7 scale.

Table 2: Average rankings of 7 cups on 1-7 scales.

Cup	Spun AL	Slip Cast Ceramic	Blown Recycled Glass	Blown Primary Glass	Injection Molded PP	Roto Molded HDPE	Roto Molded LLDPE
Common (1) to Rare (7)	4.20	5.25	2.90	2.71	2.29	1.99	1.59
Durable (1) to Delicate (7)	1.53	6.25	3.70	4.06	1.84	2.13	2.31
Degradable (1) to Lasting (7)	5.53	3.28	5.56	5.46	5.20	4.83	4.79
Raw (1) to Sophisticated (7)	3.30	2.62	4.57	4.58	3.89	3.50	3.34
Harmless (1) to Toxic (7)	2.96	3.52	2.07	2.09	4.29	4.53	4.59
Inexpensive (1) to Costly (7)	4.61	2.90	4.26	3.90	2.39	2.06	1.91
Meager (1) to Luxurious (7)	3.96	2.87	4.50	4.33	2.57	2.07	1.93
Natural (1) to Artificial (7)	3.84	3.32	3.56	3.68	6.17	6.19	6.34
Precious (1) to Valueless (7)	4.11	4.91	3.80	3.93	5.37	5.83	5.91
Recyclable (1) to Waste (7)	2.60	4.22	3.09	2.83	4.07	4.03	4.01

3.1. Individual word-pair results

It is visually apparent in the chart of the data (Figure 2) that there is no one cup that is perceived to be sustainable on all of the word-pairs.

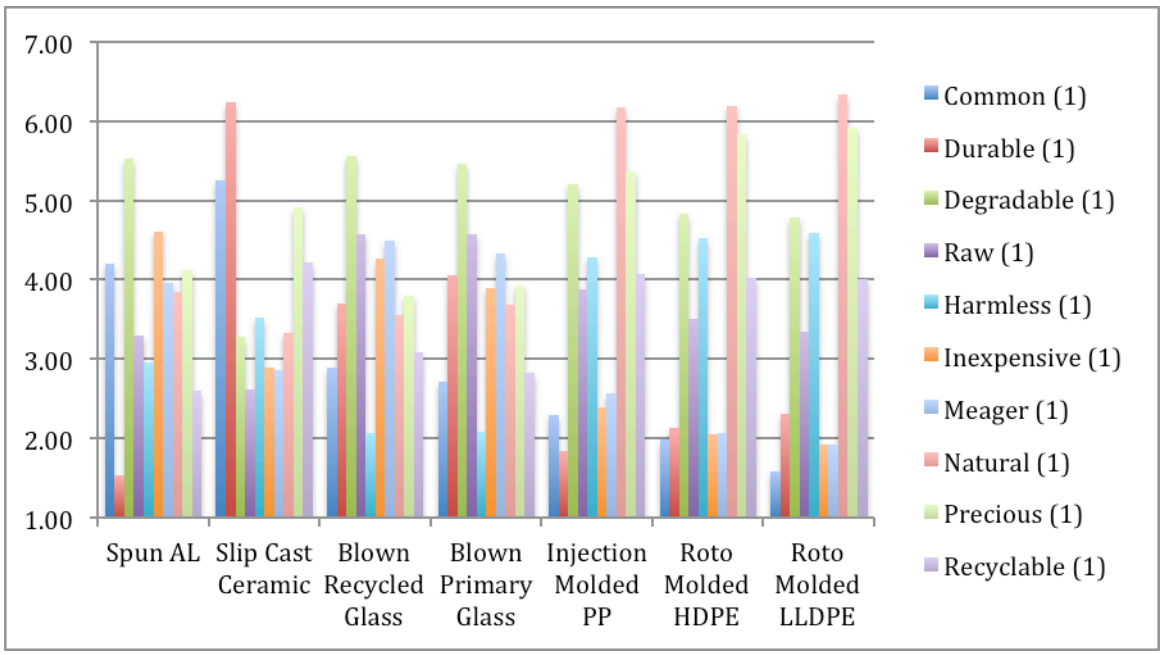

Figure 2: Rankings of seven cups for each of ten attributes of sustainability. Attributes are ranked on scales of 1-7, with 1 indicating highest sustainability and 7 indicating lowest sustainability.

3.2. Trends

From Table 2 and Figure 2, outlying factors are apparent:

- Of the 70 individual rankings in the matrix, 35 tended toward midline. 50% were outliers from midline. 23 outliers were below 3 (33% of total), 12 above 5 (17% of total).
- The blown recycled glass has the narrowest range in responses. 7 of the 10 word-pairs average in the 3.00-5.00 midline area.
- The polypropylene cup has the widest ranges of responses. Only 3 of the 10 word-pairs average in the 3.00-5.00 midline area.
- The polymer cups were ranked similarly in all word-pairs.
- The glass cups were ranked similarly in all word-pairs.
- The aluminum cup is seen as the most durable. It is the strongest perception of any factor and of any cup tested.
- Very low durability of the – very thin – ceramic cup is perceived. All other durability factors lie 2 points or more lower.
- None of the cups are seen as highly degradable. The cup with the strongest perception of degradability is the ceramic, which as noted above is not seen as durable.
- The perception of harmlessness is strongest in the 2 glass cups.
- The three polymers are not perceived as natural. The strongest negative perception of sustainability is the artificiality of the LLDPE cup.
- The aluminum cup has the strongest perception of recyclability.

4. DISCUSSION AND CONCLUSION

Compared to prior studies of peoples' perceptions of the sustainabilities of materials (Muenchinger, 2012; Muenchinger, 2013a; Muenchinger, 2013b), this study produced a more diverse and divergent response than materials samples in the form of spheres or flat plaques provoked. The responses from this cups study did not bunch in the midline area as occurred in the prior studies. These identifiable products with a specific use elicited stronger opinions. Future studies with other products would provide insight into where our perceptions of materials are influenced by a particular product use. Cups, for example, have a highly intimate use scenario, as they are held in our hands, come in contact with our mouths and deliver sustenance to our bodies.

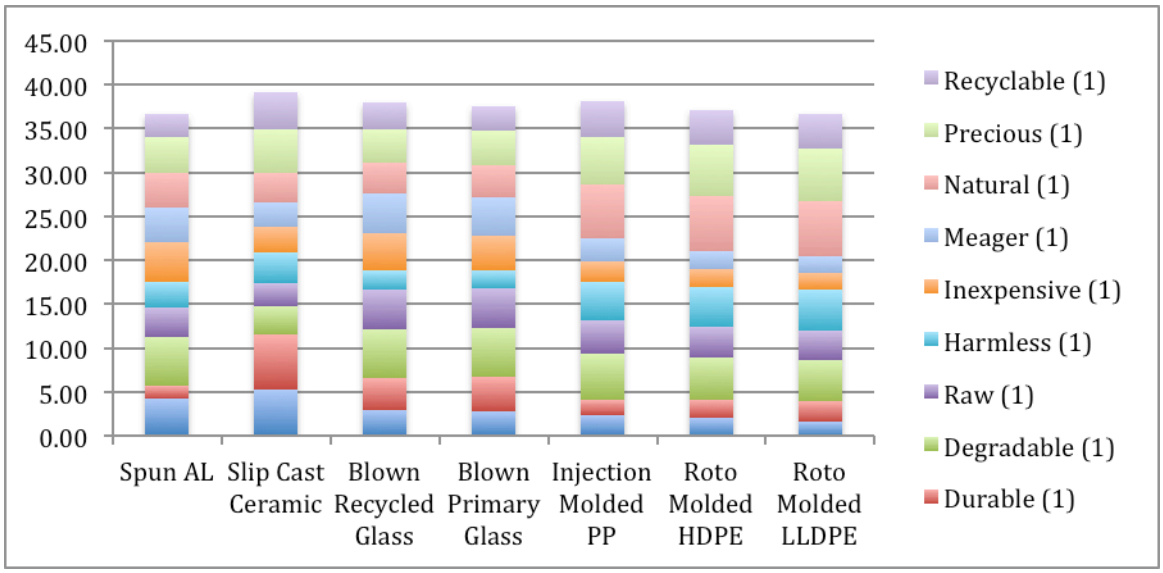

Figure 3: Sum totals of average sustainability perceptions for seven cups.

4.1. Perceptions of Spun Aluminum Cups

The sum totals of the average perceptions across all 10 word-pairs for each cup show the spun aluminum cup with the lowest total (36.64) as seen in Figure 3, implying the strongest perception of sustainability inclusive of these 10 word-pairs.

- The aluminum cups were perceived to be the most Durable, despite the thinnest wall of all of the cups.
- They were perceived to be the most Recyclable of all of the cups. This result differs from the study of spherical material samples (Muenchinger, 2013b) in which the aluminum sample was not perceived to be particularly recyclable. The aluminum cups did not have the high degree of polish that the spherical material samples in the previous study had.
- The spun aluminum cup was the second most Raw cup.
- It was the most Costly material. It is interesting that this material is perceived to be both Raw and Costly. Intuitively, one might consider a more processed-looking, sophisticated material to be perceived as more costly. In this case, the spun aluminum cup held a perception of cost and a perception of rawness.

4.2. Perceptions of Slip Cast Ceramic Cups

The slip cast ceramic cups had a sum total average of 39.13 (Figure 3), the highest of all of the cups in this study.

- The only cup perceived to not be Durable is the ceramic cup, which is also the cup that was consistently broken during the tests. It had a wall thickness similar to that of the aluminum cup, and was consistently broken during testing.
- While none of the cups were perceived to be particularly Degradable, this cup had the lowest perception of Degradability at 3.28. This may have been influenced by the breaking.
- This cup had the strongest perception of being Waste rather than Recyclable. People may not perceive recyclability in ceramics because municipal ceramics recycling is rare.
- Raw, Inexpensive and Meager were the most sustainable traits for the ceramic cups. These perceptions also may have been influenced by the breakage and the thin walls of the cups. The wall thickness was unusual (1.4mm) compared to a typical ceramic drinking vessel (5mm).
- Natural and Degradable may be perceived as similar qualities, but the ceramic cups are the only cups that had similar perceptions in these two categories. The ceramic cups had the strongest perception of being Natural compared to Artificial at 3.32.

4.3. Perceptions of Blown Primary and Recycled Glass Cups

The two glass cups showed similar responses in all of the word-pairs. The recycled glass cups were thicker, and visually were less consistent and more wavy than the primary glass cups. The mold, blowing and finishing processes for these two cups was the same.

- Both glass cups were perceived as the most Harmless of all of the cups. The perception of glass being non-toxic or inert is a strong quality for sustainable design.
- Both glass cups were perceived as the least Raw and least Meager, and most Precious of all of the cups. These perceptions were not the strongest in this study, but they do point to an appreciation for the basic material qualities of glass.
- The glass cups had strong sustainability perceptions of being Natural and, implied by least Raw, least Meager and most Precious, strong perceptions of high-quality. ‘Natural’ and ‘high-quality’ are materials perceptions that Karana notes would aid the consumer-acceptance of bio-plastics (Karana, 2012). The material qualities of glass could be used to inspire the chemical development of bio-plastics to achieve similar results.
- While both cups were perceived as recyclable, they were not strong in this perception. With long-standing municipal recycling of glass bottles, there is common knowledge of glass recycling. The cup product could move the perception that glass in this particular form or in this

particular product is not recyclable, but this did not seem to be the case for the aluminum cup. Perhaps the perceptions of Preciousness, Luxury and Sophistication of the glass cups reduce the perception of Recyclability.
- The recycled glass cups were perceived as the least Degradable of all of the cups. The aluminum and primary glass cups were close.

4.4. Perceptions of Injection Molded Polypropylene Cups

The injection-molded polypropylene cups were the most dimensionally precise and consistent of all of the 7 cups fabricated for this study. It had the thickest wall of the three polymer cups at 5mm. This is thicker than a typical polymer cup that would be found for retail purchase, which would measure around 2mm in wall thickness. This cup is thicker than a normal polymer cup due to the design intent of testing cups with equivalent Okala impacts.

- While all of the polymer cups were perceived and ranked similarly on the word-pairs, the polypropylene cup was perceived to be the most durable and the least Degradable of the three polymer cups. This perception may be influenced by this cup's thicker wall.
- This cup was perceived as less Raw than the other 2 polymer cups. This may be due to the tighter tolerances held in injection molding. The tight tolerances do not seem to make the cup appear highly Sophisticated, or processed, however, as the score is mid-range at 3.89.
- This cup is perceived to be slightly more Costly and Luxurious than the other polymer cups, but as both of these word-pair rankings are well below the mid-range, it does not appear that the precision of injection molding has strong influence on the overall sustainability perceptions on these word-pairs. The materiality appears to influence the perception of sustainability to a much greater degree than the production process.

4.5. Perceptions of Rotationally Molded Linear Low-Density Polyethylene Cups

Surprisingly, the rotationally molded LLDPE cup has the second-lowest total (36.73) average (Figure 3). While all of the polymer cups were ranked as highly Artificial and Valueless and had higher ratings for Toxicity and Lasting-ness than the other cups, the sum total for LLDPE was the second lowest overall after the aluminum cups. The polymer cups are more divergent than the other cups in how the various factors of sustainability are seen.

- They are all perceived to be highly Common, Durable, Inexpensive and Meager. Excluding Durable, these attributes tend not to be considered good attributes for new products even though they are attributes of environmentally friendly products.
- The strong perception of Valueless-ness is contrary to the perception of being Inexpensive. How a product can be both Inexpensive and Precious may be a prime target area for sustainable design tactics.
- The perception of Artificiality of polymers is an issue being addressed with bio-polymers such as polylactic acid (PLA). Artificiality is a prime area to target for the acceptance of polymers as a sustainable material.

4.6. Overall Analysis

The Kansei study of the perceptions of the sustainabilities of various materials is stronger and more nuanced when testing products compared to testing materials samples. The product testing with cups corroborates results from prior studies, such as polymers having a strong perception of Artificiality, and Inexpensiveness (Muenchinger, 2012; Muenchinger, 2013a). This perception is strong and consistent across multiple studies. Because these perceptions are so strong, the goal of imbuing polymers with materials properties that convey 'naturalness,' as described by Karana (2012) is not a strong strategy for current polymer products. Based on the strong Natural response to glass, transparency may influence the perception of naturalness, and that is a possible

material property for polymers. However, focusing on 'high-quality' as it pertains to Durability, a trait that is strong for polymers across several studies, is a sustainability story that consumers are more likely to emotionally understand and trust.

Statistical analysis of these results should be performed to determine which sustainability factors, or word-pairs, are more important or more noticeable to customers. The important factors are the ones that more dominantly influence purchasing decisions and would therefore have a stronger effect on market-driven sustainable products.

Fabricating equal-impact products for this study should also be examined. Using products with equal impacts was intended to eliminate a variable for this Kansei study of perceptions. Whether equalizing the field of products in this way had an affect on the study is unclear. Statistical analysis of the results may show the value of testing equal-impact products. Future product-based studies would be more accessible on less similar products, and could be performed confidently if the quantitative effects of impact are negligible.

The desire from consumers, designers and companies to have more sustainable products is a driver that will remain indefinitely. There is a long-term need to continue assessing human perceptions around materials and sustainability. There is a gap in product design's toolbelt. A public reference database of materials and metrics would aid new sustainable product design. As our knowledge grows, the usefulness of the database will only increase.

More complete tools give us confidence in our developments, and in our definitions of what a sustainable product is. Kansei studies of materials will help us attain more specific and more consumer-accepted sustainable product definitions.

ACKNOWLEDGMENTS

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BIOGRAPHY

Kiersten Muenchinger is an Associate Professor and the founding Director of the Product Design Program at the University of Oregon. Her research and creative practice focus on unusual materials use with an emphasis on sustainability and metrics. She utilizes Kansei engineering studies to quantify consumer perceptions of the green-ness of product materials, and references them with Okala Life Cycle Assessment data. Her original product work was featured recently in the Salão Design exhibition in Brazil. Before joining UO, Kiersten held design engineer positions with IDEO, Sottsass Associatti, Walt Disney Imagineering, and the Long Now Foundation.

Influence of Visual and Pressure Information on Clothing Pressure Sensation

- From Evaluation of Autonomic Nerve Activity and Sensory Test -

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Abstract: Clothing comfort sensation is composed of multisensory processes and involves complex processes, in which a large number of stimuli from clothing and external environments are communicated to the brain through multiple channels of sensory responses to form subject perceptions. We get much information through visual sensation, so studies on the influences of visual information on clothing pressure sensation is very important. The purpose of this study is to investigate the effect of clothing pressure on physiological and psychological responses in order to create a method for evaluation of clothing comfort. We have measured physiological and psychological responses in the clothing pressure sensation under 3 visual conditions; Condition 1 was that the subjects had their eyes open and looked forward, Condition 2 was that the subjects looked at themselves in a mirror, and Condition 3 was that the subjects without a waist belt look at other subjects who wore a fastened waist belt. Consequently, in all three conditions, the sympathetic nerve activity decreased. The sympathetic nerve activity decreased also in Condition 3 in which the information of clothing pressure was added through only visual sensation. In the re-rest period, the response in Condition 2 was significantly larger than that in Condition 1 and Condition 3. We concluded that it is important to consider the effects of visual information as well as the effect of clothing pressure sensation in the evaluation of clothing comfort sensation.

Keywords: Clothing pressure sensation, Visual sensation, Multisensory, Physiological responses, Psychological responses

1. INTRODUCTION

The purpose of this study is to quantitatively clarify clothing pressure sensation by measuring the physiological and psychological responses when the information of clothing pressure fastened with waist belt is received from visual and pressure sensations in order to confirm the necessity of assessing clothing comfort from the viewpoint of multisensory integration.

Normally, we perceive and recognize clothing comfort not with a single organ but with multisensory integration. Clothing comfort can refer to feelings of a number of aspects, such as thermal comfort, tactile comfort, body-fit comfort, and esthetic comfort. This suggests that clothing comfort is multisensory and involves complex processes in which a large amount of information from clothing and external environments is communicated to the brain through multiple channels of sensory responses to form subject perceptions.

There are many reports about the multisensory integration (Kumazaki, Terada & Ito, 2006; Okamura, 2012; Ueda & Saiki, 2007). For example, a typical is the McGurk effect in which a pronunciation is heard as “da” when the actual pronunciation of “ba” is synchronized with seeing the movement of the lips when pronouncing “ga” (McGurk & MacDonald, 1976). It is assumed that integrating information from various sensory organs generates a new perception which differs from the perception of a single organ.

There are few reports related to multisensory integration regarding evaluation of clothing comfort. We have reported that the physiological and psychological responses due to the clothing pressure was different in the states of closed eyes versus open eyes when we evaluated the sensation of pressure on the abdomen from a waist belt (M. Uemae, T. Uemae & Kamijo, in press). That is, the physiological and psychological responses were different for the stimulation presentation that combined the sense of pressure with visual stimulus and the stimulation presentation of only the sense of pressure. In this paper, based on these results, we measured physiological and psychological responses to the stimulation presentation combining pressure sensation and visual sensation to evaluate clothing comfort from the viewpoint of multisensory integration.

Experiments for this research were conducted with the approval of Shinshu University's Ethical Committee for Research on Humans.

2. EXPERIMENTALS

2.1. Experiment Method

The experiment to investigate the difference in psychological and physiological responses to mono-sensory information and to multi-sensory information was carried out under the following three conditions: clothing pressure stimulus by pressure sensation [Pressure sensation], clothing pressure stimulus by pressure and visual sensations [Pressure + Visual sensations], and clothing pressure stimulus by visual sensation [Visual sensation]. Table 1 shows the three experimental conditions.

Pressure amounting to 90% of the subjects’ waist size was applied to their abdominal region by a waist belt. Assuming normal clothing pressure in daily life, the waist belt used in this study was of a non-elastic material and 4 centimeters in width.

We measured physiological and psychological responses in the clothing pressure sensation under three visual conditions; Condition 1 was that the subjects had their eyes open and looked

forward, Condition 2 was that the subjects looked at themselves in a mirror, and Condition 3 was that the subjects without a waist belt look at other subjects who wore a fastened waist belt.

Figure 1 shows an experimental procedure. The procedure was repeated three times, once for each of the three experimental conditions. The break between conditions was 5 minutes. The three experimental conditions were carried out in random order to offset an order effect.

Table 1: Experimental conditions

		Rest	Stimulation	Re-rest
Condition 1	**Visual condition**	Eyes open and look forward	Eyes open and look forward	Eyes open and look forward
	Pressure by wearing a fastened waist belt	No pressure	Pressure	No pressure
Condition 2	**Visual condition**	Eyes open and look forward	Look at themselves in a mirror	Eyes open and look forward
	Pressure by wearing a fastened waist belt	No pressure	Pressure	No pressure
Condition 3	**Visual condition**	Eyes open and look forward	Look at another person who wore a fastened waist belt	Eyes open and look forward
	Pressure by wearing a fastened waist belt	No pressure	No pressure	No pressure

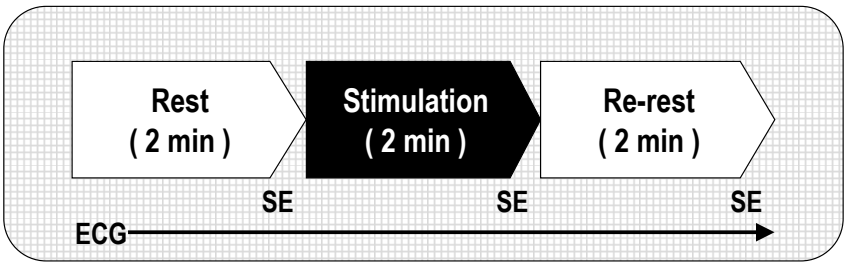

Figure 1: Experimental procedure

The influence of clothing pressure on mental and physical response was evaluated by the following measurements: electrocardiogram (ECG) and sensory evaluation. 10 healthy subjects were recruited, 6 males with ages of 22.0 ± 0.6 years old, waist sizes of 75.4 ± 11.3 centimeters and Body Mass Indexes (BMI) of 21.1 ± 4.8 kg/m^2, and 4 females with ages of 21.8 ± 1.0 years old, waist sizes of 72.6 ± 7.5 centimeters and BMI of 21.4 ± 2.7 kg/m^2. The subjects were prohibited from eating, drinking and smoking for two hours before the experiment started. All

subjects were required to wear underwear, a short-sleeved shirt, and short pants. Atmospheric conditions in the room were maintained at a temperature of 25°C and a relative humidity of 60%. During the recording procedure subjects were seating in a reclining chair to maintain their posture. As shown in Figure 1, ECG was recorded for 6 minutes in total including rest state (2 minutes), stimulation state (2 minutes) and re-rest state (2 minutes). Sensory evaluation was carried out three times, once each in rest state, stimulation state and re-rest state.

2.2. Measurement

ECG was measured in the limb leads by the system of MP150WS (BIOPAC SYSTEMS, Inc.) with 200Hz sample frequency. The semantic differential (SD) method was used in rating subjective perception. Subjects were asked to rate the sensations of comfort, tightness and arousal on a 7-point equal-interval ordinal scale (+3 = feel extremely; +2 = feel very much; +1 = feel slightly; 0 = neither; -1 = don't feel slightly; -2 = don't feel very much; -3 = don't feel extremely).

2.3. Analysis

We removed the trend of ECG, and then a bandpass filter with a bandwidth of 5-40 Hz was applied. The ECG data for 5 seconds immediately before and after measurement were eliminated to prevent the introduction of noise. For analysis of the autonomic nerve system, the ECG data were processed by spectral analysis of heart rate variability (Pagani et al., 1986; Pomeranz et al., 1985; Sayers, 1973). After R-wave peaks were detected, RR interval time-series data were determined. The RR interval data were processed by spline interpolation, and a heart rate variability spectrum was calculated by FFT with Hamming window. Frequency ranges were as follows: low-frequency (LF):0.04-0.15Hz and high-frequency (HF):0.15-0.40Hz. (LF/HF) power ratio was calculated as an index of sympathetic nerve system activity. (HF/(LF+HF)) power ratio was also calculated as an index of parasympathetic nerve system activity. These power ratios were used as an index for assessing physiological response to pressure stimuli (Ishimaru, Nakamura, Nonomura & Yokoyama, 2010; Tamura & Okamoto, 2006).

All statistical analysis of measurement data was performed using the Excel statistical software package (Excel-Toukei 2010; Social Survey Research Information Co., Ltd.). The data were analyzed by the Bonferroni multiple comparison test.

3. RESULTS AND DISCUSSION

3.1. Autonomic Nerve Activity

The results for the sympathetic nerve activity are shown in Figure 2. In addition, error bars in this paper indicate standard deviation. In all three conditions, LF/HF decreased in the stimulation period. LF/HF decreased also in Condition 3 where the information of clothing pressure was added through only visual sensation. There were significant decreases in both Condition 1 and Condition 2 ($p<0.01$). In addition, there was no significant difference between Conditions 1 and 2 in the stimulation period. The results in Condition 2 with both pressure and visual sensations were similar to those in Condition 1 with only a sensation of pressure. It is considered that the results were due to the appearance of the physiological response for the pressure sensation stimulation that was common to these two conditions. Moreover, in the re-rest period, the values in Condition 2 were significantly higher than those in Condition 1 and Condition 3. The increase is considered to be due

to the counteraction by release from the stimulation that was input through both visual and pressure sensations.

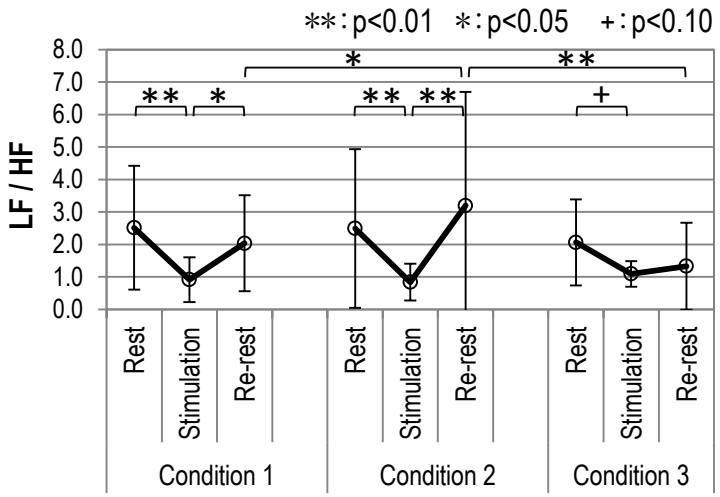

Figure 2: Sympathetic nerve activity

The results for the parasympathetic nerve activity are shown in Figure 3. In all three conditions, HF/(LF+HF) increased in the stimulation period. It is presumed that the accentuation of parasympathetic nerve activity was based on the homeostatic-maintaining mechanism that regards a change from a steady-state as stress (Uemae et al., in press). There were significant increases in both Condition 1 and Condition 2 ($p<0.01$). In addition, there was no significant difference between Conditions 1 and 2 in the stimulation period. The results in Condition 2 with both pressure and visual sensations were similar to those in Condition1 with only a sensation of pressure. It is considered that the results were due to appearance of the physiological response for the pressure sensation stimulation that was common to these two conditions. Further, the results in Condition 2 in the stimulation period were significantly higher than the values in Condition 1. It is considered that the information of clothing pressure from not only visual sensation but also pressure sensation caused HF/(LF+HF) to increase.

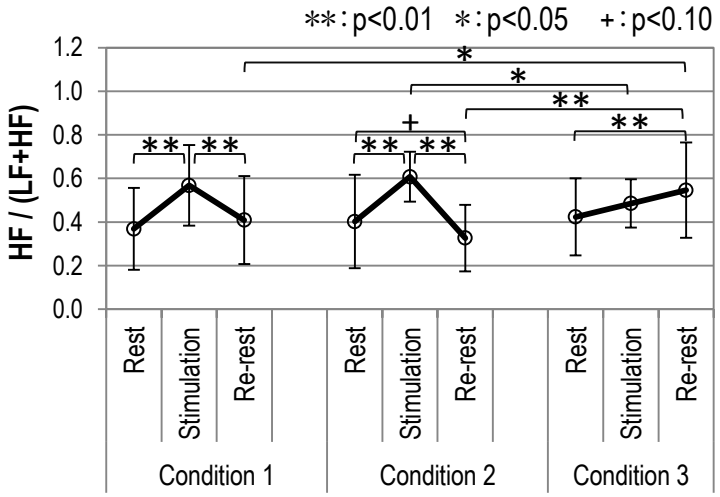

Figure 3: Parasympathetic nerve activity

3.2. Sensory Evaluation

The results for the sensory evaluation are shown in Figure 4. In all three conditions, when the stimulation is applied, comfort feeling decreased and tightness feeling increased. The pressure sensation increased significantly when only clothing pressure information from visual sensation in Condition 3 is presented as stimulation. It decreased significantly in the re-rest period. These results mean that visual information that another person has received clothing pressure affected the subject's own psychological response. In Condition 2, the score of tightness feeling in the re-rest period was higher than in the rest period. We guess that the reason for this result is that stimulation from both pressure sensation and visual sensation hindered recovery from the mental stress of clothing pressure.

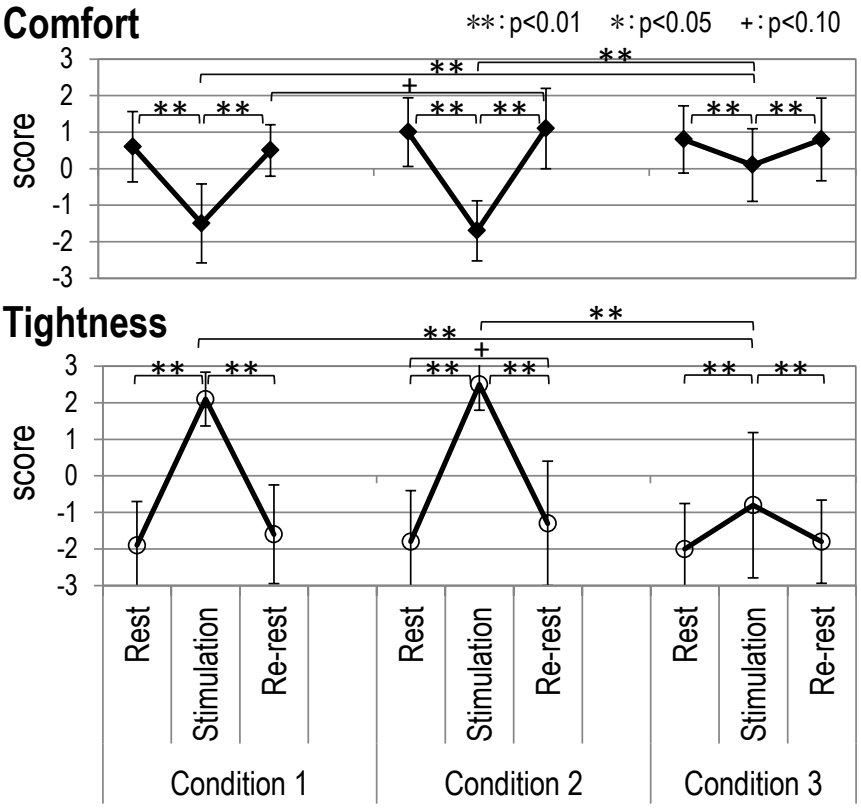

Figure 4: Results of sensory evaluation

4. CONCLUSIONS

We investigated the differences of psychological and physiological responses between mono-sensory information and multi-sensory information regarding about clothing pressure.

For autonomic nerve activity, the change tendency in the state of seeing other subjects who wore a fastened waist belt was similar to the tendencies both in the state of wearing a fastened waist belt and in the state of seeing such posture in a mirror. Further, in the experimental condition that clothing pressure information was input through senses of both pressure and visual, there was the reactionary response that the value in the re-rest period exceeds the value in the rest period.

For autonomic nerve activity, it is inferred that the response to pressure stimulation was larger than the response to visual stimulation.

For sensory evaluation, it was shown that clothing pressure information through visual sensation increased the score of the tightness feeling. Moreover, it was suggested that the stimulation from both pressure sensation and visual sensation hindered recovery from the mental stress caused by clothing pressure.

The above results would suggest that the information of clothing pressure through visual sensation influenced psychological and physiological responses. Clothing comfort sensation might, in near future, need to be evaluated by taking into consideration multisensory integration to all stimuli such as clothing pressure, temperature property, tactile property, appearance, odor, and rustling of clothes.

ACKNOWLEDGMENTS

This study was supported by Grant-in-Aid for Scientific Research (B) (#25280099) by the Ministry of Education, Culture, Sports, Science, and Technology of Japan.

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BIOGRAPHY

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Hardness Evaluation for Silicone Rubber Button on the Basis of Tactile and Visual Information

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Abstract: Information about the product value acquired through the five senses is important and if a new factor can be added to a product, it would lead to the differentiation of such a product from other similar products, as well as would improve the value of such a product. This research was aimed at investigating how the evaluation of objects is impacted by the hardness of an object as determined by the tactile sense. This investigation was carried out using silicone rubber and involved examining how the findings can be applied to the differentiation of product values. The investigation indicated that the results of sensitivity evaluation of a product depend on the hardness of silicone rubber and that the hardness values can be distinguished if they vary by at least five degrees. However, it was also found that once the hardness exceeds 60 degrees, it becomes harder to distinguish between the hardness values. Furthermore, when experiments on the application of silicone rubber to push switches were performed, sensitivity evaluation for the products was simultaneously performed, and the evaluation results indicated that the distinction between hardness values became more sensitive by the use of silicone rubber.

Keywords: Hardness Evaluation, Kansei Evaluation, Tactile Information, Visual Information, Paired Comparison Method.

1. INTRODUCTION

We use various products around us by using our five senses. Information concerning products and services broadcast by television advertisements and the like, for instance, is received by consumers as visual information or auditory information leading to the conception of images on the values of advertised products and services. This then leads the consumers to actually visit a store to look at and feel such products in order to determine their values to make a purchase. The various types of information acquired through the five senses, therefore, have an important role in

evaluating products and services.

The “tactile sense” can be considered the most important sense out of these five senses for evaluating the quality and structure of a product itself. And it has been reported that they have investigated discrimination and influence elements for tactile sensation [1], [2]. However, there is still a shortage of researches for investigating factors that can improve product values through the information acquired from the tactile sense.

This research was focused on information pertaining to the hardness of objects, acquired from the tactile sense, among the five senses. Silicone rubber was selected as our experimental material, since a wide range of hardness values can easily be achieved for this rubber and also because it is used in many products. We decided that the objective of the research shall be to investigate how the difference in hardness values as perceived by the tactile sense influences the evaluation of an object through experiments and to examine how the results obtained can be applied to differentiate product values.

2. Preliminary experiment 1

2.1. Outline

The possibility of the thickness of an object having an influence on the evaluation of hardness of the object can be considered. The potential influence of the thickness of objects has been reported in a prior research [3]. Re-examining the extent of this influence from the thickness of an object and selecting a suitable sample thickness for evaluation were set as the objectives of preliminary experiment 1. The standard for the measurement of rubber hardness JIS K 6253a was adopted as the standard for hardness and all hardness values were set to 20 degrees. Furthermore, the thickness was broken down into six levels of 4, 6, 8, 10, 12, and 14 mm. The diameter was set to 20 mm to ensure that the hardness can be determined using a finger and to make the sample size suitable for application to push buttons used in the main experiment. The paired comparison method was used to evaluate and analyze the hardness of six silicone rubber pieces prepared as described above. A total of 20 people, 14 males and 6 females of ages 21 to 22, were asked to assist as test subjects.



Figure 1: Experimental environment for evaluations based on tactile information only.

2.2. Method

The possibility of visual information on the thickness having an influence on the tactile information was considered, since the difference in thicknesses of silicone rubber pieces could be determined visually by the test subjects when they evaluate hardness. In order to investigate the relationship between visual and tactile information, experiments were conducted by setting up situations where test subjects could only acquire tactile information, only visual information only, and both visual and tactile information. First, a panel was set up to block visual information on silicone rubber to have our test subjects evaluate the hardness of silicone rubber pieces on the basis of tactile information alone (Figure 1). Next, the panel was removed to have our test subjects evaluate the hardness of silicone rubber pieces on the basis of visual information alone. Finally, our test subjects were asked to feel the silicone rubber pieces with their fingers to evaluate the hardness of the silicone rubber pieces on the basis of both tactile and visual information. Furthermore, in order to avoid any influence from differences in how the evaluations were performed, the manipulation of rubber silicone pieces by “grasping or lifting with fingers” was eliminated as a restriction on evaluations and the hardness evaluations were conducted by “pushing movements of fingers only.”

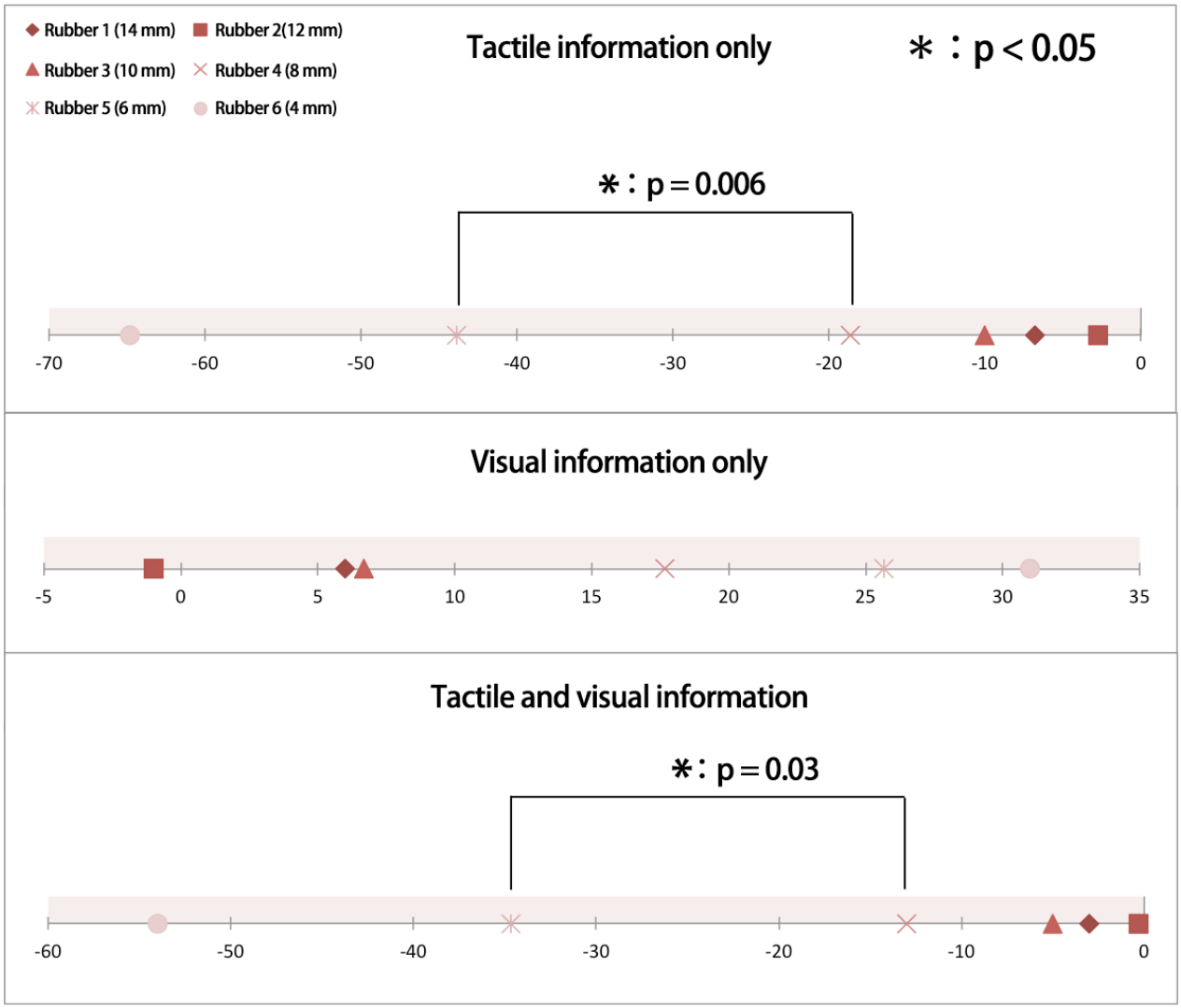

Figure 2: Results of preliminary experiment 1

2.3. Results and considerations

In terms of analysis, after conducting multiple regression analyses, a binomial test was performed to verify if there was any significant difference in the comparison evaluations on pairs of two silicone rubber pieces (Figure 2). Figure 2 depicts a plot of the results of evaluations on respective silicone rubber pieces, derived from the partial regression coefficient of the regression equation. Furthermore, in cases when any significant difference in thickness values was observed between neighboring pieces with six different thicknesses, for instance, in the case of 14 mm and 12 mm, such instance was marked with an asterisk (*). The experiment results revealed that when hardness evaluations were conducted on the basis of visual information alone, the thinner pieces were perceived as being softer. On the other hand, when hardness evaluations were conducted on the basis of tactile information alone or on the basis of both visual and tactile information, the thicker pieces were perceived as being softer. This led us to conclude that the thickness of an object is a factor that affect the evaluation of its hardness. Furthermore, our test subjects were considered to have placed more emphasis on the tactile information than on the visual information (thickness of silicone rubber pieces) when they were able to acquire tactile information to evaluate the hardness of an object.

3. Preliminary experiment 2

3.1. Outline

Silicone rubber pieces used in the experiments were prepared with color coding according to their hardness, in order to distinguish the differences in their hardness. In a previous report, it was mentioned that the evaluation of hardness was impacted by the difference in the color of objects [4]. Preliminary experiment 2 was conducted to re-examine whether the visual information provided by the difference in colors influenced the hardness evaluations. A total of 30 people, 22 males and 8 females of ages 21 to 22, were asked to assist as test subjects.

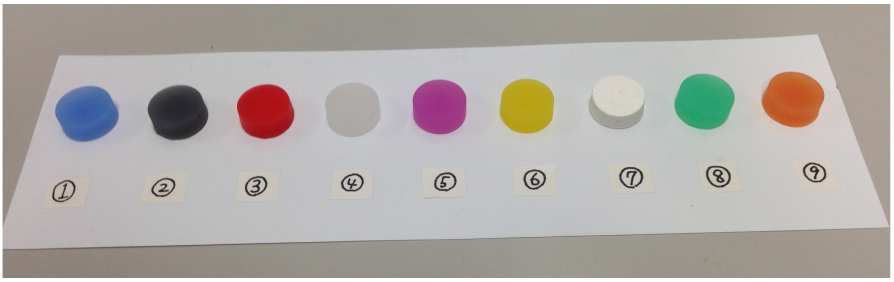

Figure 3: Nine silicone rubber pieces with varying colors



Figure 4: Evaluation sheet for entering ranking

3.2. Method

Nine pieces of silicone rubber with various colors were prepared. Test subjects were asked to

evaluate the hardness of these pieces without touching them and solely by looking at them; they were further asked to decide on the order of their hardness by using the Ranking method. Silicone rubber pieces with varying colors were randomly placed in a single horizontal row and were assigned numbers ① to ⑨ (Figure 3). The test subjects were asked to rank the pieces according to their hardness and to enter the number in the empty columns on the evaluation sheet (Figure 4). The silicone rubber pieces used for the experiment had a diameter of 20 mm and a thickness of 6 mm but had varying hardness (5, 10, 20, 30, 40, 50, 60, 70, and 80 degrees according to JIS K6253a). The order of their placement was in the sequence of 60, 40, 10, 70, 80, 30, 5, 50, and 20 (from left to right).

3.3. Results and considerations

The analysis was conducted by performing the Friedman test (Table 1). The calculation equation for the test is shown below.

$$\chi_F^2 = \frac{12}{nk(k+1)} \sum_{i=1}^{k} R_i^2 - 3n(k+1)$$

(k = 9, n = 30)

where k is the number of pieces subjected to testing, and n is the number of test subjects. It would be fair to say that there is a variance in the evaluation of hardness on the basis of color, since the sample statistic was indicated $p < 0.05$ in accordance with the chi-square distribution having eight degrees of freedom, on the basis of calculation results listed in Table 1. This implies that the difference in the color of samples used on this occasion had little influence on hardness evaluations. When considering the results for the hardness of 5 and 10 degrees, the evaluations were concentrated on the “hard” scale. Furthermore, many test subjects provided opinions, such as that “they felt that the feel of the material was different for silicone rubber pieces ③ and ⑦ (hardness of 5 and 10 degrees)”; “the degree of transparency appeared to be low”; and “they felt as if other materials were used.” This is considered to have been due to the fact that the colors of these two samples had lower transparency than other silicone rubber pieces and instead of color, factors such as material feel and material quality were believed to have influenced the evaluations.

Table 1: Analysis on the basis of Friedman test

N number	30		
Group number	9		
X ~ 2r (statistical quantity)	91.49		
Degrees of freedom	8	→	In accordance with the chi-square distribution having eight degrees of freedom

4. Main experiment

4.1. Outline

According to the results obtained in preliminary experiment 1, significant differences were present when the thickness according to the visual information was 6 mm or more and the hardness evaluation was impacted. The value of 6 mm was therefore set as the suitable thickness for hardness evaluation in the main experiment. On the basis of the results obtained in preliminary experiment 2, furthermore, the colors of silicone rubber pieces were not changed for the main experiment, as the difference in the colors of samples used in the experiment had little influence on hardness evaluation. Silicone rubber pieces of 20 mm diameter, 6 mm thickness, and nine varying hardness values (i.e., 5, 10, 20, 30, 40, 50, 60, 70, and 80 degrees according to JI K6253a adopted as the standard) were prepared and test subjects were asked to evaluate them according to the details provided on the evaluation sheet for the paired comparison method consisting of ranking in scales of five levels. A total of 30 people, comprising 22 males and 8 females of ages 21 to 22, were asked to assist as test subjects.

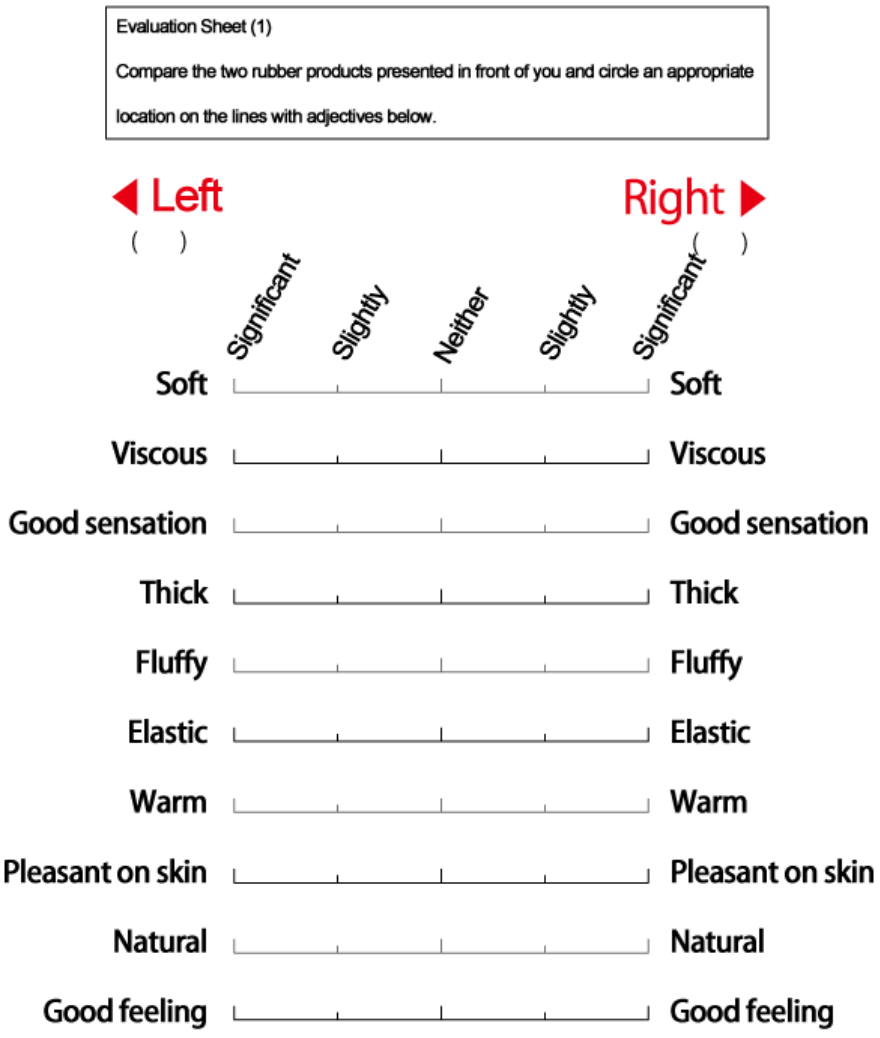

Figure 6: Evaluation sheet for the paired comparison method for experiment I (case with silicone rubber only)

4.2. Method

Since the application of silicone rubber in products can potentially manifest changes in hardness

evaluation, the experimental environment was split into two types, namely, the "case with silicone rubber only" and the "case with application on a push button switch," to conduct the experiments. Furthermore, more test subjects used their index finger for evaluating the hardness than in preliminary experiment 1. In order to avoid the influence of how the hardness evaluation was performed, the test subjects were instructed to perform their evaluations on hardness by using the "index finger only," as a restriction of the experiment. Furthermore, they were also asked to perform their evaluation of hardness with "push motion" only, as was the case with the preliminary experiments.

Experiment I (case with silicone rubber only): Test subjects were presented with pairs of silicone rubber pieces with varying hardness and were asked to touch the pieces, evaluate their hardness, and make their entries on the evaluation sheet for the paired comparison method, containing adjectives (Figure 6). Adjectives were considered to be associated with hardness evaluation based on tactile senses and ten adjectives, namely, "soft," "viscous," "good sensation," "thick," "fluffy," "elastic," "warm," "pleasant on skin," "natural," and "good feeling," were adopted. This process was conducted with all combinations of the nine possible hardness values of the silicone rubber pieces, or 9C2 = 36 patterns.

Experiment II: (case of application to push button switches): After experiment I was completed, a break of about 5 min was taken and then experiment II was started. Push button switches were presented to our test subjects two at a time in experiment II (Figure 5). These switch components were installed with silicone rubber, and as before, the test subjects were asked to touch them with their finger, evaluate the hardness, and make their entries in the evaluation sheet for the paired comparison method, containing adjectives. The adjectives comprised the ten types that were used in experiment I and that were associated with hardness evaluation. Further, two more adjectives, "good response" and "stable," were added in consideration of the application of silicone rubber to products such as push button switches, thereby making the total number of adjectives to 12. Experiment II was also conducted with all combinations of the nine possible hardness values of the silicone rubber pieces, or 9C2 = 36 patterns.

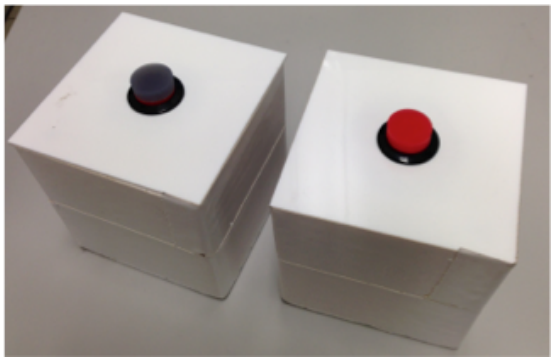

Figure 5: Push button switch

4.3. Results and considerations

In the case of experiment I with silicone rubber only, there was a declining trend in evaluations on the seven adjectives of "soft," "viscous," "good sensation," "fluffy," "elastic," "warm," and "good feeling" with increasing hardness. This implied that there was a trend for materials with lower hardness to be evaluated on the basis of these adjectives. On the other hand, the evaluation for the adjective of "thick" appeared to have an increasing trend with increasing hardness. These results

differed from those obtained in preliminary experiment 1, in which “those that were thicker were perceived as being softer.” This is believed to have been due to the influence of visual information, since the difference in thickness could be distinguished visually in the experimental environment for preliminary experiment 1. There was a decreasing trend with evaluations for the adjective of “natural” and “pleasant on skin” with increasing hardness to some extent, but this appeared to be contrary to this trend in some parts. This led us to conclude that when only information on hardness was available, these two adjectives did not show a concentrated evaluation trend. Furthermore, a binomial test was performed to verify significant differences in evaluations due to difference in hardness. The results revealed many significant differences in the cases of combinations involving silicone rubber pieces with a hardness of 50 degrees and lower. In cases of combinations where the hardness was 50 degrees or higher, however, a trend that no more significant differences appeared was observed. From these results, a hardness difference of at least 5 degrees was considered necessary for confirmation of any significant difference with evaluations owing to the difference in hardness. Furthermore, the difference in hardness was considered difficult when the hardness exceeded 60 degrees in the case of experiment I with silicone rubber pieces only.

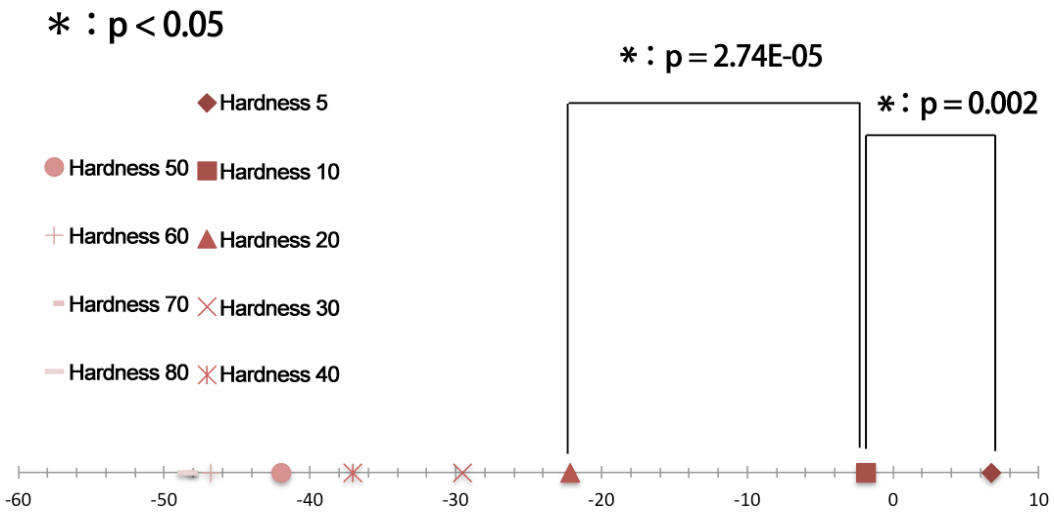

Figure 7: Analysis result example: plot of evaluation results for the adjective “soft”

Experiment II: A decreasing trend was observed in the evaluations with the eight adjectives of “soft,” “elastic,” “fluffy,” “viscous,” “warm,” “pleasant on skin,” “good feeling,” and “good sensation” with increasing hardness in the case with silicone rubber applied to switch buttons. This implied that there was a trend of evaluating materials with lower hardness on the basis of these adjectives. The evaluation for the three adjectives of “thick,” “good response,” and “stable,” on the other hand, appeared to have an increasing trend with increasing hardness. The results indicated that the evaluation of the adjective “thick” provided the same results as the trends of experiment I. The evaluations of the two adjectives “good response” and “stable” were considered to have resulted from the test subjects placing more weight on the evaluations of push button switches than evaluations of silicone rubber pieces. The evaluations of the adjective “natural” showed roughly the same trend as the results from experiment I. Furthermore, a binomial test was performed to verify significant differences in evaluations due to differences in hardness. The results revealed that many significant differences appeared in cases of combinations involving silicone rubber pieces with a

hardness of 60 degrees or lower, whereas the differences ceased to appear in cases of combinations involving silicone rubber pieces with a hardness of 60 degrees and higher. As a result, the difference in hardness was considered difficult to determine when the hardness exceeded 70 degrees in the case of experiment II with silicone rubber applied to switches. In comparison with the cases involving silicone rubber pieces only in experiment I, in the cases involving application of silicone rubber on switch buttons in experiment II, the boundary value for the emergence of a significant difference in evaluations was higher by 10 degrees. This led us to believe that the evaluations of the difference in hardness became more sensitive when silicone rubber was applied to products.

5. Conclusions and future issues

This research confirmed that the results of sensitivity evaluation varied according to differences in the hardness of silicone rubber pieces. The fact that visual information on the thickness of silicone rubber pieces influence the evaluations based on tactile sense was also confirmed.

When the hardness was 60 degrees or lower and if the difference was at least 5 degrees, the trend was that it was easy to distinguish the difference in hardness. The apparent trend was that the distinction of hardness became difficult when hardness was higher. When silicone rubber was applied to products such as push button switches, the sensitivity evaluation for products was performed in addition to the sensitivity evaluation for silicone rubber, increasing the number of items for the evaluation. Furthermore, the distinction of hardness was more sensitive in comparison with experiments involving silicone rubber pieces only. The fact that the difference in the hardness of flexible objects can become product values presents a potential for future applications with development of products using flexible objects such as silicone rubber.

In cases of comparison evaluations for silicone rubber pieces with identical hardness but different thickness, the pieces felt softer with a larger thickness during the experiments in this research. On the other hand, in cases of comparison evaluations for silicone rubber pieces with identical thickness but different hardness, the trend was that they felt thicker with more hardness. This was believed to have occurred owing to the mutual influence of visual information and tactile information and this needs to be examined further in the future [5], [6]. According to the results of these experiments, furthermore, some of the test subjects were conducting their evaluations with “stroking with finger” movements, in addition to “pushing with finger” movements during the evaluations for the adjective “pleasant to skin.” The evaluation for this adjective, therefore, was believed to have been conducted by evaluating the “quality of object” rather than “hardness of object,” and for that reason, it would be necessary to examine the differences in evaluation for materials other than silicone rubber as well in the future.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

The waiting room

Improving space through smell

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Abstract: Waiting is an inevitable part of life and the spaces in which we wait can contribute to either improve or worsen the experience. This paper covers the process and results of "The waiting room", analyzing if the presence of specific smells has a significant impact in how the room and the waiting experience are perceived. Two different odorants were selected, lavender (relaxing) and orange (stimulating); 63 participants from 32 different countries were assigned into three groups (between-groups approach): Control (unscented), Orange and Lavender. Results show that both scents affected the room and waiting experience evaluation in different ways and overall increased the surrounding space perception compared to the unscented condition. Participants exposed to lavender scent were inclined to rate as higher the 'psychological' properties of the room such as *pleasantness* and *warmth*; in addition the scent-evoked memories were emotion based. Participants exposed to orange scent tended to rate as higher the 'physical' properties of the room such as *brightness* and *height*; scent-evoked memories were object based. Lavender scent had a stronger influence in space perception than orange, suggesting the relevance of congruency and coherence between scent and physical environment when incorporating scent as a valid design tool in architecture.

Keywords: Kansei Architecture, Space Perception, Smell, Waiting experience.

1. INTRODUCTION

As part of our daily life activities we constantly have to wait and depending on what are we waiting for, this can be either a positive experience or a negative one. In terms of architecture, spaces designated for waiting are a transition space (physical and/or psychological) between the outside and the inside. Architecture influences the way we experience life; design processes focused on *intentions* rather than just *functions* achieve more meaningful projects. From this

perspective, the waiting experience can also be enhanced through adequate design elements.

Design oriented disciplines have been conventionally focused on visual elements as the predominant stimulus. Without disregarding the importance of visual information, it is essential that the design process and its outcome incorporate elements able to reach the user through a multisensory approach.

According to Pallasmaa, “the timeless task of architecture is to create embodied existential metaphors that concretize and structure man’s being in the world”. This initial concept of just *being* in the world is sustained by the mechanisms the senses provide us with, and architecture has the ability to enable them by using the adequate stimuli as design tools. Given the fact that all sensory input is relevant, what makes the sense of smell so special?

There is a traditional hierarchy of the senses, the major ones being sight, hearing and touch; taste and smell are usually referred to as ‘primitive’. Even though throughout history they have played an essential role in both individual and public aspects of daily life, scents have been tacitly disregarded as primary contributors to the sensory experience in architecture because they are invisible; they cannot be reached through tangible means as their ‘major’ counterparts. Nevertheless, their invisibility (usually conceived as a negative trait) gives scents the possibility to blend in with other elements, using them as carriers. Scents have dimensions and presence; they can also *fill* spaces.

Most of the existing research concerning scents is focused on their benefits on the individual’s mood, performance and behavioral aspects. When it comes to their role in space perception, little research has been done. Most studies considering ambient scents are focused on their effects on products and retail experiences; their importance is addressed as a necessary but indirect element that contributes as an enhancer of the global concept of environment.

Henshaw has made remarkable research on the relationship between existing smells in urban spaces and the user’s experience while being in said spaces, stating that odors affect the image of places. According to her book Urban Smellscapes, olfactory perception combines “information collected and mediated by the sense of smell (along with information gained through the other senses) with information gained from memories, odour recognition and association. Olfactory perceptions of place are similarly informed by social and cultural factors, including prior understandings of that place gained from representations made by others” (Henshaw, 2013). A relevant concept portrayed in her research is the role of *smellwalkings* in the analysis of the interaction between user and space through the sense of smell. The smellwalking derives from the concept of *sensewalking*, a method to analyze how people utilize the space through sensorial aspects of the environment, emphasizing non-visual clues. Henshaw has conducted several smellwalkings in different cities with the “primary purpose of exploring the smells that people can detect, what they think about them, how these change between places and how the built environmental form and component parts influence the urban smell experience”.

From an anthropological perspective, Beer has done research on the interrelation between person, place, space, smell and emotional memories. In her article Smell, Person, Space and Memory, Beer states that anthropological research on space perception has emphasized mostly visual, acoustic and recently kinesthetic cues, neglecting smell and its role in said interrelation. However, as she states: “in natural settings there’s no smell-neutral space. Space is always filled with smells produced by components of the environment, influenced by climate and human actions” (Beer, 2007).

Both Henshaw and Beer point out the relevance of smell in the way users perceive surrounding space, but they emphasize the relationship between *existing smells* and how users *experience* the space under those existing smells.

The present study intends to establish an initial approach on what specific aspects and elements of the space are affected by the deliberate use of precise scents. The main purpose is to determine whether based on context scents can be used as tangible design tools to increase space perception and therefore its quality.

1.1. Objective and hypothesis

The main objective was to analyze the possible differences in terms of space perception, in the evaluation of a room and the experience of waiting when participants were exposed to orange and lavender odorants, compared to a control condition when no odorant was applied. A secondary objective was to determine the role of odor awareness in terms of space perception: establishing if preconceived notions concerning scents affect the participants' room and experience evaluation. The hypothesis stated that scented condition will increase the space perception of the room and that lavender and orange scent will affect perception in different ways, considering the relaxing and stimulating connotations of each odorant.

2. METHODS

2.1. Participants and experiment concept

63 participants from 32 different countries were invited to take part in an experiment concerning space perception; the experiment took place in the Laboratory for Advanced Research in the University of Tsukuba. Participants were randomly distributed in three different groups (n = 21 each), and each participant belonged exclusively to one of them. Groups division: Control, Orange and Lavender. They were not informed about the presence/absence of scent in the room to avoid biased impressions and were told they only had to 'rate some architectural images while some physiological conditions were going to be measured'; therefore, they had to wait while machine preparations were made in the 'real experiment room'. But in reality the true experiment took place during the waiting period.

A room was set as a fake *waiting room* in which participants were asked to sit and wait by themselves for five minutes. Any possible distractors (e.g., digital devices, watch, books) were collected before entrance with the intention to make the participant aware of the room. After five minutes we entered the room and gave them the evaluation questionnaires in order to 'save time while the room was still being prepared'. As soon as they completed the questionnaires, participants were told the real purpose of the experiment and were informed about the presence of smell in the room. All procedures before, during and after the experiment were performed according to the guidelines established by the ethical committee of the University of Tsukuba.

2.2. Materials

The room itself was the main stimulus in the experiment. The selected space had a 'negative' connotation in terms of *atmosphere*: lack of aesthetic elements, cold and unwelcoming environment and furniture, reduced size and irregular shape (Figure 1).

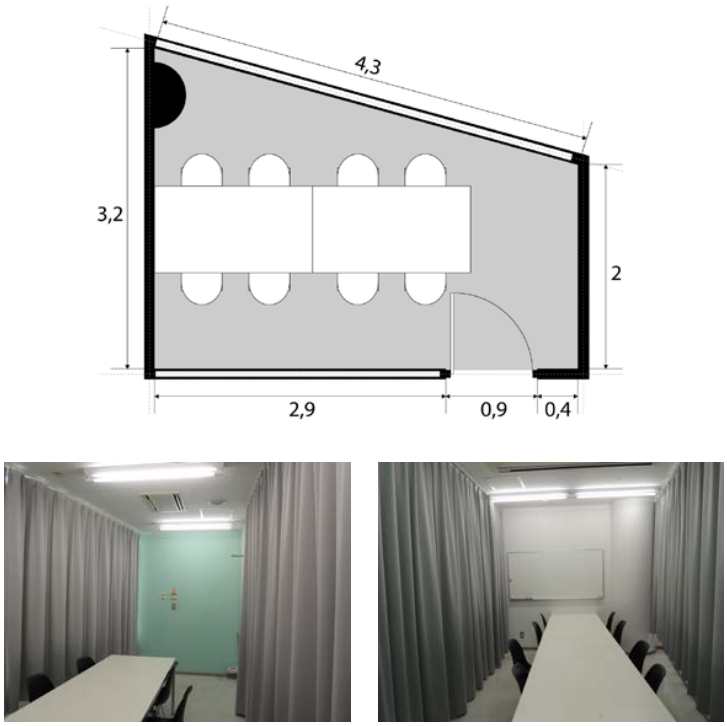


Figure 1: Room top plan and views

Orange and lavender essential oils were selected as the scent stimuli and were distributed in the room through an ultrasonic diffuser placed in the room for 15 minutes before each session. In order to avoid smell contamination, an odorant remover and natural ventilation were used as air cleaners before and after all sessions. A different device was used for each scent and same proportion of water/essential oil was used according to manufacturer directions. Scents did not represent any health harm for the participants.

Scent selection was based on a previous study concerning lavender and orange scents as anxiety reducers and mood boosters in a waiting room in a dental office (Lehrner et al., 2005). Moreover, according to Warrenburg, citrus scents (orange) tend to be more stimulating while floral scents (lavender) tend to be more relaxing. The purpose was to measure whether it was a significant different in perception when using a stimulating and a relaxing scent, both of them eliciting a positive reaction in the participant's mood (Warrenburg, personal communication, August 10, 2013).

2.3. Questionnaires and evaluation

Four points were measured while participants where in the room exposed to one of the three smell conditions: room evaluation, experience evaluation, odor awareness and memories and associations. All questionnaires were prepared in both English and Japanese.

Concerning room evaluation, nine properties (divided into physical and psychological properties) were measured through Semantic Differential method (SD) and Visual Analogue Scale (VAS): width, brightness, fun, pleasantness, color, warmth, relaxation, height and identity. In terms of experience evaluation, level of comfort and perception of waiting time were measured also through SD and VAS (from 0 'Not at all' to 5 'Very much'). In the case of scented conditions, the scent liking and perceived strength were also measured. Participants were also asked to state whether they felt the scent and to define it through selecting one or more categories according to what they

thought the smell was (Categories: floral, fruits, spices, wood, musk and fresh).

As a conjoint project with the Department of Psychology from the University of Tsukuba, an existing Odor Awareness Scale (OAS) was administered to establish the olfactory background of the participant in terms of the importance of smell in daily life activities and situations. The questionnaire contains 32 items considering smell in different categories. At the end of the questionnaires participants were asked if the smell triggered specific memories or associations, this was a free-answer question.

3. RESULTS

Data was processed using analysis of variance (ANOVA) and principal component analysis (PCA) in SPSS software.

3.1. Room evaluation

In general terms all properties in the room were rated as higher under the presence of scent in the room, as stated by the individual room score evaluation, which is the average evaluation score per participant (Figure 2). Participants rated the room as wider, warmer, more fun, relaxing, pleasant and with more identity when exposed to lavender scent. On the other hand, the room was rated as brighter and with a higher ceiling when orange scent was present (Table 1). However, a statistically significant difference was only found between Control and Lavender groups concerning pleasantness and warmth levels (Table 2).

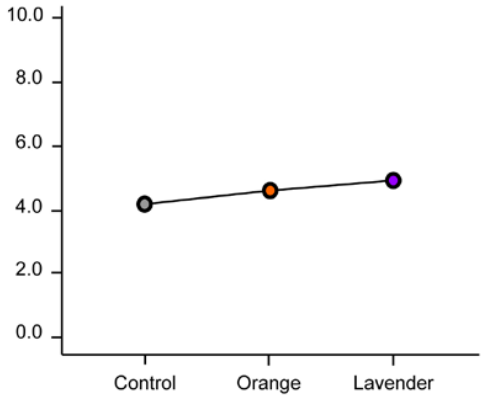


Figure 2: Individual room score

Table 1: Descriptive data for room evaluation

Scent		Width	Fun	Brightness	Pleasantness	Color	Warmth	Relaxation	Height	Identity
Control	Mean	2,98	2,71	6,53	5,10	2,99	3,54	5,22	5,14	3,13
	SD	1,29	1,69	2,01	2,03	1,66	1,24	1,95	1,71	1,94
Orange	Mean	2,87	3,17	7,15	5,07	3,37	4,09	5,62	5,88	4,30
	SD	1,53	2,05	1,55	1,65	1,91	1,88	2,36	1,47	2,64
Lavender	Mean	3,46	3,83	6,20	6,26	3,66	4,73	6,14	5,54	4,45
	SD	1,89	2,01	1,65	1,66	2,08	1,44	2,14	1,55	2,15
Total	Mean	3,10	3,24	6,63	5,48	3,34	4,12	5,66	5,52	3,96

	SD	1,58	1,95	1,76	1,85	1,88	1,59	2,15	1,58	2,30

Table 2: ANOVA for room evaluation

		Sum of Squares	df	Mean Square	F	Sig.
Width	Between Groups	4.09	2	2.04	.81	.45
	Within Groups	151.45	60	2.52		
Fun	Between Groups	13.40	2	6.70	1.81	.17
	Within Groups	221.98	60	3.70		
Brightness	Between Groups	9.74	2	4.87	1.59	.21
	Within Groups	183.10	60	3.05		
Pleasantness	Between Groups	19.38	2	9.69	3.02	.05
	Within Groups	191.94	60	3.19		
Color	Between Groups	4.76	2	2.38	.66	.51
	Within Groups	214.03	60	3.56		
Warmth	Between Groups	14.90	2	7.45	3.13	.05
	Within Groups	142.57	60	2.37		
Relaxation	Between Groups	8.91	2	4.45	.96	.38
	Within Groups	278.34	60	4.63		
Height	Between Groups	5.80	2	2.90	1.16	.31
	Within Groups	149.41	60	2.49		
Identity	Between Groups	21.77	2	10.88	2.12	.12
	Within Groups	306.99	60	5.11		

3.2. Experience evaluation

As expected the room was rated as more comfortable under the presence of both scents. The perceived waiting time decreased from Control to Orange and Lavender, in that order (Figure 3). Statistically significant difference was only found between Control and Lavender in terms of comfort levels (Table 3). Concerning scent evaluation, there was no difference between scents in terms of liking. Lavender scent was rated higher in strength.

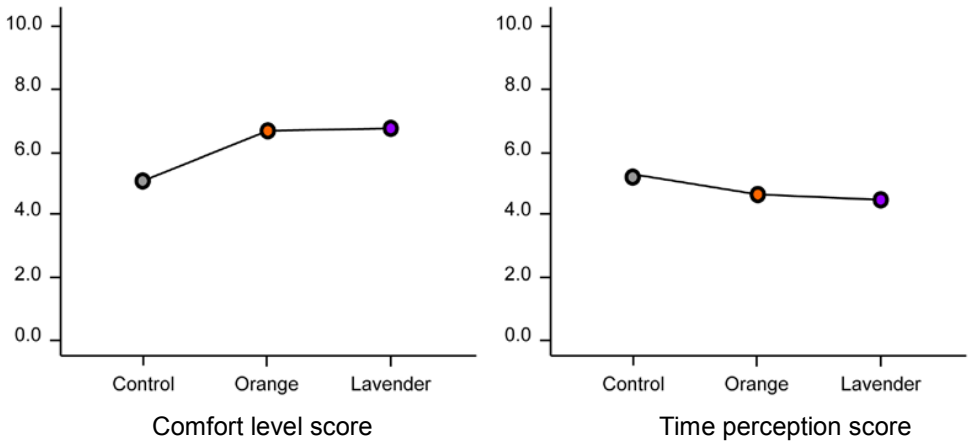


Figure 3: Experience evaluation (comfort and time) average scores

Table 3: ANOVA for experience evaluation

		Sum of Squares	df	Mean Square	F	Sig.
Comfort	Between Groups	36.591	2	18.295	4.531	.015
	Within Groups	242.267	60	4.038		
Time	Between Groups	5.405	2	2.703	.733	.485
	Within Groups	221.316	60	3.689		

3.3. Correlations

A correlation analysis was performed for all room properties and experience evaluation variables. Expected positive correlations were found in the three groups between these properties: pleasantness-relaxation, pleasantness-comfort and relaxation-comfort. In the case of scented groups an expected positive correlation was found between relaxation-liking. However, analyzing each group, different correlations between properties were found, suggesting that perception worked differently under the three conditions.

Control group: positive correlations were found between fun-color, pleasantness-height, relaxation-height and comfort-height (Table 4).

Table 4: Control group correlations (Pearson's *r*)

	Width	Fun	Brightness	Pleasantness	Color	Warmth	Relaxation	Height	Identity	Comfort	Time
Width	1,00	.454*	0,30	0,19	-0,05	0,28	0,19	0,39	.572**	0,05	0,03
Fun	.454*	1,00	0,09	0,43	.492*	0,37	0,06	0,40	0,26	0,03	0,20
Brightness	0,30	0,09	1,00	0,26	0,10	0,30	0,18	0,27	0,06	0,38	-0,20
Pleasantness	0,19	0,43	0,26	1,00	0,34	0,13	.674**	.698**	-0,18	.810**	0,11
Color	-0,05	.492*	0,10	0,34	1,00	0,29	0,04	0,22	-0,01	0,09	0,22
Warmth	0,28	0,37	0,30	0,13	0,29	1,00	-0,07	-0,04	0,15	0,03	0,32
Relaxation	0,19	0,06	0,18	.674**	0,04	-0,07	1,00	.643**	0,04	.643**	0,12
Height	0,39	0,40	0,27	.698**	0,22	-0,04	.643**	1,00	0,35	.578**	0,03
Identity	.572**	0,26	0,06	-0,18	-0,01	0,15	0,04	0,35	1,00	-0,30	0,03
Comfort	0,05	0,03	0,38	.810**	0,09	0,03	.643**	.578**	-0,30	1,00	-0,12
Time	0,03	0,20	-0,20	0,11	0,22	0,32	0,12	0,03	0,03	-0,12	1,00

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Orange group: positive correlations were found between width-time and liking-strength. Negative connotations were found between pleasantness-time and relaxation-identity (Table 5).

Table 5: Orange group correlations (Pearson's *r*)

	Width	Fun	Brig.	Pleas.	Color	Warm.	Relax.	Height	Ident.	Liking	Stren.	Comf.	Time
Width	1,00	0,27	0,21	0,19	0,13	0,36	0,32	-0,12	-0,26	0,40	0,34	0,12	.445*
Fun	0,27	1,00	-0,24	0,09	0,24	0,30	-0,21	0,00	0,13	-0,08	-0,02	-0,33	0,13
Brig.	0,21	-0,24	1,00	0,20	0,17	0,11	0,24	0,33	0,04	0,29	0,17	0,00	-0,10

Pleas.	0,19	0,09	0,20	1,00	0,10	-0,06	.475*	-0,03	-0,04	0,07	0,05	.562**	-.531*
Color	0,13	0,24	0,17	0,10	1,00	0,36	0,01	0,26	0,29	0,07	0,32	-0,26	0,00
Warmth	0,36	0,30	0,11	-0,06	0,36	1,00	0,12	0,25	0,13	-0,27	-0,22	-0,13	0,02
Relax.	0,32	-0,21	0,24	.475*	0,01	0,12	1,00	0,25	-.569**	.505*	0,00	.516*	-0,15
Height	-0,12	0,00	0,33	-0,03	0,26	0,25	0,25	1,00	0,32	0,23	0,31	-0,40	-0,30
Identity	-0,26	0,13	0,04	-0,04	0,29	0,13	-.569**	0,32	1,00	-0,31	0,13	-0,39	-0,16
Liking	0,40	-0,08	0,29	0,07	0,07	-0,27	.505*	0,23	-0,31	1,00	.569**	0,08	0,35
Strength	0,34	-0,02	0,17	0,05	0,32	-0,22	0,00	0,31	0,13	.569**	1,00	-0,30	0,17
Comfort	0,12	-0,33	0,00	.562**	-0,26	-0,13	.516*	-0,40	-0,39	0,08	-0,30	1,00	-0,12
Time	.445*	0,13	-0,10	-.531*	0,00	0,02	-0,15	-0,30	-0,16	0,35	0,17	-0,12	1,00

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Lavender group: positive connotations were found between: pleasantness-liking, warmth-comfort and liking-comfort. A negative connotation was found between liking-strength (Table 6).

Table 6: Lavender group correlations (Pearson's *r*)

	Width	**Fun**	**Brig.**	**Pleas.**	**Color**	**Warm.**	**Relax.**	**Height**	**Ident.**	**Liking**	**Stren.**	**Comf.**	**Time**
Width	1,00	0,43	0,04	0,38	-0,18	0,38	0,22	-0,07	0,24	0,08	-0,05	0,41	0,14
Fun	0,43	1,00	-0,06	0,42	0,02	-0,03	0,29	-0,10	0,29	0,18	-0,16	0,12	-0,33
Brig.	0,04	-0,06	1,00	0,08	0,14	-0,19	0,17	0,01	-0,08	-0,19	0,26	-0,22	0,09
Pleas.	0,38	0,42	0,08	1,00	0,12	0,25	.806**	-0,25	0,12	.514*	-0,32	.562**	-0,25
Color	-0,18	0,02	0,14	0,12	1,00	-0,07	0,18	0,03	-0,10	0,16	0,13	-0,12	-0,32
Warmth	0,38	-0,03	-0,19	0,25	-0,07	1,00	0,25	0,13	0,07	0,19	0,38	.545*	-0,24
Relax.	0,22	0,29	0,17	.806**	0,18	0,25	1,00	-0,01	0,00	.613**	-0,29	.593**	-0,37
Height	-0,07	-0,10	0,01	-0,25	0,03	0,13	-0,01	1,00	-0,06	0,33	0,01	0,21	-0,28
Identity	0,24	0,29	-0,08	0,12	-0,10	0,07	0,00	-0,06	1,00	-0,29	0,12	-0,12	-0,18
Liking	0,08	0,18	-0,19	.514*	0,16	0,19	.613**	0,33	-0,29	1,00	-.459*	.592**	-0,20
Strength	-0,05	-0,16	0,26	-0,32	0,13	0,38	-0,29	0,01	0,12	-.459*	1,00	-0,07	0,14
Comfort	0,41	0,12	-0,22	.562**	-0,12	.545*	.593**	0,21	-0,12	.592**	-0,07	1,00	-0,08
Time	0,14	-0,33	0,09	-0,25	-0,32	-0,24	-0,37	-0,28	-0,18	-0,20	0,14	-0,08	1,00

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

3.4. Odor awareness

General odor awareness score was higher in scented groups compared to Control group (Figure 4). From the 31 total items on the scale, eight items concerning scents and space perception were isolated and analyzed: distraction by scents in environment, noticing scents when visiting new places, happiness when picking pleasant scents in environment, annoying feeling for unfamiliar scents in environment, anxiety produced by unpleasant scents remaining in the environment, memories revived by scents and bad smells as a reason to choose not to return to a place. From

the mentioned items two main factors were extracted through principal component analysis: the first factor involves influence of scents in environmental perception with a positive connotation and the second one with a negative connotation (Figure 5).

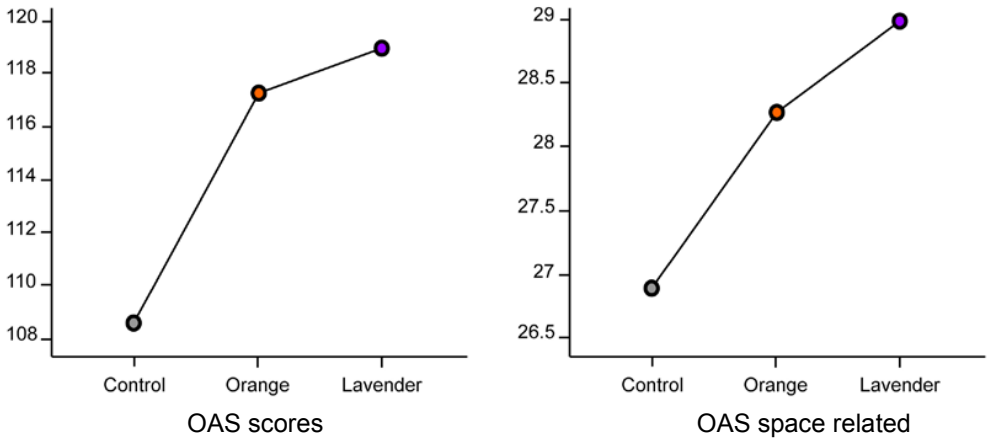


Figure 4: Odor awareness evaluation mean scores per group

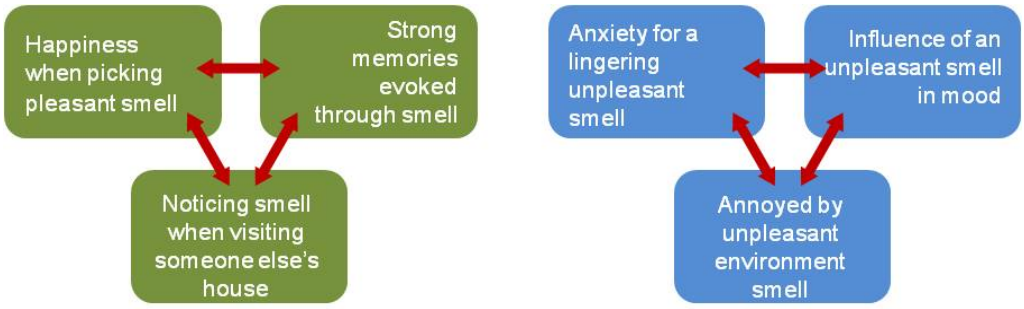
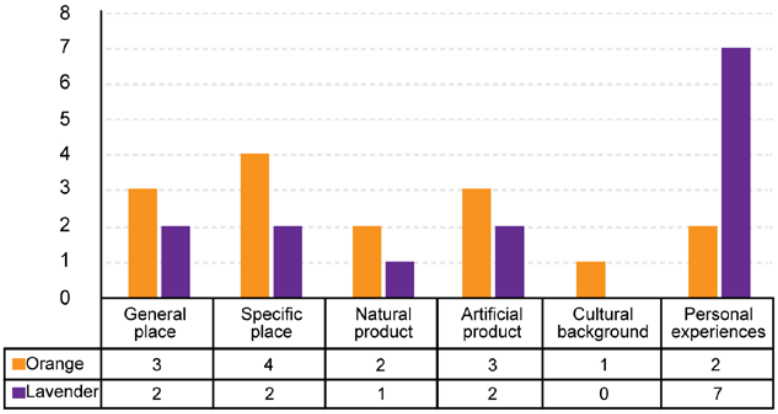


Figure 5: Positive and negative connotation factors in odor awareness in space

3.5. Memories and associations

For Orange and Lavender groups participants were asked whether they could associate the scent with any specific memories. For Orange group (n = 21) 15 participants reported memories, for Lavender (n = 21) 14 participants reported memories. All free answers were assigned into six different categories (Figure 5). Orange scent evoked more memories overall. Most of the memories evoked by lavender are related to personal experiences. Memories evoked by orange scent are more related to specific places and artificial products instead.



	General place	Specific place	Natural product	Artificial product	Cultural background	Personal experiences
Orange	3	4	2	3	1	2
Lavender	2	2	1	2	0	7

Figure 6: Memories categorization

4. DISCUSION

The main objective of the experiment was to compare both the room and experience evaluation to establish if there was an improvement due to the use of two different scents compared to an unscented condition. In addition, by analyzing general odor awareness and associations triggered by scents it was possible to define the relevant aspects for the users in terms of scent when associated to space.

4.1. Did scent improve room and waiting experience evaluation?

Overall the answer is affirmative, compared to Control group, when exposed to both odorants participants rated as higher all properties. However statistical difference was found only in comfort, warmth and pleasantness level, suggesting that the most relevant differences between scented and unscented conditions involve psychologically oriented aspects rather than physical. It was noticeable that highest evaluation scores were found in Lavender for most of the properties. In the case of Orange, the highest scores correspond to brightness and height levels in the room. This is relevant because it sets different effect mechanisms for two odorants which are known to have a positive influence on individuals. Knowing what aspects of a space are affected by certain odorants will establish guidelines and patterns on how to use scents congruently to improve space design. In terms of the waiting experience, as expected comfort levels increased and perceived waiting time decreased under the presence of both scents.

Moreover, the correlations found between room and experience properties show that all properties relate to each other in a different way for each group: orange scent had a strong effect in correlations involving perceived time, width and identity of the room; in the case of lavender, its strongest effect was on correlations involving pleasantness, warmth and comfort (sustained by statistical difference). An important aspect was also the evaluation of scent itself, a positive correlation between scent liking and scent strength was found in Orange group while a negative one was found in Lavender group, showing that intensity of scent works differently for each scent, therefore the amount of odorant necessary to trigger good responses happens on a case-by-case approach. This means that using specific scents can trigger particular properties associations

within space.

4.2. Awareness and memories

From an initial perspective, it might seem logical that odor awareness scored higher in scented groups compared to the unscented condition. The isolated space related items in the scale also report a higher score in scented groups; this indicates that scents have a powerful influence in the users' awareness concerning the surrounding environment at an unconscious level. Results suggest that odor awareness is context-based rather than a fixed evaluation statement and subsequently can be used to modify space properties by altering perception.

Memories and associations were also different according to the scent, orange tended to triggered more physical related memories while lavender evoked emotional related memories, a noticeable aspect was the lack of specific cultural associations in both groups (with one exception in Orange group) regardless of the multicultural background of the participants. This suggests that memories evoked by scent are context-based as well as awareness. Even though culture plays an essential role in sensory appreciation, individual experience could be more relevant when it comes to define the extent of scent in space perception.

4.3. Present study limitations

Measuring effects caused by scents is a difficult task mainly due to their multidimensional nature; conventionally scents are not presented on a physical continuum (unlike wavelength of light) (Laurent, 2002), therefore they can vary from small molecules to long-chained hydrocarbons, making them vulnerable to change as a result of environmental variations. This adds up to their abstract and subjective character, especially when attempting to establish perceptual differences. It was an essential point to perform all experiment sessions under the same conditions, however, the uncontrolled effect of environmental conditions cannot be dismissed from any possible variation in the scent composition.

Considering the subjectivity of the topic, one of the main purposes of this research was to focus on the individual responses towards scents, based on the immediate context rather than on cultural constructs; nevertheless, analyzing each of the room evaluation variables into detail, the graphs show heterogeneity amongst responses and the remaining question would be whether that difference is due to individual and subjective opinion or the indirect influence of cultural associations.

The purpose of the experiment was to isolate olfactory stimulus as possible from other elements that could interfere as distractors, therefore a neutral room was selected for the experiment. However, *congruency* between scent and other physical stimuli in the room was not considered as an influential factor in space and experience perception. Schifferstein states that olfactory information needs to compete against other stimuli to gain attention (Schifferstein et al., 2011); yet if the scent is not paired with other congruent environmental cues, it might turn into ambiguous stimuli.

Michon et al found that ambient odors are more likely to affect users' cognitive levels (perception of the environment) rather than emotions (Michon et al., 2005), based on that mood was not considered as a mediator for perception in the current research.

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2A - Kansei Information Design 2

KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

About the nature of Kansei information, from abstract to concrete.

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Abstract: Designer's expertise refers to the scientific fields of emotional design and kansei information. This paper aims to answer to a scientific major issue which is, how to formalize designer's knowledge, rules, skills into kansei information systems. Kansei can be considered as a psycho-physiologic, perceptive, cognitive and affective process through a particular experience. Kansei oriented methods include various approaches which deal with semantics and emotions, and show the correlation with some design properties. Kansei words may include semantic, sensory, emotional descriptors, and also objects names and product attributes. Kansei levels of information can be seen on an axis going from abstract to concrete dimensions. Sociological value is the most abstract information positioned on this axis. Previous studies demonstrate the values the people aspire to drive their emotional reactions in front of particular semantics. This means that the value dimension should be considered in kansei studies. Through a chain of value-function-product attributes it is possible to enrich design generation and design evaluation processes. This paper describes some knowledge structures and formalisms we established according to this chain, which can be further used for implementing computer aided design tools dedicated to early design. These structures open to new formalisms which enable to integrate design information in a non-hierarchical way. The foreseen algorithmic implementation may be based on the association of ontologies and bag-of-words.

Keywords: Kansei information, Abstract-Concrete, Formalisms, Early design.

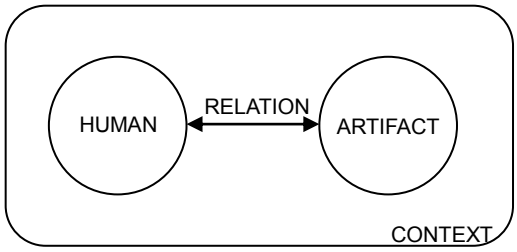
1. INTRODUCTION

Kansei studies refer to the holistic consideration of the cognitive and affective processes which occur during user experience. Historically, kansei engineering has been firstly focused on the semantic differential approach of Osgood applied in pro-active design contexts [Nagamashi, 1995, Schütte, 2004, Lokman, 2010, Nagamashi, 2011]. The semantic differential enabled to evaluate products and then to generate automatically design rules and solutions with semantic input data. Afterwards, emotions were integrated into kansei approaches. Progressively, evaluations have been completed by physiological measurements in order to reduce the subjectivity involved in those evaluations and also to capture some real time unconscious reactions [Lee & Harada, 2002, Yamanaka & al, 2002, Tomico & al, 2008, Levy & al, 2011]. This trend developed firstly in Japan and more recently in Europe [Kim & al, 2011, Rieuf & al, 2014]. These objective measures help in the interpretation of emotional evaluations and adding physiological and behavioral information is still in process. This completion is made possible only through the current convergence of various disciplinary perspectives.

Indeed, kansei studies have been much enriched from the disciplines of design science, marketing research, psychology, and artificial intelligence. The cross influence between these disciplines brought new dimensions into kansei approaches, such as multisensory design information, the inclusion of personality [Lee, 2005], values [Authors, 2009], and culture related items, and also new formalisms and algorithms which lead progressively towards the consideration of a whole enriched experience. Considering the whole experience from a kansei perspective is an emerging field which also takes into account new dimensions such as time and context. The measure of emotions in design provides a way of interpreting the effect of a holistic aesthetic experience [Overbeeke, 2000, Hummels & Overbeeke, 2010] including stimuli such as style, sensory dimensions, semantics and behavior and interaction. More subtle dimensions such as the adequacy of a style or semantics or sensory properties to human values can also be extracted from emotional measures. As kansei information is rich, heterogeneous and refers to a complex system between human and artifact, it is crucial to structure this information in the form of theoretical models that will help designers and researchers to better understand kansei information systems. These models will also facilitate the use of kansei information as generative or evaluation operational matter in order to improve the experience of users and designers in design projects. Finally, we propose a theoretical model which purpose is to link abstract and concrete dimensions of kansei, and which constitute a focal point for collaborative research between the disciplines of design science, marketing research, psychology, and artificial intelligence.

2. KANSEI INFORMATION

The kansei information, exchanged for instance by a design team, refers to a complex system between human beings and artifacts. Human beings can be, depending on the context, designers or end-users, and artifacts are the products or services to be developed. The intended experience may be taken into account, defined, and discussed at the various stages of the research and development process. The artifacts to be designed play the role of stimuli with which human beings will develop physiological, cognitive, and behavioral response. The exchanged kansei information can be related to the human, to the artifact, and to the physical context, as well as to the relation between them (i.e. interaction, temporal context, situational context) [Gentner et al., 2013].



- Human related information,
- Artifact related information,
- Human-artifact related information,
- Context related information.

Figure 1: Entities and flows related to kansei information

2.1. Human related information

As intrinsic dimensions on the human side, we consider parameters which characterize the targeted population. As such, sociological values are highly structuring in the kansei information systems. Indeed, previous experiments proved that sociological values impact the emotional reactions of subjects in front of specific semantics [Bouchard & al, 2009b]. The cultural factor is also impacting in so far as the perception of design information is very influenced by cultural ways of perceiving and interpreting design information. Gender, age, values (e.g. terminal and instrumental), and personality are other significant factors that influence the kansei experience between the human and the artifact.

2.2. Artifact related information

A second entity to consider in the kansei information system is the artifact. From the product side, all information related to product attributes and behavior is to be considered into the kansei information system. For instance some attributes such as colors, shapes, textures, style, materials, technical details, styles, and even the production process, provide relevant information from product side. As kansei information and kansei rules are often field-dependent, the product sector must also be taken into account (e.g., automotive, tableware, packaging…).

2.3. Human-artifact related information

There is a reciprocal relation between the human and the artifact. This relation includes every dimension which is difficult to distinguish one from the other. For instance, semantics is depending on both the human and the product. The product can be seen as a system of signs which will convey a specific image and the human will perceive this image through the filter of his/her subjectivity, according to individual characteristics such as values, culture, or experience. This way, semantics is a bilateral dimension that cannot be seen on one side or another. Emotions can also be considered as a main dimension of human-artifact related information. Emotions are resulting from the perception of static or dynamic artifacts. They can be related to the real time and short time situation and eventually to more persistent psychological state. Sensory information is also covering the human-artifact relation (i.e. sensory pleasure). The perception will convey a feeling of warmth or roughness coming from product parameters but this perception is also linked to the inner temperature of the subject and its physical capabilities (e.g. tactile abilities). Similarly, interaction attributes are linked to both the human and the artifact. They encompass the degrees of engagement and of immersion. These degrees evolve in a continuous relation of interaction that will transform them progressively into sequential states (which can be seen as mutual behaviors). Other interaction attributes are the interface characteristics, the action enabled, the gesture of the users and the feedbacks of the artifact [Gentner, 2014].

2.4. Context related information

Context related information relates any potential circumstances of the situation where the experience takes place. It can be summarized as time (temporal context), situation, location (situational context), space, and environmental conditions (physical context) [Ortíz Nicólas & Aurisicchio, 2011]. The temporal context encompasses the notions of pre-experience, experience and post-experience [Ocnarescu & al, 2012]. The situational context is about the moment, location, and the situation in which the interaction occurs (e.g. work-state, play-state) [Hassenzahl, 2010]. Finally the physical context is about the place where the experience takes place and the other elements the interaction considered (e.g. other humans, other artifacts).

3. KANSEI STRUCTURE: ABSTRACTION DIMENSION

In the previous part, we describe kansei information by explaining the reciprocal human-artifact relation and the various dimensions involved in the kansei experience. On the other hand, kansei information can be positioned on an axis between abstract and concrete dimensions. It is true that designers' skills lie mainly in this ability to establish intuitively a relation between abstract and concrete dimensions. For instance, which colors will give the feeling of freedom, or how to express power into styling lines for a sport vehicle, or finally how to provide an aesthetic experience to a user of sports competition devices? So every kansei dimension may be positioned on an axis going from high-level information to low-level information. High-level information encompasses the most abstract dimensions such as values or semantics. Low-level information includes the most concrete dimensions such as product attributes. As this information structure turns to be relevant in various disciplines such as design science, artificial intelligence and marketing research, we finally formalize a theoretical model which follows this structure.

3.1. Abstract-concrete information structure in design science

According to designers, some major dimensions processed in early design are emotions and personality of artifacts. Even if designers recognize that their activity deals with emotional content, this process is not necessarily explicit. The concept of kansei in the framework of early design activity brings theoretical support for formalizing the core skills of the designers, which are highly linked to semantics and emotions. Kansei can be seen as both a subjective and objective process which enables to link high-level abstract information, as semantics, emotions (affectivity), or sociological values, with low-level information such as shape, color and texture, and artifact's behavior related data. All of these dimensions apply in early design stages, both when selecting inspirational materials and also when generating or evaluating new design solutions. As current evolution in design is going towards the involvement of end users at an increasingly early stage, Kansei information system potentially address to a whole system including users and designers. The emotional impact and the hedonic dimensions are partly due to quality of design solutions such as aesthetics, freshness, coherency, and more or less pleasure in interaction. Coherency depends on inter and intra-relations between high-level and low-level dimensions. For instance aesthetics entails harmony rules that may apply to the low level with color harmonies, or color-textures-shape harmonies, but also to low-level and high level semantics.

We investigated in some founded research projects which aimed at elaborating new tools for early design [Bouchard & al, 2009; Kim & al, 2010], but also in industrial design projects [Gentner, 2013],

the possibility to formalize the semantic relations the designers carry out in their activity. The experiments led in those projects confirmed that the designers may employ different type of design information which consisted of different levels: high-level (values, semantic words, analogy, and style), middle-level (sector name, context, and function), and low-level information (color, form, and texture). These levels of information can be seen as the position of an axis going from abstract (high-level information) to concrete (low-level information). The structure of design information enabled the construction of a design domain ontology used in this project for an image retrieval function. In order to gather and formalize Kansei information in relation to the earliest stages of design, we adopt a two-way approach. The first way is based on the extraction of kansei information by annotation or purge related to previous design projects. The second way is based on experimental observations and analysis from fictive design tasks [Bouchard, 2009, Kim, 2010]. From this dual approach, we proposed a model which structures kansei information from abstract to concrete dimensions. According to this model (see table 1), kansei information in early design can be structured according to the three levels high, middle, low and the 10 categories (Semantic words (Hs), Values (Hv), Analogy (Ha), Style (Hy), Emotions (He), Sector name (Ms), Context (Mc), Function (Mf), Color (Lc), Form (Lf), et Texture (Lt)).

Level	*Categories*	*Code*	*Description*	*Examples*
High level (H)	Values	*Hv*	Final or behavioral values	Security, Well-being, Freedom, Ethics
	Semantic adjectives	*Hs*	Most of these adjectives are related to color, shape and texture	Romantic, Aggressive, Muscled, Fluid, Robust, Balanced
	Emotions	*He*	Emotions as effects of design stimuli	Amused, Enthusiastic, Ill at ease
	Analogies	*Ha*	Objects, entities from other sectors from which some design elements are transferred into the reference sector by similarity	Rabbit → quick, fast
	Style	*Hy*	Characteristics of every levels through a specific style	Edge Design, Work wear.
Middle level (M)	Sector names	*Ms*	Objects names describing a sector or a sub-sector representing a specific trend	Sport devices, automotive design, interaction design, cosmetics
	Context	*Mc*	Moment, place, activity	Family leisure
	Function	*Mf*	Function, usage, component	Modularity
Low level (L)	Color	*Lc*	Color properties	Yellow, light blue, pale indigo
	Shape	*Lf*	Shape combinations, size	Square, corrugated, geometric, tight lines
	Texture	*Lt*	Motifs (abstract, figurative) and texture	Plastic, metallic

Table 1: Design information [Bouchard & al, 2009, 2011, Kim & al, 2010]

Defining a theoretical model of kansei information going from high level=abstract to low-level=concrete dimensions enables to provide a common model and format for the disciplines of design science, artificial intelligence, and marketing research. We emphasize in the next parts why the abstract-concrete structure makes sense in all of these disciplines.

3.2. Abstract-concrete information structure in artificial intelligence

A major problem in *artificial intelligence* is how to match information features such as shape, color or textures with semantics. This problem occurs particularly while developing new Content Based Image Retrieval systems (CBIR). While CBIR is a well-developed research area, there are very few information retrieval systems dedicated to industrial designers. This is due to the nature of design information, which includes low-level information (visual and image information) and high-level information (semantics and emotions). Linking high-level information with low-level information is a main issue, due to the semantic gap [Ferecatu & al, 2008]. The semantic gap illustrates the difficulty to relate two object descriptions at two different levels (see figure 1, in which semantic is very different even if the image descriptors are similar). High-level is more described by linguistic representations coming from design tasks while low-level is more a computational

representation founded on color numeric descriptors. Considering that there is no automated way of translating from one language into another, image retrieving tools are so far mainly based on low-level features.

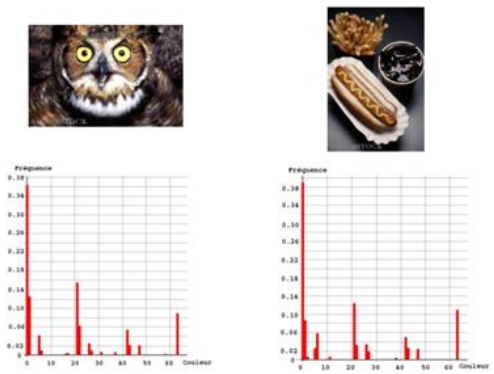


Figure 2: Semantic gap [Ferecatu & al, 2008]

Recent studies in the area of CBIR concentrate on extracting semantics from images using color features or lexical databases and adopting Kansei Engineering perspective. Kansei engineering methods enable to assess evoked feelings on the base of impression words including frequently semantic adjectives (urban, romantic, aggressive…) and more rarely affective or emotional adjectives (amused, astonished) describing the viewer. Even though they are not really formalized and externalized, the rules which enable to link low-level attributes with high-level dimensions are used on daily basis by the designers. This linking task is very subjective and varies from person to person. New systems are being developed, which integrate high-level information in their processes. These systems are often based on a strong interaction between the end-users and the system itself, with for instance the possibility for the user to choose among multiple images. Likewise, rules automation is frequently done with the intervention of the end-users through the use of neural networks or genetic algorithms, completed by semantic based indexing and annotation [Naphade, 2006, Shibata & al., 1999]. This approach follows both a bottom-up and a top-down process which allows matching semantics and impression words with physical features (color, shape, texture, regions, size effects) in a reciprocal way [Black, 2004, Hayashi & al. 1997]. This strategy applies to different sectors of application: professional images databases, clothing and fashion design [Shieh & Cheng, 2003]… We can assume that the structure of information based on abstraction levels is also relevant and operational in the field of artificial intelligence and more precisely in CBIR. Moreover, this structure may make further progress to face the technological issues to be solved in the development of CBIR systems. The interest in high-low structure for the discipline of marketing research is discussed in the next part.

3.3. Abstract-concrete information structure in marketing research and in engineering design

In the field of marketing research, the method of cognitive chaining of means-ends [Valette-Florence, 1995] aims at structuring product information according to more abstract values. This method enables to highlight how values influence consumer behavior. It formalizes the value-product relation through a chain of hierarchical cognitive sequences following various abstraction levels. The high-level corresponds to values and the low-level corresponds to products attributes. Concrete product attributes such as shape, color, texture, material, in relation to abstract dimensions such as semantics bring all together psycho-sociological consequences for the

consumer in helping him to attain his end-values. Values are instrumental (specific behavior modes, such as courage, honesty or romantic attitudes) or end values (aims of life to be attained through instrumental values, such as self-fulfillment or hedonism). Rokeach has defined a list of values in a list [Rokeach, 1973] which provides a finite number of values such as comfort, pleasure, etc. Each of these values may be defined into words following the values-functions-solutions chain. This way, formalizing the values-functions-solutions may support the production of relevant relations and solutions both in the products and values spaces. Current applications are associated with products segmentation and advertising. Consumers associate the attributes determining their choices with behavioral or end-values. This method is of considerable interest because of its predictive aspect concerning product consumption and brand names [Young & Feigin, 1975]. The semantic space is determined by considering the number of occurrences of individual items in the various types of chains, then by carrying out a multiple factor analysis dealing with the compatibility between individual items and types of chaining. This method is of great support for the translation of abstract values into concrete product attributes or vice-versa.

In design science, it provides more inspiring paths to be followed in an intuitive way by the designers during creative sessions, when working with images, mood boards or when sketching new concepts. Mood boards including user's values, products and their attributes constitute a good representation through which the values-functions-solutions chain can be expressed. We investigated the value-function-attributes chain in the framework of car design projects. For instance, to improve a technological innovation linked to an automotive dashboard, the technological innovation related value proposed by the marketing team was expressed in the following way: family, cohesion, family unit, cocooning, peace, smoothness. This approach was used for the elaboration of inspirational boards and design concepts (see table 2).

Terminal values of Rokeach	*Related values*	*Semantic descriptors*	*Related semantic descriptors*	*Low-level descriptors*
Pleasure	Well-being	Pleasing	Comfortable Nice Sympathetic	Curves
Security	Safety	All-land	Robust Powerful	Oversizing
Exciting life	Dynamism	Sport	Fast Light Resistant High-quality Reactive Alive	Tensed and dissimetric lines

Table 2: Design information [Bouchard & al, 2007a]

This table shows a representation where the value-function-solution chain appears at the top of the table, and the values are listed in the first column. The terminal values are defined into words following as well as semantic descriptors which are linked to the values. Semantic descriptors are highly used by the designers when working with images and sketching new design concepts [Kim & al, 2010].

To conclude this part, the value-function-attributes chain provides an explicit formalization on a concrete-abstract axis of the link between marketing and design universes (see table 2). In the previous part we show from the literature the relevance of a concrete-abstract structure for kansei information in the disciplines of design science, artificial intelligence and marketing research. In the following part, we investigate some formalism which can be used for the implementation of information systems towards computer supported technologies.

4. KANSEI FORMALISMS

Kansei information refers to a complex system between human and artifact. Kansei information calls for heterogeneous forms of data. Indeed, if we step back from the methods and concentrate on the nature of information, we can recognize this information may encompass various dimensions under a variety of formats. Qualitative data are naturally involved in the design process by the designers from generative tasks. Quantitative data are mainly involved in design research or sometimes in design contexts in the evaluative part of design. In the context of early design, the kansei information system may include a set of dimensions such as color, shape, texture, sound, smell, which can be expressed or conveyed in the generative phase of design through different formats such as sample pallets, multi-sensory compositions, keyword's sets, mood boards, sketches and prototypes. In addition, kansei information may be conveyed in the evaluation phase through quantitative data, coming from physiological measures or from differential scales with keywords or labels used in order to grasp the user state in front when experiencing specific static or dynamic design stimuli. To summarize, the main formats through which kansei data are potentially expressed are threefold (see table 3):

- Qualitative data (categories of words from various categories: brand or human values, semantics, sensory characteristics, emotions, styles, design elements, product sectors, multisensory design elements such as shape, color, texture, sounds, smells, and behavior).
- Quantitative data from differential scales associated to keywords (emotions, semantics, sensory, values, familiarity, numbers or icons, or from design elements digitization and description (global and local descriptors of shape and color),
- Quantitative data used in direct quantitative user measures (galvanic skin response, brainwaves…).

Kansei information	*Dimensions*	*Formats*
Qualitative data related to product	Color	*Keywords* *Sample Pallets* *Multi-sensory compositions* *Mood boards* *Sketches* *Prototypes*
	Shape	
	Texture	
	Sound	
	Smell	
Discrete quantitative measures related to user cognitive appreciation through product perception	Emotions	*Keywords* *Icons* *Numerical values from Lickert scales*
	Semantics	
	Sensory	
	Values	
	Familiarity	
	Shape descriptors	*Numerical values from region, contour, 3D descriptors*
	Color descriptors	*Numerical values from dominant color, color histograms*
	Texture descriptors	*Numerical values from edge histograms, Fourier descriptors*
Continuous quantitative measures related to user emotional response	Galvanic skin conductance	*Numerical values from electro-dermal activity*
	Brainwaves	*Numerical values from cerebral activity frequency*
	Posture	*Numerical values from momentum*
	Gesture	
	Facial expression	
Relations	Inter-dimensions rules	*PCA, FA, ANOVA, MDS* *Algorithms (GA, NN, FS, RS, ...)*

Table 3: Kansei dimensions and formats

Kansei vocabulary provides valuable formats because it makes possible to communicate every kansei dimensions, and it is such a language which is daily used by the designers. It is also well adapted to the early design phases, the generative and the evaluative ones. We will focus more in

the following parts of this paper on kansei vocabulary, keeping in mind the limits of this format in terms of subjectivity, dependency to context, and necessary consciousness of the users. Kansei formalisms, on the other side, must involve formats that are possible to implement with algorithms. Consequently, two formalisms which enable to formalize kansei design information into a lexical format are explored: ontologies and bag-of-words. Finally we propose a format which may be implemented by a hybrid technology.

4.1. Ontologies

Ontologies can be used in early design for formalizing kansei data in order to establish a classification and a conceptualization of designer's knowledge on the base of semantic relations [Bouchard & al, 2008, Setchi & al, 2010]. The applications affect essentially the indexation of non-structured information in image databases or multimedia and digital libraries, in order to design and implement new information systems able to link semantics with this visual information. In addition, some authors studied how to structure kansei information through a kansei vocabulary which conveys human feelings and shapes or colors [Baek & al, 2005a, 2005b]. Their research aimed at formalizing design knowledge with an ontology based on visual information (colors, shapes, textures, motives) and kansei vocabulary. The Wordnet thesaurus was used as a lexical database and principal component analysis was applied to establish relations. Results showed a big influence of the factor curved/straight line more than whole silhouette. In addition a similar approach was applied to color. Some similarity measures enabled to link Wordnet adjectives between kansei color and queries. Target words of Wordnet may be disambiguated with Lesk's algorithm [Banerjee & Pedersen, 2003], by selecting the definition of the dictionary and by examining its sharing with the biggest number of definitions of neighbors words. This algorithm compares the definition of a pair of concepts and calculates a score by counting the number of shared words. This approach does not make difference between a simple word and one sentence and process each definition such as a bag of words by removing empty words. The best relations found were those which were proposed by the user queries with descriptors such as pleasure, pained, angry, happy. Natural language was used to characterize this language because natural language is understood quite universally [Kobayashi, 1990; Nagumo, 2000]. Results enabled to find systematically the relevant colors from semantic descriptors. Wordnet is a thesaurus which organizes information according to groups of synonyms called synsets. The most frequent relation for adjectives is similarity: *is similar to*. The other possible relations for measuring similarity between kansei color and a query are: *attribute of*, *also see*, *similar to*, *pertainym of, participle of* and *antonym of*. Some relations characterize two sets of adjectives which have a semantic proximity but which are not sufficiently close to belong to the same synset. This relation which is the most open is called *also see*. It is very representative of the relations the designers naturally do. As ontologies so far involve mostly hierarchical relations, this format still may be constraining when dealing with designer's knowledge.

4.2. Bags of words

Some studies were led in order to formalize semantic information in inspirational phase of design. The purpose of these studies was the development of computer aided design tools [Bouchard, 2008, Setchi & al, 2010]. These researches aim at defining and developing new semantic formalisms that can be implemented into data processing models and which can relay designer's skills. The aim is to formalize data and rules under particular formats which can be further

implemented by ontologies or Bags-of-Words and computerized into algorithms (see figure 3).

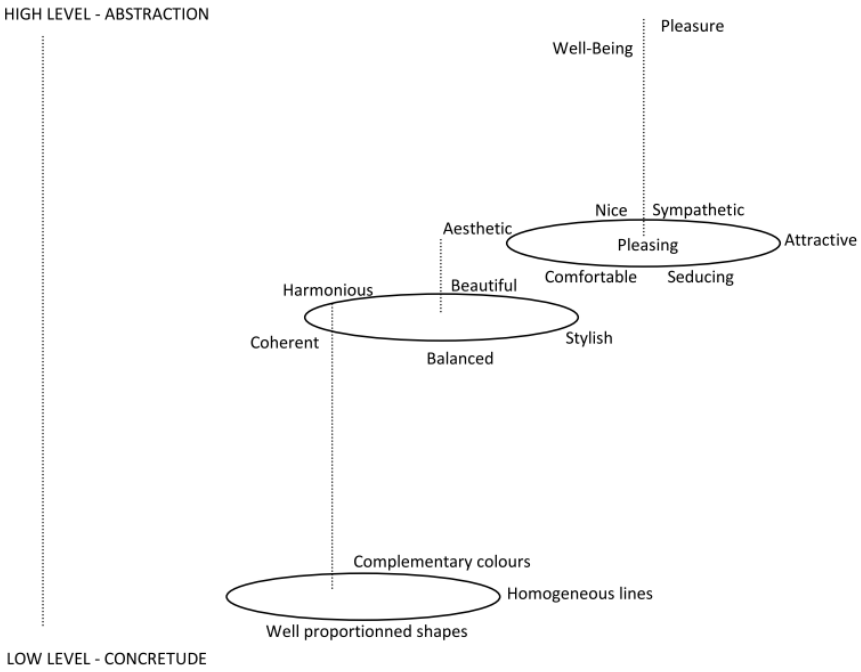


Figure 3: Examples of bags of words

The Bags of Words offer a more flexible structure and are open enough for earliest phases of design. They are based on semantic proximity which is fuzzier than the notion of synonymy or antonymy (*also see* relation). Considering that they do not obey to hierarchical formats, they are so better adapted to design information. Indeed, they are more based on the property to belong to a same group, than to be an attribute of, in a top-down or bottom-up relation. BOW can be combined to ontologies to provide better results in the context of semantic search engines. Anyways, they constitute an important filter which enables to increase significantly the relevance of results processing after semantic requests [Setchi, 2010]. In the context of design formalisms, there are two different kinds of Bag of words. The first category can be seen as horizontal BOW. This case, every words of a bag are at the same level of abstraction. For instance, *dynamic=intense, fast, enthusiastic, energetic, sportive, undertaking, effective, active…* The second category is more vertical. This means that the words inside may characterize different levels of abstraction. For instance, *aggressive= violent, imposing, speed, irritated, stressed, choleric, sport, brutal, provoking, dangerous, sharp, angular, edge, tensed, energetic, …* This second category relates to kansei rules which formalize by essence vertical relations by linking high-level features with low-level features.

Most used adjectives for image retrieval	***Related words (synonyms and related words)***	***Impacted low-level features: possibly quantified***
Balanced	*Stable, secure*	*Shape :* symmetry
Beautiful	*Aesthetic, gorgeous*	*Shape:* use of formal harmonies *Color:* use of chromatic harmonies
Bright	*Brilliant*	*Texture:* reflectance
Classic	*Traditional*	
Clear	*Clean, pure*	*Colors:* white, light greys
Cold	*Fresh, freezing, aqua*	*Colors:* cold colors
Dark		*Colors:* dark colors
Dynamic	*Active*	*Shape:* dissymmetry, tense lines, diagonal stripes
Elegant	*Refined*	
Exciting	*Seductive, appealing*	*Colors:* saturated colors
Freedom	*Irregular, unconventional*	*Shape :* Non regular forms / volumes

Heavy		*Shape:* dimensional ratios
Kitsch	*Loaded*	*Shape, color, texture:* Many reference objects
Light		*Shape:* dimensional ratios *Colors:* light colors
Original	*Fresh* *Bizarre* *Funny*	*Shape, color and texture:* Formal distance to the reference archetype
Motionless		*Shape :* symmetry
Natural	*Simple* *Authentic*	*Colors:* natural colors (green, …)
Quality	*Clean*	*Texture:* finishing, coating with visual and tactile effects
Relaxed	*Comfortable*	*Shape :* curves with big radius of curvature
Romantic	*Glamour*	*Colors:* unsaturated colors (pastels)
Simple	*Basic, clean*	*Shape:* elemental geometrical volumes *Colors:* plain colors
Soft	*Light*	*Shape:* curves *Colors:* pastels *Texture:* smooth matter
Warm		*Colors:* warm colors (orange, …)

Table 4: Kansei Dictionary [Bouchard, 2007b]

5. TOWARDS AN EXPERIENCE ENTITY DIMENSION?

A research composed of several experiments also identified another dimension, complementary to the abstraction dimension, permitting the description of kansei information exchanged by pre-development team: the experience entity dimension [Gentner, 2014]. This second dimension corresponds to the entity of the experience (as detailed in section 2) to which the design information is referring. The related scale is composed of three disjoint levels: human related kansei information, interaction related kansei information (human-artifact related and dynamic context), and environment related kansei information (artifact and static context). The original design information categories (see Table 1) were enriched with new ones. The original *context* category was for instance extended into *physical* and *temporal context* and the *texture* category was extended to *tactile attribute*. The extensions permitted to cover more accurately these context and artifact related attributes. In order to enhance the coherency of the model some original categories were also combined: *form* and *color* were combined into *visual attribute*, and *analogy* and semantic word were combined into *semantic descriptor*. Finally, several categories were also added that correspond to the design information that was observed during the different experiments but was not originally described. The new categories are *emotion*, *lifestyle*, *culture*, *morphology*, *auditory attribute*, and *olfactory attribute*. Figure 4 shows the position of all these categories on the related two-dimensional kansei information model.

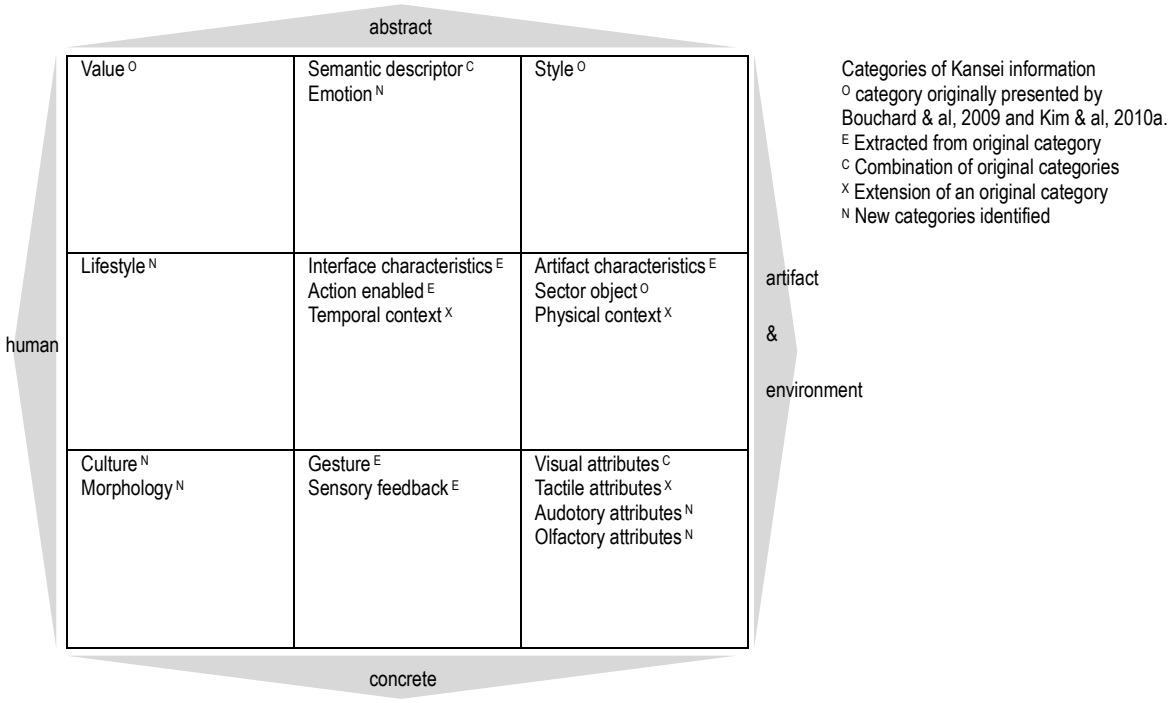


Figure 4: Two-dimensional kansei information model [Gentner, 2014]

6. CONCLUSION

In this paper we provide a definition of kansei information. We first describe the entities and reciprocal relations related to kansei experience: human, artifact, relation, and context. Then we specify the kansei dimensions inherent to these entities.

In a second time we discuss about how to structure all of these dimensions according to a format that would benefit to various disciplines, i.e. design science, artificial intelligence and marketing research. Indeed all these disciplines are now focusing on kansei information systems and trying to propose relevant formats. Finally, by examining some information structures in these disciplines, it becomes obvious that a structure on a concrete-abstract axis is relevant in all of them. Indeed this structure reflects some methods that have been developed on the base of linking high-level information with low-level information. After considering the various dimensions and related formats which can be found in kansei information systems, we propose to explore some formalisms involving kansei vocabulary. Indeed kansei words enable to refer to every dimensions of kansei and correspond to one of the modalities which are daily used by the designers.

We investigated two formalisms which can be implemented by semantic technologies: ontologies and bag-of-words. We then propose a schema which consists of a combination of both. The vertical dimension is an abstract-concrete axis. The horizontal dimension is that of bag of words. This way, the resulting structure includes both a value-function-solution chain, and more fuzzy bag-of-words at the level of semantic descriptors.

Finally the discussion was also opened to the consideration of the entity dimension as additional way to describe kansei information. It indeed permits to better transcribe the complex system

occurring during a human-artifact interaction. This consideration also permitted to identify additional categories of kansei information that should now be taken into account in further studies.

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BIOGRAPHY

Carole Bouchard is professor at Arts&Métiers, ParisTech (France). She teaches and guides research in The Product Design and Innovation Laboratory. She obtained her PhD in 1997 in the field of automotive design and is professor since 2012. Her research focus lies on Kansei Design, as well as creativity and innovation in early design stages. She pilots various research projects that seek to develop innovative design tools to efficiently integrate the Kansei in the design process and was one of the organizers of KEER 2010.

Alexandre Gentner recently defended his PhD research focusing on the definition and representation of user experience intentions in the early phases of the industrial design process. This action research was made possible because of a long-lasting collaboration between Arts&Métiers ParisTech (university) and Toyota Motor Europe (industrial partner). In this research, he explored the bridges existing between user experience and kansei research and the way these aspects can be addressed in early design activities. Some of the industrial contributions of this research were the creation of tools and methodologies supporting the reciprocal understanding of design information-rich representations of user experience directions.

Daniel Esquivel is Engineer and Senior Manager in Kansei department at Toyota Motor Europe. After a master research in Engineering design, he adopted a pioneering approach and contributed to the implementation of Kansei methods by a continuous transfer of research advances into industry.

KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Perception theories and kansei design

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Abstract: Approaches to create artifacts taking kansei into consideration are multiple and are shared among various disciplines, such as kansei engineering, kansei science, and kansei design. In this paper, I focus on the discipline of kansei design and show that various approaches exist within this discipline. These can be characterized based on their focus: either the physical or the interactive materiality of the artifact. Indirect kansei design, mostly focusing on the physical materiality, is based on indirect (or mediated) perception theories. It often relies on representations, models, and metaphors to provide meaningful input to the design. Direct kansei design, mostly focusing on the interactive materiality, is based on direct (or ecological) perception theories. It mainly relies on the designerly attitude of the designer in the process, and apprehend design meaning to emerge from the reflection upon design exploration within the process. Describing and differentiating these two approaches show how kansei is considered differently by different approaches of kansei deign, looking forward a dialogue between these approaches in order to obtain a greater insight on kansei and on its consideration for designing.

Keywords: perception, interaction, perception theory, kansei design, direct kansei design.

1. INTRODUCTION

Recent works have shown the multidisciplinary quality of the field of kansei research, in which kansei engineering, kansei science, and kansei design are non-exhaustive disciplines related to the making of artifacts (Lévy, 2013a). After mapping the discipline of kansei design in the field of kansei research, in this paper I intend to explicitly focus on the discipline of kansei design, to address the theoretical foundations of the two major approaches existing in kansei design, and to propose these foundations as a means to categorize kansei design projects.

2. DISCIPLINES IN KANSEI RESEARCH

The topic addressed in this section can be examined more in detail in previous works (Lévy, 2013a, 2013b). The literature shows three main disciplines related to the creation of artifacts: kansei engineering (Fukuda, 2011; Nagamachi, 2011), kansei science (Harada, 2003; Lévy, Yamanaka, & Tomico, 2011), and kansei design (Gentner, Bouchard, Esquivel Elizondo, & Favart, 2012; Lee, Harada, & Stappers, 2000; Lévy, 2013a). I briefly introduce here these three disciplines and explicit the way they differ from each other.

Kansei engineering was mainly initiated by Nagamachi in the 1980s (Nagamachi, 2002). kansei engineering is part of a family of engineering methods aiming at translating user's feelings into concrete product parameters. However, Schütte (Schütte, Eklund, Axelsson, & Nagamachi, 2004) clearly explains that "kansei engineering does not develop new theories or tools in the different areas at all. Rather, it is an all-embracing methodology containing rules for how different tools can interact with each other in order to quantify the impact a certain product trait has on the users' perception". Kansei engineering collects and organizes tools coming from other fields of research (mathematics, computer science, psychology...) in order to evaluate users, impressions. This structure explains both why and how kansei engineering evolves over time, and why it has been claimed not only in the discipline of product engineering, but also e.g., in marketing or robotics. Kansei engineering is defined by a structure and a purpose; tools, technologies and topics follow.

Kansei science was first proposed by Harada during the same period as the creation of kansei engineering (Harada, 2003). While kansei engineering has been a meeting between kansei and engineering, kansei science is a trans-discipline at the crossing of kansei and cognitive sciences. The research initiated in the 1980s by Harada aimed at describing holistically users' cognitive processes related to preference and choice of products. Kansei science is built upon brain science, mostly cognitive neuroscience and psychophysiology, and relies on related philosophies. Human's thinking and resulting behaviors can be best understood by using a model involving mental representational structures and mental procedures that operates on these structures (Thagard, 2011). These models and structures can be studied by psychophysiological approaches (Yagi, 2000, p. 364). In this academic context, kansei science research aims to characterize and to evaluate emotional experiences and creativity, to contribute to a better understanding of the mind based on physiological and psychological approaches. Moreover, kansei science has very often been relevant to design research by developing conjointly new methods for design and communication (Lévy et al., 2011).

Kansei design is, on the other hand, an emergent discipline in the field of kansei research. Although kansei engineering literature has often used the term 'kansei design' to characterize kansei engineering works which have output actual industrial products, in the present work kansei design is introduced as a novel kansei approach based strictly on design and design research (Koskinen, Zimmerman, Binder, Redstrom, & Wensveen, 2012). In our perspective, kansei design requires a designerly attitude towards the making of artifacts.

3. APPROACHES IN KANSEI DESIGN

Approaches in the discipline of kansei design can be characterized based on their focus:
The first type of approaches focuses on the physical materiality of artifacts (i.e., their intrinsic properties), and their evaluation or preference by the user (Kushi, Kitani, & Fujito, 2005; Lee et al., 2000). This type is very close to kansei science in terms of domains of application and tools (often

based on semantics), but differs by its attitude towards ambiguity and uncertainty. While kansei science intends to avoid it or to “solve” it by means of logic reasoning, kansei design deals with it by means of design skills. The second type of approaches focuses on the interactive materiality (Stienstra, Alonso, Wensveen, & Kuenen, 2012) of artifacts (i.e., the qualities of the artifact in interaction) (Lévy, Deckers, & Restrepo, 2012). However, underlying their foci, it is the theoretical standpoint they take that clearly differs these two approaches. These theories will therefore be described in order to clarify their influence on the kansei design approaches.

The notion of sensory perception relates to the way one recognizes and makes sense of the surrounding world. Theories of perception are often categorized in two groups. The first group, more conventional and by far dominant, is called the indirect (or mediated) perception theory, as it assumes that perceiving is an animal faculty which requires information processing to make sense of the surrounding. Perception is mediated, and therefore indirect. The second group is called direct perception theory, as it assumes that the world is perceived directly (without the need of information processing such as inference, memories, or representations) and that perceiving is an animal-environment system.

Based on these two categories of perception theories, kansei design approaches can be also be categorized in two groups. The first group focuses on the physical materiality of artifacts (i.e., their intrinsic properties), and their evaluation or preference by the user (e.g., in textile design (Otomo, 2012; Yahaya, 2012), and in automotive design (Kushi et al., 2005)). The second group focuses on the interactive materiality (Stienstra et al., 2012) of artifacts (i.e., the qualities of the artifact in interaction).

Both perception theory approaches will be introduced here, together with their related kansei design approach. The specificities of these design approaches will also be discussed.

3.1. Indirect approach

3.1.1. Indirect perception theory

The perception flow described by indirect perception theory is well known. Sensory receptors capture stimuli (i.e., environmental changes) and convert them into neural information (this conversion is called transductance) to be processed by the central nervous system. Each sensory organ is capable of converting a certain type of stimuli into neural information. In the case of sight, visible light is captured by the photoreceptor cells at the surface of the retina, creating the retinal image. This retinal image is then converted into a neural signal. However, this captured input is meaningless as is: a complex set of cognitive processes is required to translate this signal into a meaningful perception of the surroundings.

This approach suggests three aspects which are important to understand the relation between the subject and the world. First, the capture input is not the world itself, but – in case of sight - the retinal image of it. This image is a distorted two-dimensional projection of the three-dimensional world on the retina. The visual cognition process has to be able to rearrange the retinal image and the reconstruct the lost dimension. Second, the retinal image is a mosaic of stimulations, leaving to the cognition process the role of reconstructing the spatial continuity of the worlds. Third, experience is composed of perceptual moments (Smith, Gosselin, & Schyns, 2006), leaving to the cognition process (highly involving iconic memory) the role of reconstructing the continuous flow of events (i.e., the continuity of the temporal dimension) as we experience it.

From this, a couple of reflections can be pointed which have consequences for indirect kansei design. First, it is a representation (i.e. the retinal image) of the world that is perceived, and not the

world itself. This aspect explains well the value of representation, metaphors and models often present in indirect kansei design approaches. Second, a unique retinal image is senseless on its own. Iconic memory needs some retinal images captured in a series of perceptual moments to make sense of the dynamics of the world. This suggests that perception is not a continuous but somehow discreet process, and that memory plays a crucial role in the 'reconstruction' of the continuous flow of a perceived event. Third, in the description of the perceptive process, the body is quasi absent. As show in Fig.1, the body is 'just' the carrier of the senses which transform information towards the central nervous system. However, the motivity of the body appears irrelevant in this process. The Cartesian nature of this theory is therefore obvious.

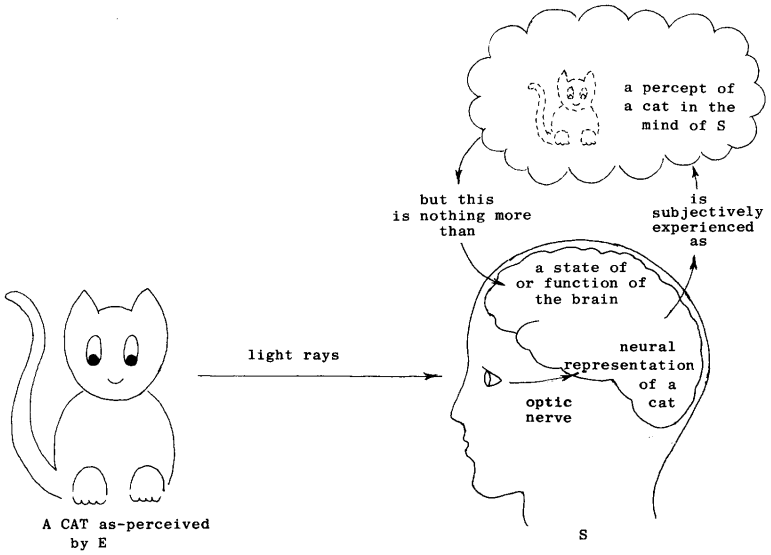

Figure 1: A dualist model of the causal sequence in visual perception (Velmans, 1990)

3.1.2. Indirect kansei design

Different works have been done to support the development of indirect kansei design. Two notorious ones are the work well presented by Lee (Lee et al., 2000) and the work developed by Toyota Motor Europe.

According to Lee (2000), the designer has to balance between objective and subjective properties, between functional technology and emotional expressiveness, between information and inspiration. Kansei design is proposed as an approach to implement these considerations in the design of a product in order to trigger a certain type of affective reaction. The result of this implementation is described and the *subjective properties* of the object.

The attempt developed by Toyota Motor Europe (TME) constructs an upstream phase integrated to the early design process phases of the company (Gentner, Bouchard, Aoussat, & Esquivel Elizondo, 2012; Gentner, Bouchard, Esquivel Elizondo, et al., 2012). Kansei design was initially described as the way to introduce kansei engineering approaches into the scope of design thinking (as described by Gero (2010)). The aim was to determine the design space (understanding), create propositions fitting in this space (creating) and to assess propositions based on users' kansei (assessing). TME uses kansei engineering techniques for assessing, but has come to recognize the need for a design approach in the first two parts: understanding and creating, i.e., the need for a kansei design approach to create a *kansei space*. The kansei design approach developed by TME

aims at bringing users' experience earlier into the creation of the design space.

3.1.3. Case study

The *Colourful Rain project* (Lévy, Kim, Tsai, Lee, & Yamanaka, 2009) is the kansei design of an umbrella letting the user experience a synaesthetic perceptive phenomenon: all the sounds of the environment in which the umbrella is being used are also perceived as colors (visually) on the umbrella canopy (cf. Fig.2). To do so, the synaesthetic phenomenon was detailed from a psychophysiological point of view, which was used both as an inspirational starting point for the design activity (Lévy et al., 2011) and as a means to determine the design requirements for a consistent synaesthetic experience.



Figure 2: The *Colourful Rain umbrella*, an indirect kansei design

This project illustrates how representations are involved in the design towards, in this case, an augmented experience of the auditory surrounding of the person. The colors on the canopy are a representation of the sound of the environment. Based on the psychophysiological approach taken as a model in this project, this representation is believed to be a reliable expression of how sound could be seen by the synaesthetes. What is interesting to notice here, which I may conjecture for indirect design approaches, is that the substantial meaning of the design is an input in the design process. It is brought by powerful means such as of interdisciplinary inspiration, metaphors (Lévy & Yamanaka, 2008; Saffer, 2005), etc., and does not originate and emerge from the design process. If so, this appears to be a fundamental difference with the direct approach.

3.2. Direct approach

3.2.1. Direct perception theory

The direct perception theory is radically different in the way it considers the richness of what is perceived. Whereas indirect perception theory considers the retinal image, being a poor stimulus enriched by the cognitive processes, direct perception theory considers richness to relies directly from the stimulation itself.

A major direct perception theory (also called ecological psychology), mainly developed by J.J. Gibson, reformulated the notion of stimulus and showed how richness can be located in the animal-world couple (i.e. human-artifact from a design perspective). The notion of stimulus, described by indirect perception theory as an energy captured by the senses, is described in direct perception theory as an information being *the structure that specifies an environment to an animal*. Consequently, direct perception theories do not regard cognitive processes as the place where meaning arises. However, direct perception does not refute the existence of cognitive processes involved in the perceptual activity. Differently, cognitive skills contribute to the perceptual activity,

but is not the place of the construction of the perceptual richness, i.e., the place where meaning is constructed. Meaning is constituted in between the animal and the world, and cognition is one of the crucial activities taking place on the animal side of this coupling.

From this perspective, perception is not limited to a perceptual moment delivering and impoverished stimulus, but is the determination of (rich) information through an extensive length of time during which an event - itself nested in other events - is perceived. This way, perception is a continuous activity of determining information within a continuous flow of events in space and time.

This consideration leads to a second significant difference between the two perception theories: the active nature of the perceiver. For indirect perception theory, the stimuli are captured automatically, effortless for the perceiver. The perceiver is passive (although some theories would claim that the perceiver is cognitively active to reconstruct the richness of what is been captured). For direct perception theory, the perceiver is engaged, and therefore active in obtaining the information of its environment.

This fundamentally impacts the way perception theories consider the perceiver-environment relation. Indirect perception theories consider the dualism perceiver-environment, i.e., the perceiver and the environment are separate and independent entities. Consequently, indirect perception psychology focuses on the on-going processes taking place "inside" the perceiver (from stimuli capture to behavioral response), and the environment is “just” considered as input for the inquiry. Differently, direct perception theories consider the ecological system perceiver-environment, i.e., they are part of one system which needs both to function and to be comprehended. Perception is about understanding the perceiver’s environment, in which her/his body is, and actually is part of. Therefore, considering the relation between the perceiver and the environment in the inquiry addressed by ecological psychology, and considering the fact that understanding the environment requires the perceiver to be active in the environment she/he is engaged in, it seems impossible to consider these two entities separately. Moreover, because understanding a perceiver can be done by describing her/his environment from her/his unique perspective, and the other way around, I can conclude that according to direct perception theories, the perceiver and the environment are not only dependent on each other: their relation is mutually constitutive.

In this being-environment eco-system, information is also present. Relevant information, i.e., the one that can be perceived by the being, can be so depending on the composition of the environment, on the sensory system the being is equipped with, and on the way this being engaged in the environment. However, one supplementary fundamental condition is necessary for the information to be relevant: what Gibson calls the *affordance*.

Affordances are what can be done in interaction with the objects, the places, or the events. Gibson (1979) describes "the affordances of the environment as what it offers animals, what it provides or furnishes, either for good or ill". However, it is important to look at affordance from the ecological system perspective, that is to consider both the constitution of the environment and the animal to understand this notion. A chair can be seated on only if it has the physical properties (surface, steadiness...) and if the being is capable to sit on it. The capability depends on the physiological qualities (corpulence), the strength, and the skills of this being. Looking at the object qualities, we can imagine that a chair, a bench, a table, or a guardrail may be seated on. It is not the intention of the designer, nor the intended primary function of the object, nor the term used to label an object that dictate how the object can be used. It is the way it stands in the world, the way it is structured, the way it appears to the being that influence the way it can be used. Moreover, it is not these qualities alone that condition the way it can be used. A priori, a small child cannot sit on a

table or on a bar stool on her own. The purposely behavior of the being is called *effectivities*. If one can walk, run, swim, or fly will influence the way one engages with the world, and therefore the relevant quality of the information available in the environment varies.

Gibson argues that it is affordances that are perceived. In other words, the one perceives (i.e., makes sense of) the world by what one can do or behave within it. One does not perceive chairs, benches, tables or guardrails, but places to sit on. This perception is therefore dependent on information available in the environment and on the effectiveness of the being. That means what is perceived is relevant (and rich) information available, detectable, and usable in the perceptive ecosystem.

3.2.2. Japanese theory on direct perception

The Japanese world of philosophy and psychology does not escape from this debate between indirect and direct perception theories. However, the Nishidian philosophy brings a strong and relevant perspective on perception for the discussion stressed in this paper. Three Nishidian notions can be very instructive on this perspective: *action-intuition*, *pure experience*, and *basho*. "We see a thing by action, and the thing we see determines us as much as we determine the thing. That is action-intuition" (Nishida, 1952/1987, p. 131). *Action-intuition* describes the view that intuiting entails acting, and acting intuiting. Both the world and the subject are formed mutually and are reflected in one another (Maraldo, 2010); *pure experience* corresponds to the notion what the primal undifferentiated form that subsequently dirempts into differentiated forms including: experiencing subject and experienced objects, intellectual intuition and reflective thought, objectified nature and objectifying spirit—all on their way to a higher unity (Maraldo, 2010); *basho* is described as the place where individuals are located in terms of their substance and attributes. This basho is not the world of actual, concrete beings but an initial and partial reflection that abstracts part of that world so that it can become intelligible (Heisig, 2010).

These notions obviously appear to be constitutive of the Japanese approach on kansei, as well as on perception, on experience, and on context. Moreover, the notions introduced by Nishida can be considered in regards to the Gibsonian ecological psychology. The Nishidian philosophy suggests that the subject and the environment (or *basho,* being fundamentally the *experienced object*) are related by essence (*pure experience*) and are 'formed mutually and are reflected in one another' *(acting-intuition).* This approach appears therefore as an ecological nature and is close to the Gibsonian psychology.

3.2.3. Direct kansei design

A direct kansei design approach is therefore also possible as it can be supported by an inquiry in Japanese philosophical or cultural works related to kansei, using them as inspirational means for design. Therefore, I suggest here that direct kansei design explores Nishida's philosophy (and other related philosophies and Japanese cultural traits) as a source of knowledge and opportunities to be handled by design.

With its roots in Japanese culture, direct kansei design takes the Japanese tradition for craftsmanship into highest consideration (Sennett, 2008; Yanagi, 1989) and reaches end users through the relationship between craftsmen and their artifacts. The stance of an artifact is not revealed only by the experience of the users. It also acquires meaning through the intention of the designer. This is how kansei should be explored in the design process, incorporating all the varieties of points of view held by designers and users.

3.2.4. Case study

The *passage* is the design of transition in between space. The design draft was in the in-between space. During a course on kansei design, Eindhoven University of Technology students were asked to design for an experience in between two spaces, without designing for one of the two spaces. This brilliant result proposes an indirect light projection on the door. A series of light-emitting diodes (LED) light on aluminum foil, which reflects the light on the door. If the door is closed or open to the maximum, the projection is invisible. From an experiential point of view, none of the two spaces are directly involved in the interaction. Moreover, depending on the way the user opens the door, the air flow generated by the door influences the movement of the aluminum foil, which influences the light behavior. That is, the qualities in interaction emerge from the interplay between the person and the artifact, and therefore can be described only from an ecological perspective.



Figure 3: *Passage*, a direct kansei design,
designed by Gracia Goh, Chiyong Lim, and Kate Vermeyen

Differently from the conjecture proposed for the indirect design approaches, the meaning in interaction has emerged from the design process itself, and the artifact appears to have an identity on its own (which can be associated to the famous 'metaphors suck' of Djajadiningrat's pamphlet (Djajadiningrat, Overbeeke, & Wensveen, 2000). Here as well, I would conjecture that beauty in interaction design based on a direct approach comes from the design exploration itself, which therefore requires a design process involving iterative reflections upon design explorations. The Transformative Reflective Design Process (Hummels & Frens, 2009), involved in the design of the *passage*, provides such a framework.

4. CONCLUSION

Although the discipline of kansei design is still in an emerging phase, looking for its position and its role in both the research fields of kansei and of design, it is possible to identify different types of kansei design approaches. The first one, indirect kansei design, is based on an indirect (or classical) perception theory, and is consequently close to kansei science from a theoretical perspective. The second one, direct kansei design, is based on a direct (e.g., ecological) perception theory, and is close to interaction design as described by Overbeeke (2007).

Therefore I argue here that a primary fundament of kansei design is the perception theory on which the notion of kansei is approached. An indirect kansei design approach relies on knowledge created by indirect perception theories and on external input for the creation of meaning. Kansei is then defined as a high function of the brain related to emotions, sensitivity, feelings, experience and intuition, including interactions between them (Lévy, Nakamori, & Yamanaka, 2008). Beauty is evaluated from the way the design is experienced in the user's mind. A direct kansei design approach relies on designerly iterative explorations from which meaning emerges. Kansei is then described as the ineluctable and affective experience of "being-in-the-world" (Lévy, 2013a). Beauty

is in interaction between the user and the artifact, i.e., as a quality of the interplay.

This primary structure provides a set of means (theory, approaches, tools…) for various kansei design processes. However, it also opens numerous questions (e.g., applicability and relevancy of each theory depending on the nature of the design project). I expect that the attempt to answer these questions will help the kansei design community to explore and to clarify further the discipline, to gain insights on kansei, to better differentiate and associate kansei design with other types of design disciplines, and to progressively create tools and frameworks to better operate kansei design projects.

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BIOGRAPHY

Pierre Lévy is assistant professor in the Design Quality in Interaction group of the faculty of Industrial Design at Eindhoven University of Technology, the Netherlands. He gained a doctoral degree in kansei science at the University of Tsukuba in 2006. He has been publishing numerous papers on kansei science and kansei design. He is an active member to the JSKE, being a member of the IJAE Editorial Board, and is currently the chair of the Scientific Committee of KEER2014. His focus is mainly in direct kansei design, designing for subtleties in immediate experience.

KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Communicating Emotion through Haptic Design

A Study Using Physical Keys

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Abstract: This paper explores how designers may communicate with the users of their products through haptic design. More specifically, how tactile properties of materials evoke emotions such as satisfaction, joy, or disgust. A research through design approach has been followed; mood- and material boards and prototypes of four 'haptically enhanced' (physical) keys were created. Types of keys selected include home, bicycle, hobby, and basement. An experiment with ten participants was conducted, using word association and a software to elicit product emotions (PrEmo). Results show a mapping between the designer's intent and the user's inference. We conclude that it is thus viable to communicate emotions using haptic design. Moreover, we found that when using their sense of touch, participants' previous positive or negative memories and experiences were projected onto the objects.

Keywords: Affective Engineering, Design Communication, Emotional Design, Haptic Perception, Rapid Prototyping.

1. INTRODUCTION

"I am giving them [products, added by the authors] new tactile properties, so that the user has to think while touching" (Rouillon, 2013). Artists inspire us to explore how we experience products in the digitalised world of today and make us wonder whether we are losing (the sense of) touch and thereby perhaps an important source of information, let alone an experience?

We are interested in understanding how we as designers may best evoke intended emotions in the users who are interacting with the artefacts we design. More specifically, we wonder, how we may best communicate our design intent using the senses of touch.

From a design research point of view, communicating design intent has been an important topic in trying to understand how users interact with designed systems such as physical artefacts, digital interfaces or services (Crilly, 2011). Design intents may be varied and ways of expressing manifold. We focus on emotional design through haptics. Emotions have been emphasised as a central quality of human existence, contributing to our ability to understand the world and learn new things (Norman, 2004). And in particular, the senses of touch are highlighted as part of the fabric of everyday, embodied experience (Paterson, 2007). Moreover, emotional design has been put forward as a differentiator and competitive attribute for designed products (Desmet and Hekkert, 2009; Jordan 2000).

Our aim is, therefore, to explore how we as designers may communicate emotions as our design intent through haptic design (Hara, 2007). To support this goal, we decided to use physical keys as most of us are using (physical) keys on a daily basis. Keys have for centuries accompanied our lives to open our homes, cars, workplaces, or safety deposits. And this is still the case, irrespective of the increase in use of electronic chips, codes, and fingerprints. Following a research through design approach, we created mood- and material boards and prototypes of haptically enhanced physical keys. We subsequently conducted an experiment with 10 participants, using a combination of word association and an assessment method to elicit product emotions, the PrEmo tool (Susa Group, 2013).

The article unfolds as follows: Section 2 gives the literature background for this study, in particular drawing on and integrating literature from the focus areas of design communication, emotional design, and haptic design. Section 3 provides an overview of methods used in preparing the material for the experiment with the users. Results are presented in Section 4. Section 5 discusses the results and provides conclusions.

2. LITERATURE BACKGROUND: TOWARDS AFFECTIVE HAPTICS

2.1. Design as communication

Studying design as communication has been an important topic in design research and practice (Crilly et al., 2009) where artefacts may be represented as media in the design process (Crilly et al., 2008). In this view, artefacts such as physical products are seen as media of communication between the designer and stakeholders such as users, where users infer design intent as expressed in product. Which sense do we try to appeal to when we as designers try to elicit intended emotions from users interacting with the designed object?

2.2. Design for emotion

"Nobody *would argue against the idea that usage experience should be pleasurable"* (Desmet, 2009). Users expect that products are easy to use, well-functioning and that they in some way touch them emotionally (Desmet, 2002). Knowing well that *"emotions cannot be separated from product*

function and issues of usability" (Desmet, 2009), it appears to be evident that attractive 'things' make people feel good and tend to work better (Norman, 2004). As such, an essential strategy to increase a product's competitive edge in the consumer market is to incorporate emotional values (Chang et al. 2007).

But how do you as a designer ensure that the users share the emotions towards a product that you may have intended to elicit? "[…] *products often evoke 'mixed' emotions. Rather than eliciting one single emotion, products can elicit multiple emotions simultaneously […]"* (Desmet, 2008). Designers want to be able to get an insight into users' emotions to understand whether a product will please the user (Jordan, 2000) and to anticipate positive emotional responses and thereby avoid potentially unwanted effects. *"[…] We all have emotions and thus, from experience we all know what they are."* (Desmet, 2008). Emotions may be evoked by different cues in the product; cues that appeal to different senses. Gant (2005) emphasises that one of the most influential ways for the designer to get a deeper emotional connection between products and users is to strategically select the material used. The choice of material influences how the user interacts with the product.

2.3. Affective haptics through the sense of touch

Vision has often been described as the most dominant sense (Dagman et al., 2010). However, recent studies indicate that other senses are as important in the way we experience products, such as the haptic sense relying on stimuli through physical contact. *"Touching is one of the ways to explore an object's aesthetics and the dimension of comfort […]"* (Jeon, 2011). Affective haptics as an emerging research area focusing on the design of systems ranging from products to services. It focuses on how the emotional state of people interacting with such systems may be elicited, enhanced or influenced through the sense of touch. The brain receives information from the sensory system that consists of receptors, including kinaesthetic receptors (the mechanoreceptors in muscles, joints and tendons) and the cutaneous receptors (the receptors embedded in the skin) (Lederman et al., 2009). When we haptically experience a product, *"[…] we are able to see an object sensorially and perceptually through our hands and body so that when designing an object, designers should consider the way people touch it to feel and appreciate it […]"* (Jeon, 2011).

3. METHODS: RESEARCH THROUGH DESIGN EXPERIMENT

The focus area for the experimental study is to incorporate specific emotions into everyday objects that will be decoded only by utilising the sense of touch. As this is an explorative study we simplified the study to increase the chance of success, by choosing a target group somewhat homogenous and equal to the designers. "*Although emotions may be subjective, the process of emotion is universal and people that share concerns and appraisals will experience similar emotions to a given product*" (Desmet et al. 2007). Therefore, the target group was chosen to be in their mid-twenties. The design objects were selected to be (physical) keys. See figure 1 for an illustration of the steps in our research through design process.

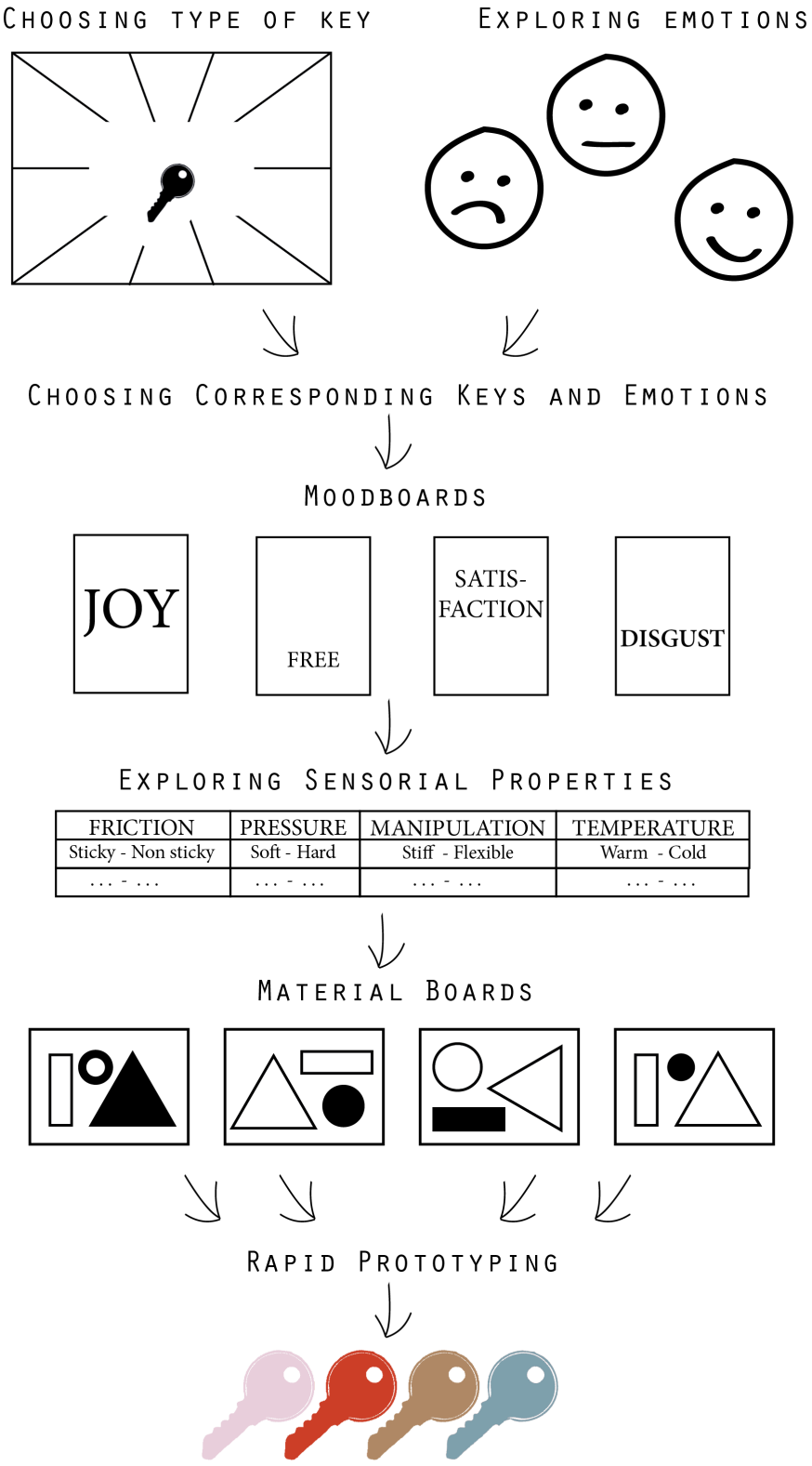

Figure 1: Towards haptically enhanced keys: A research through design process preparing the experiment

3.1. Preparing the keys to be used in the experiment

3.1.1. Selecting a set of different type of physical **keys** as our study object

To explore the types of keys the target group was using on a daily basis, a field study was conducted. In total, 33 people participated, 18 women and 15 men. A standard setup, which can be seen in figure 2, was used to structure and document the different types of keys.

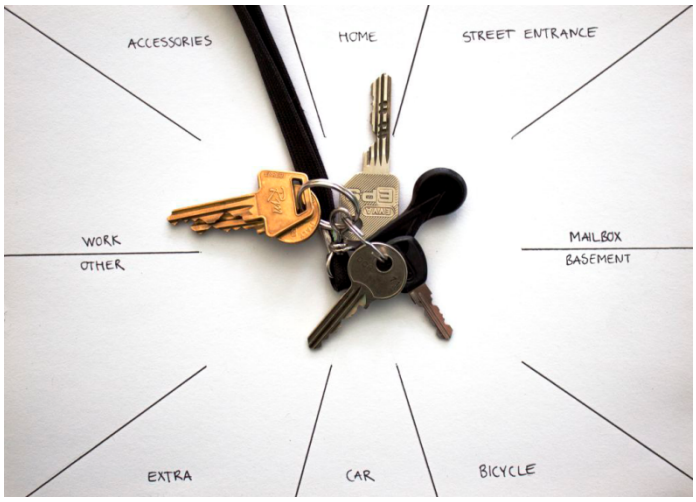

Figure 2: Eliciting which type of keys people carry with them on a daily basis

We selected the keys present in most key chains for incorporation of haptic- and emotional design aspects. The four keys were: Home, Bicycle, Hobby and Basement.

3.1.2. **Selecting emotions** associated with the design object

It was important that the four keys represented different types of emotions to challenge us as designers and to see if the participants would be able to perceive and identify the intended emotions. Inspired by a list of emotions (Desmet, 2012) and the circumplex model of affect with product relevant emotions (Desmet, 2008; adapted from Russell, 1980), the authors associated the following emotions with the four keys (table 1):

Table 1: Emotions associated with the different keys

Home	Bicycle	Hobby	Basement
Relaxed	Free	Passion	Cold
Warm	Eager	Satisfaction	Alarmed
Comfortable	Impulsive	Joy	Disgust
Joy	Reliable	Puzzled	Fear
Love	Exposed	Amused	
Secure		Thrilled	

3.1.3. Developing **moodboards** for mapping keys with intended emotion

To get a clear understanding of the different emotions associated with each key, four different moodboards were created. The moodboards served as visual tools to agree on what overall sensation we as designers wanted to convey with each key (see figure 3).

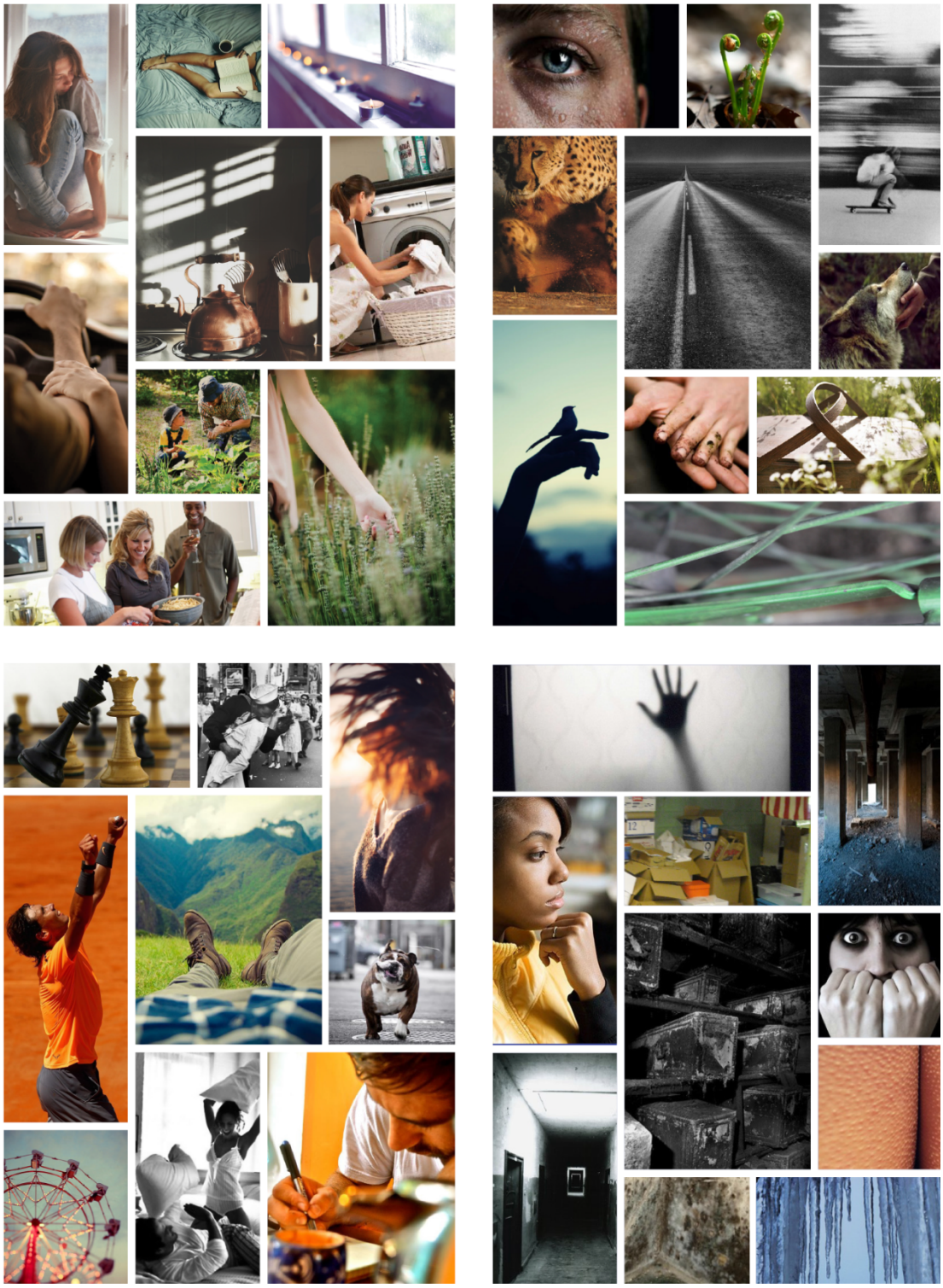

Figure 3: Moodboards for the four keys from top left to bottom right: Home, bicycle, hobby, and basement

3.1.4. Developing **material boards** to include intended sensorial properties

The Materials in Product Selection tool (van Kesteren et al., 2007) was used as inspiration for defining the material profile of our new products in terms of sensorial properties and for choosing the specific material. Four material boards were created with different sensorial properties. This was done to emphasise the emotions in each moodboard. Examples of the material boards can be seen in figure 4.



Figure 4: Material boards for *home and basement* respectively

We examined the material boards with a number of actions that people undertake when manually exploring products: they may stroke, lift, press, squeeze, feel the temperature or follow the outline (Lederman et al., 2009). These actions encompass activities for both the cutaneous- and kinaesthetic receptors and were used when examining the material boards.

3.1.5. Rapid prototyping: **Making 'haptically enhanced'** keys

The material boards served as inspiration for combining different materials and as the basis for prototyping. Specific emotions were selected to be incorporated into each key, see table 2:

Table 2: Keys and intended emotions

Key	Home	Bicycle	Hobby	Basement
Emotion	*Joy*	*Free (as a combination of pride and joy)*	*Satisfaction*	*Disgust*

Based on our own interpretation, we express 'free'/'the sense of being free' through a combination of pride and joy. This way, we include the sense of being free', currently not present in the test programme PrEmo (described in section 3.2).

The development and outcome of a rapid prototyping session can be seen in figure 5 and 6.

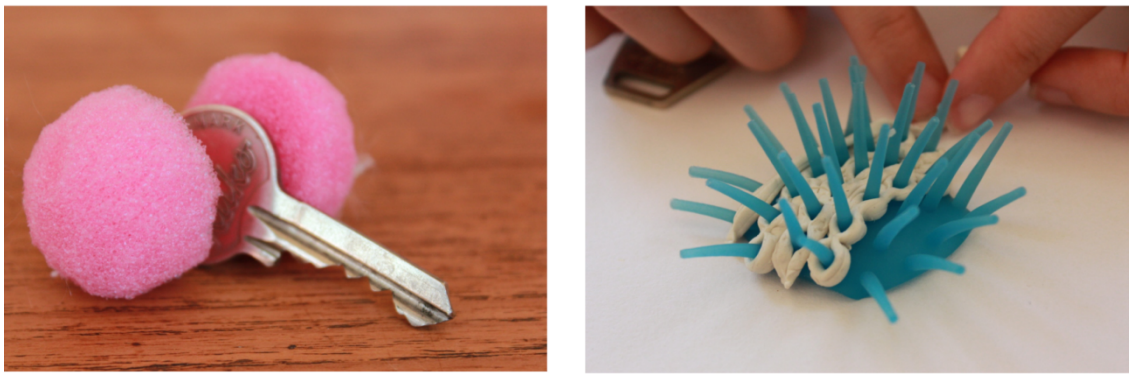

Figure 5: Development of the prototypes for home and basement respectively



Figure 6: Rapid prototyping results for the keys from the top left to right:
Home, Bicycle, Hobby and Basement

The four keys that were haptically improved had all somewhat similar sizes and weights. A description of each key can be found below.

Home: The overall geometric shape is chosen to be spherical, so the weight is equally distributed. From the material boards the properties furry and squeezable are chosen, so the test person is able to compress the key. When using lightweight foam to create the shape, a relatively large, but in comparison light key is created, which feels comfortable in the hand. When interacting with the key pleasant and joyful emotions should come to the mind of the user.

Bicycle: This key provides circular movement which should be joyful to play with. A functional element is also incorporated to allow the user to feel pride when decoding the moving pattern, just as if they had successfully accomplished a task. Rubber was chosen to give a none-smooth surface resembling the control and stability of tires. When combining these interactive elements, this key should relate to being free.

Hobby: From the material board the properties hard and warm are chosen, along with the overall round geometric shape. The surface should be smooth and have some convex curvature, which should influence the test person to follow the smooth round curvature continuously. The intention is that the participant does not want to stop the movements, just as it is hard to stop doing something you are fascinated about.

Basement: The key for the basement should be sticky to clarify the feeling of disgust when touching. Also the surface should have some irregularities. The key chosen has an overall trapeze shaped outline and is on purpose kept cold.

3.2. Conducting the experiment using PrEMO

3.2.1. Describing PrEMO

With our 'material' in place, we then prepared the experiment to see whether the emotions we would like to elicit as designers are indeed evoked in the user. For that, we used the Product Emotion (PrEmo) Tool (SusaGroup, 2013). The PrEmo tool is a nonverbal self-reporting instrument that uses animated cartoon characters to represent 12 distinct emotions. The PrEmo tool depicts a 0-4 point scale where the participant chooses to which degree an emotion is present while being influenced by the stimuli. An overview of the different emotions is shown in figure 7. The participants are able to report their emotions with the use of these visual characters instead of relying on words. This is an intuitive method that prevents the problems with interpretation of different words, *"...participants, when describing haptic product experiences, sometimes used adjectives that referred to 'visual experiences'"* (Dagman et al. 2010).

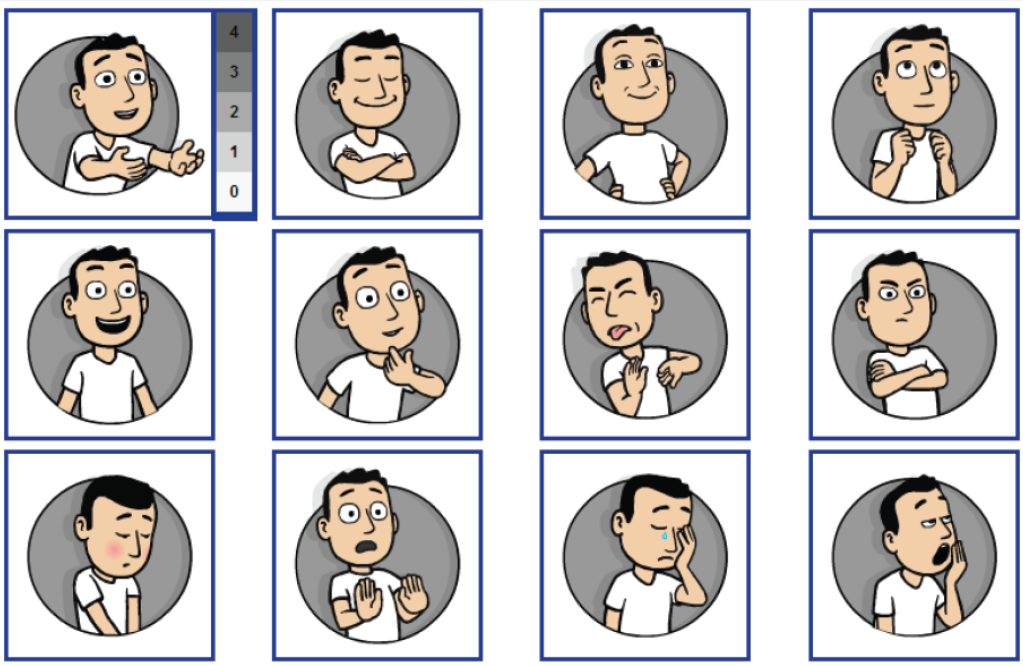

Figure 7: The PrEmo tool's different animated characters showing different emotions. The emotions are from the top left: Desire, Satisfaction, Pride, Hope, Joy, Fascination, Disgust, Dissatisfaction, Shame, Fear, Sadness and Boredom (SusaGroup, 2013)

3.2.2. User experiment

In our user experiment, we use in-depth interviews for the purpose of collecting emotional- and haptic responses from 10 participants, 6 women and 4 men within the target group. Each test lasted about 30 minutes and followed the same protocol, documented by video recordings. Participants were all first introduced to the key for home, followed by the keys for bicycle, hobby, and basement. After examining each key with their hands, participants were tasked to use the PrEmo tool to click on a corresponding emotion of their choice. Through the whole experiment, participants were encouraged to think- and talk aloud. The test setup can be seen in figure 8.

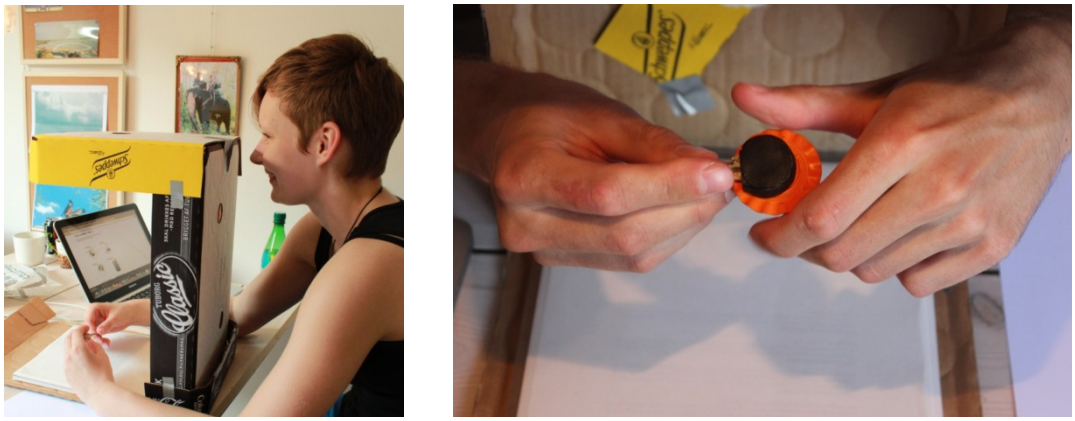

Figure 8: Testing the keys only by using the sense of touch

4. RESULTS FROM WORD ASSOCIATION AND EXPERIMENT

Data from the PrEmo tool was extracted and the average score was placed in a spider web revealing the degree to which the emotion is present (see figure 9). Word association through verbalisation by participants enrich interpretation of the results.

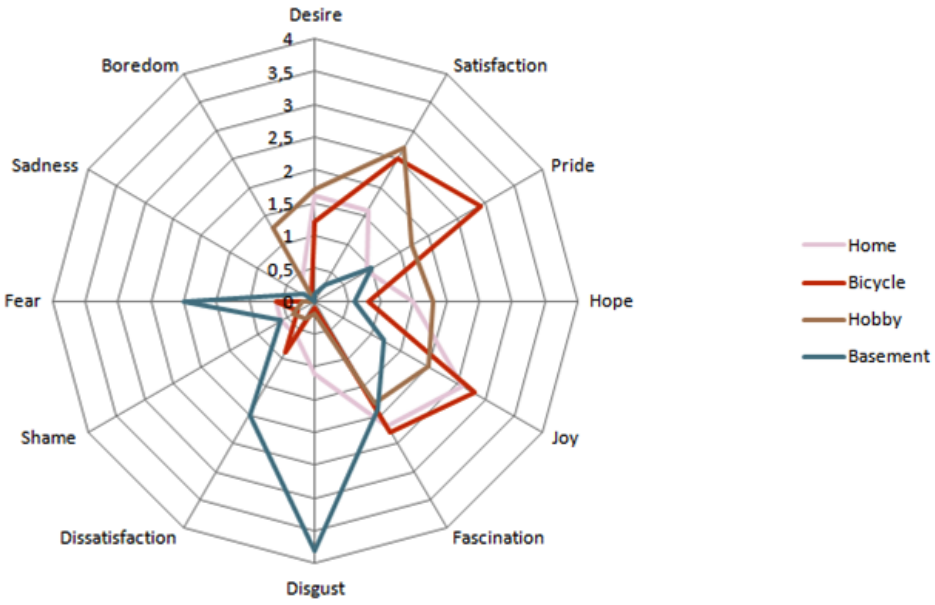

Figure 9: Reported emotions through the PrEmo tool

Home: Joy and fascination are the two emotions that the users first of all associate with the home key. It is seen that the home key overall relates to positive emotions which also are supported by the following quotes: *"It is nice that the material is soft", "It reminds me of a teddy bear, which I like",* and "*It makes me feel happy".* This correlates with the intended positive feeling of joy.

Bicycle: The bicycle key engenders most of all joy and pride, but also to some extent fascination and satisfaction. The tactility of this key is mostly related to positive emotions. The users articulated their impressions as follows: *"It seems to be functional", "Something you can walk around and play with in your pocket", and "The moving pattern is attractive".* Our intended emotion was freedom by combining joy and pride – and this was achieved.

Hobby: Satisfaction and joy are the most distinct emotions, along with a few more positive emotions. An interesting thing to notice is that some of the users found the key boring. *"Organically formed, it's nice to touch", "A little boring", "It is nice to hold in your hand"* where some of the words that were said in relation to this key. The 'inscribed' emotion was satisfaction which is one of the dominating emotions in the result.

Basement: Disgust is the emotion that gets the highest score and most unanimous indication. Fear and dissatisfaction are also highly present and is found to have the same presence as fascination. *"Ieww", "This is disgusting", "I don't really like this one" and "I am tempted to touch it again"* were some of the words that were mentioned in relation to the basement key. The aim to design for disgust has been reached.

5. DISCUSSION AND CONCLUSIONS

In this paper we have introduced a design approach to develop objects that communicate emotions through haptic design. The tactility of the applied materials in the prototypes served as a communication channel and evoked intended emotions. In the experiment, the 'targeted' emotions were articulated and verified through the use of PrEmo tool.

When communicating emotions through haptic design, manual explorations of the object are of most importance. During exploration, a communication platform emerges as the user gets familiar with the object's texture, shape and function. Combinations of these different elements arouse emotions depending of the user's relation to the elements.

Emotions are subjective and associated with previous experiences. We found that when using their sense of touch, participants' previous positive or negative memories or experiences seemed to be projected onto the objects. Participants mentioned often that the surface they touched seemed familiar, and by trying to determine the origin of the material relating to prior experience.

Results reveal that there was a mapping between the participants' inference and the designer's intent and we conclude that we were successful in communicating intended emotions through haptically enhanced design objects, also when aiming at two emotions instead of only one. The specific emotions designed for were not the only emotion present, however, the chosen ones ranked highest in the results. This demonstrates that products oven evoke a mix of emotions and that it is, however, possible to amplify the direction of desired emotions through design.

Methodologically, we observed the tendency that participants were being modest when grading the first key. It could therefore be considered to implement a test round. Also, the order of the keys had an influence on the way each key was experienced. The key (hobby) that followed the bicycle key was mentioned as *boring* since it had no significant function compared to the previous ones. The results reflect that the key (hobby) that you cannot manipulate (for example through compression, rotation, or deformation) scores higher on the scale for boredom. In further studies, a 'regular' key could be implemented as a reference product.

ACKNOWLEDGMENTS

We would like to acknowledge our research participants for their time and help. Further, we wish to thank the Susa Group for granting us a student license for the PrEmo tool.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Diffract Me! – Using a Skills-Based Approach in Design Practice

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Abstract: The potential of skills in design is intriguing; as skills open up new perceptions of the world they allow meaning to arise as we engage with the world. Several skills-based techniques that leverage this potential have been developed, and integrated into the Designing in Skills framework. The framework builds on personal engagement of designers in their practice, and promotes them to take a first-person perspective, enabling designs to be enriched with meaning. In this paper, we present the most recent workshop based on this approach, which specifically focuses on employing the Designing in Skills framework as a starting point and catalyst for design practice. We briefly introduce the Designing in Skills framework and present the DiffractMe! project in which we built on this approach to explore its potential for design practice. We conclude with reflections on the process and result by the involved designers. These reflections offer insights into the value of this approach for enriching interactive design with experiential qualities.

Keywords: Interaction Design, Engagement, Skills, First-Person Perspective, Design Process.

1. INTRODUCTION

In recent years, we have developed a number of methods, approaches and tools that leverage skills, embodiment and personal engagement in design, aiming to enrich both the design process and end-result with "richer" meaning. Examples of this work include *Rights through* Making (Trotto, 2011) and *Designing in Skills* (Trotto & Hummels, 2013). These approaches hinge on exposing individual sensibilities and unlocking richness on a personal level in relation to others, rather than

to aim for objective and universal qualities.

When looking at skills, sensibilities and richness, our work is part of the field of aesthetics of interaction and pragmatic aesthetics. According to the pragmatic approach, the aesthetics of an artefact emerge from a dynamic interaction between a user and an interactive system resulting in what has been labelled 'aesthetic interaction' or 'resonant interaction' (Locher et. al, 2010). Pragmatic aesthetics is gaining momentum nowadays, as designers move towards the digital and the HCI community moves towards experience and embodiment (e.g. Djajadiningrat et. al, 2007; Forlizzi & Batterbee, 2004; Graves Petersen et. al, 2004; Hummels & Overbeeke, 2010; Loke and Robertson, 2013; Ross et. al, 2008).

In our own endeavours in this field, we are exploring how design can create alternative ways to engage with the world, based on trusting our senses. Exploring how to sculpt a tomorrow where people can access sensitivity and quality, and how to support people to take and value a first-person perspective when interacting with the world. In this work, we take a philosophical stance based on phenomenology, pragmatism, embodied cognition and the like, which explains how we are and live in the world. We aim to synthesise these perspectives by designing towards our preferred, alternative engagement with the world (Hummels and Levy, 2013). For more information on our perspectives, earlier work and theoretical foundation, we refer you to other publications (Hummels, 2012; Hummels & Frens, 2009; Trotto, Hummels & Levy, 2012; Hummels, Trotto & Cruz Restrepo, 2011). With our focus on exploration, through design action, of the richness of meaning that exists in our bodily way of experiencing the world, our approach has clear parallels with the emerging field of *Kansei Design* (Levy, 2014). The *Designing in Skills* framework presented in this paper, celebrates the richness of experiential qualities that emerge from trusting and building on designer's subjective points of view.

In this paper, we focus on a particular part of our earlier work, centering on the consequences of designing for skillful coping and embodiment. These concepts emerge from the abovementioned theories, and can be used as foundations to create designs that elicit rich and meaningful interaction. They allow for designers to be able to tap into, explore, be sensitive to, experience, apply, enlighten, facilitate, share, discuss, reflect upon and communicate towards the richness and subtleties of skillful coping and embodiment.

Over the last years, we developed the *Designing in Skills* (*DiS*) framework (Trotto & Hummels, 2013) to facilitate and support exactly these ideals. The *DiS* framework aims to stimulate designers to use skills-based approaches in their everyday design practice. In this paper we describe a four-week workshop, in which three designers explore the potential and influence of *DiS* on their capabilities of designing for skillful coping and embodiment.

They do this on three levels. Firstly, they explore the impact *DiS* has on their sensitivity of their own personal skillful coping and embodiment. Secondly, they explore the influence *DiS* has on their shared understanding of skillful coping and embodiment. And thirdly, they explore how to open up skillful coping and embodiment for people and sensitise them during interaction with a product. This process results in the installation DiffractMe! which connects all three levels.

We conclude this paper with reflections of the designers on these three levels, which act as inspiration and directions for other designers who are eager to design for skillful coping and embodiment. Before explaining the workshop and the results, let us first briefly introduce the *DiS* framework.

2. DESIGNING IN SKILLS FRAMEWORK

By empowering designers to become more sensitive in their relation to the world around them, meaningful subjective experiences emerge. For that, designers need new tools and methods to make the subjective become communicable and transferable, and to allow for the creation of new meanings when fused within the design process. With the Designing in Skills framework, we aim at tuning designers towards skill-based designing in their practice, in which they explore new design values and directions, in which their designs include their own skill perspective as well as enable users to open up for developing new skills, and in which they share their skillful points of view in the often multidisciplinary projects.

The *Designing in Skills* (*DiS*) framework revolves around five main steps (Figure 1). As the first step, a participant (*Person 1)* reflects on his own chosen skill. This step promotes in-depth reflection on the qualities of a skill from one's own point-of-view. In the second step, *Person 2* mirrors *Person 1*'s skill, offering his own point-of-view to sharpen *Person 1's* understanding of his own skill. In step 3, the process is moved into a shared, physical conversation by creating a Design Choreography. This step reveals and re-connects between the meaning of the skill and its perceptual motor qualities. In step 4, the insights that participants gained on the experiential qualities of their personal skill is extracted from the context of the original skill by building an experiential prototype, the enabling tool. This allows others to experience a salient quality of the original skill (step 5).

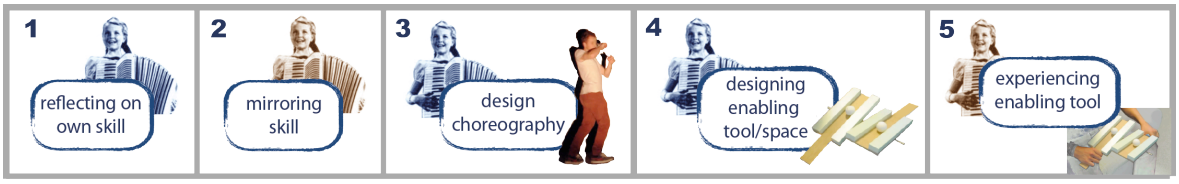

Figure 1: The five steps in the *DiS* framework

Each of these five steps in the framework relies on *making and doing* as core activities, both individual and group based. By placing an emphasis on making and doing, findings are immediately placed within a concrete realm, as opposed to allowing them to linger in abstraction. Moreover, designers are forced this way to trust their senses and intuition, and have a constructive dialogue via reflection-on-action, while minimising the use of language and abstraction, and finding certainty in "objectivity".

To explore if and how *DiS* helps designers to find new design values in their practice, as well as the effects of the approach on multidisciplinary teamwork, the approach was explored through a number of workshops (Hummels & Trotto, 2013; Trotto & Hummels, 2013). Some of these past workshops concluded with more general design assignments, in order to explore the opportunities the approach could unlock in design practice. For example, in the *Dense Spaces* workshops, architecture students were asked to integrate their findings and newly gained insights from a two-week workshop into a broader course assignment that involved the design of a space that integrated their workshop findings with political views.

For a more in-depth explanation of the *Designing in Skills* framework, please refer to the paper by Trotto and Hummels (2013).

3. GOAL OF THE WORKSHOP

The workshop we discuss in this paper, explores how the *DiS* framework influences values in a multi-disciplinary design process. We use *DiS* to initiate and catalyse an in-depth design process, to explore the richness and subtleties when designing for skilful coping and embodiment. In this workshop, we explore

1. How *DiS* refines the sensitivity of the designer's own personal skilful coping and embodiment.
2. How *DiS* helps in allowing designers to share their skilful points of view in a multidisciplinary design process.
3. How *DiS* allows for newly found design values and directions to be transposed into a design process and the final design, and how this opened up and sensitise people towards skilful coping and embodiment during interaction.

4. SETUP OF THE WORKSHOP

The workshop was organized during 4 weeks in March and April of 2013. Three designers participated (2 PhD students and 1 Master student). All participants were familiar with earlier workshops held around the *DiS* framework and the techniques used. Venue for the workshop was the studio at the Interactive Institute in Umeå, Sweden.

Based on the setup and goal of the workshops, we can identify three main phases in the four-week workshop we will elaborate below. The first phase, *Sensitizing to Skills*, involved sensitizing the participants to the qualities inherent in their skills, unlocking their potential through reflection-on-action loops. The second phase moved these insights and understandings into a shared design process, working towards integration through the creation of an *Enabling Tools*. The third phase revolved around the specific interest for this workshop, to build on the acquired insights by applying them in *Design Practice*.

Please refer to Figure 2 for the four phases of this workshop and the activities therein within the *Designing in Skills* Framework.

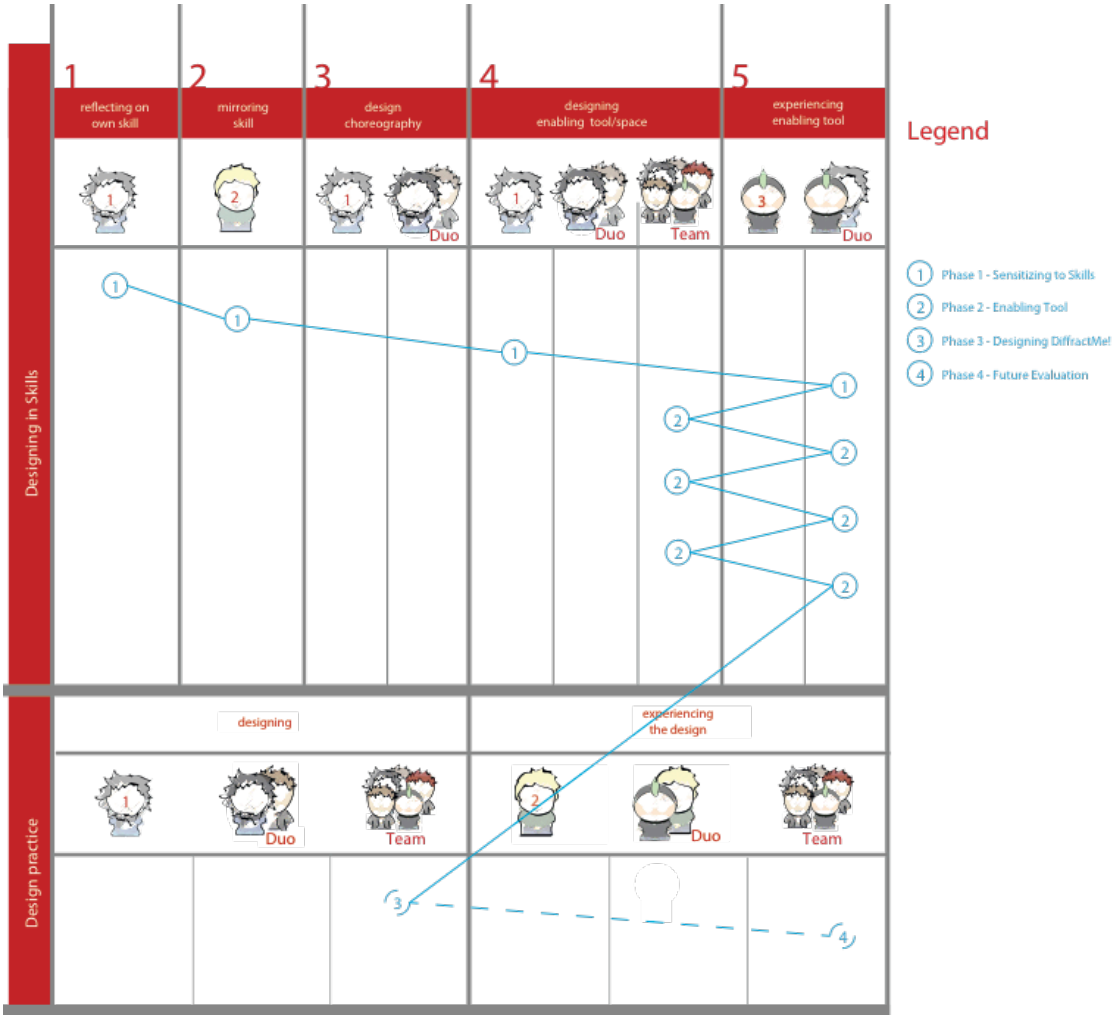

Figure 2: Schematic representation of this workshop's phases in the *Designing in Skills* framework.

5. DESCRIPTION OF THE WORKSHOP

5.1. Phase 1: Sensitizing to Skills

The workshop starts with initial explorations of skills and their meaning, using various media. The goal is to acquire a deeper and "un-tacit" understanding of participants' skills, to unlock their inherent experiential qualities. In the body text, the process is explained in terms of the steps in the *DiS* framework. The specific results and outcomes of these steps are presented in the captions. It should be noted that the descriptions of the qualities in the captions and graphics are representations of the participants' richer and deeper understanding during the process, and as such do not do full justice to their experience.

To start, each designer chooses a personal skill to reflect upon (step 1), by making a 1-minute documentary. The documentary used both as a descriptive and generative tool, aims at exploring this skill's meaning (see Figure 3). After a group presentation and discussion of the mini-documentaries, each designer switched viewpoints to Mirror each other's skill (step 2): each designer tried out another designer's skill and created a new 1-minute documentary to present his interpretation of another participant's skill (see Figure 3). This allowed a designer to gain more insights into his own skill, both by self-reflection and in response to the point-of-view offered by another designer.



Figure 3: (left) Stoffel's chosen skill was juggling, and he created a video showing juggling from various perspectives. He reflected on the salient aspect of his skill in how he experienced repetition: starting slow and with significant cognitive and motor-skill effort, but gradually moving into a flowing, resonating rhythm.

Figure 4: (right) In her interpretation of Stoffel's skill, Philémonne compared this to her experience of starting a running session. She reflected on her own skill, running, from the perspective of Stoffel's. In the video she made, she referred to her experience of a running session also changing through its course. Starting in a contrived fashion, unsure of her physical rhythm or the route she would take, to slowly running without thought or decision, and reaching a steady cadence of steps.

The next step was for the designers (*Person 1)* to integrate these two different points-of-view by designing an Enabling Tool that allows the other participants to experience a salient aspect of his skill (see Figure 5). Due to its subjective and individual nature, the other participants cannot have the exact same experience of the initial skill. The Enabling Tool is therefore an experiential prototype, designed to go beyond the boundaries and context of this initial skill by eliciting one salient aspect of the skill's meaning. This step allows the designers to extract and define subtle experiential qualities that can then be refined and applied as foundational elements in further design iterations.



Figure 5: Stoffel created an enabling tool by stretching a piece of fabric over a hole in an irregular frame, with a weight was attached to the fabric near the middle. By tapping the fabric with one's fingers and searching for "sweet spots", the weight starts to bounce up and down. Finding the right place, one of the sweet spots, as well as the right pace of tapping, creates a rapidly increasing, resonant vibration of the weight bouncing up and down.

Experiencing the Enabling Tools together and discussing their experiential qualities in a group setting further cemented the shared and individual understandings of the experiential qualities that emerged from different skills. This phase concluded with the participants jointly creating a 1 minute documentary on each enabling tool's quality, in order to anchor this new and shared understanding, but also to reflect on it. Furthermore, the group created a mapping that identifies and qualifies each of the three different qualities (see Figure 6). Each quality was identified in more detail by creating clusters of keywords. By adding a number of qualifications to each concept, the inherent abstraction as a result of creating schematics, is somewhat countered by the richness of meaning preserved in descriptive elements.

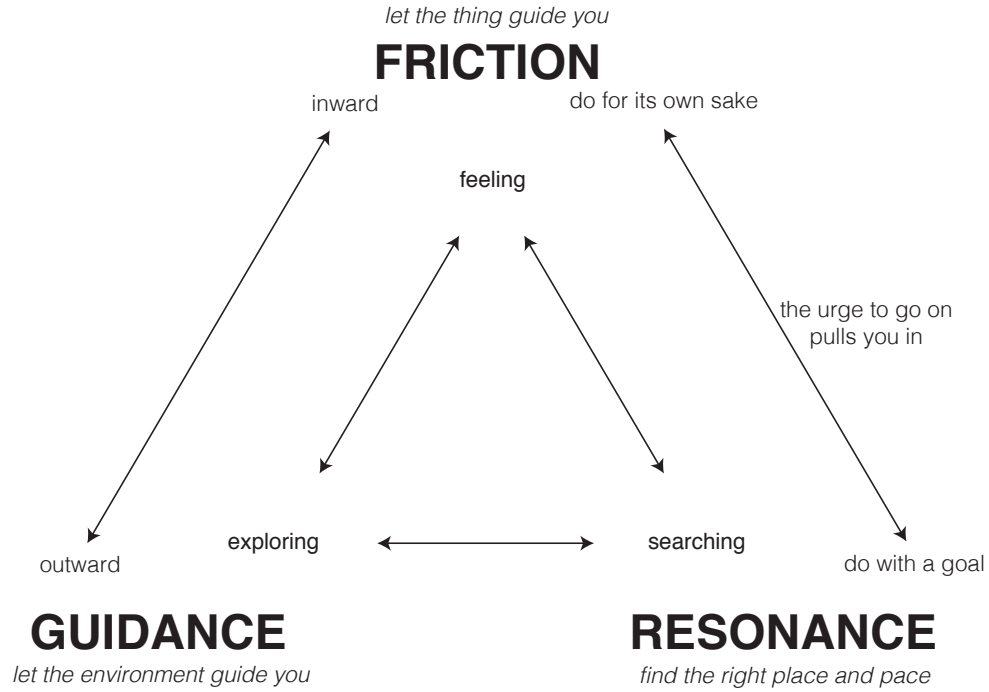

Figure 6: The salient qualities that emerged, clustered around the themes of friction, resonance and guidance. Together, these keywords hint towards describing the experiential qualities that emerged from this phase, and they should be considered as annotations to the experience the team had during the process.

5.2. Phase 2: Enabling Tool

The first phase unlocked the subtle qualities of different skills and offered insights into how they can be expressed in simple interactions. The team gained a first, shared understanding of these qualities and how they related to each other. The body text describes this phase on the process level. The work and insights gained are expanded upon in the captions under images. The descriptions of experiential qualities and the way they are materialized into prototypes are condensed representation of the richness of understanding the team experienced during this process.

The second phase built on and expanded this shared understanding through the act of making. The team entered a quick and iterative design process creating a series of the same Enabling Tool.. These experiential prototypes integrated the shared understanding by incorporating all three different themes (*friction, resonance* and *guidance*). The Enabling Tool was an interactive installation that was placed in public space as part of each individual iteration.

Over the course of a week, the designers built a new version of the Enabling Tool every day. Each iteration involved reflection, through experiencing the prototype together as well as public placement of the prototype to observe the engagement of passers-by. In this high tempo, the designers were forced to expand their understanding by making and doing, as opposed to spending large chunks of time abstracting each quality, running the danger of drifting away from experiential richness.



Figure 7: Passers-by playing with an early version of the Enabling Tool, placed in a University cafeteria. A number of discs, varying widely in size, weight, surface material and dynamic behaviour are hanging from a frame. Each disc can be touched and spun around its axis. All of the discs have different properties on a micro, haptic level. The discs feature various textured surfaces (rough, smooth, soft, etc.). Some spin freely, other feature a medium or heavy resistance. Others are connected to each other through gearing systems. This creates a set of varying interactions that happen on a very small level, between fingers, hand and disc that reflect on and explore the *friction* quality. The repetition of this interaction, where there are a large number of discs that can be spun or touched, some of them dynamically linked through gearing systems elicits an explorative behaviour. It invites to search and find discs with more pleasant experiences, and continued interaction with them. This reflects the qualities identified around the concept of *resonance*. The spatial dimensions of the Enabling Tool, a 3-meter horizontal post from which the discs were hanging, invited various behaviours in interacting with and exploring the discs. One could walk by and casually touch some discs; return on the other side, or step-by-step carefully explore the whole installation. This explored and built upon the concept of *guidance*, providing various ways for passers-by to choose their own path in resistance too, or in guidance with, the various physical interactions offered.



Figure 8: The final iteration of the Enabling Tool refined the earlier versions. Most of the discs and their interconnections were hidden using stretched piece of fabric. Hiding the inner workings of the tool made the connections and details of discs less visible, strengthening the focus on tactile experience of *friction* and stimulating curiosity through interaction rather than observation. Various pieces of material, hanging above the discs on eye level were added. These materials dropped, spun, bounced or otherwise moved through a hidden but noticeable connection to the discs. This created lighting and sound effects that triggered further exploration and manipulation of the discs and their hidden connections. By reflecting on a series of the Enabling Tools that integrated the three themes of friction, resonance and guidance, it became clearer how they related to each other. Where they were initially identified as individual, separate levels of interaction, the Enabling Tools allowed for insights on how they could exist in the same artefact: *Friction*, a very intimate, personal haptic interaction takes place on a small scale, between the person's hand and the object. *Resonance* happens on a mid-scale level: it is experienced between the person's actions and the system that particular objects form. *Guidance* emerges on an even larger level, as it is about the experience of someone engaging with the system as a whole.

5.3. Phase 3: Design Practice

The third and final phase of this workshop revolved around transposing the understanding and insights on experiential qualities gained in the first two weeks, into a design process of an engaging public installation for the Civic Forges: Weaving Neighbourhoods project. This joined project between Interactive Institute Swedish ICT Umeå and the Eindhoven University of Technology, aims at realising platforms in European cities that dynamically engage citizens, as catalysers of innovation, in creating self-empowered and sustainable communities. A general brief for this installation, detailing the most basic requirements, had been established before the start of the workshop: The aim of this public installation was to socially connect and engage visitors through rich interaction based on skills, allowing them to manipulate natural light through an interactive façade.

The qualities mapping and shared understanding that the designers had gained from the earlier phases formed the basis on which the group found a new design direction. Reflecting critically on the strengths and weaknesses of the Enabling Tools, the group was able to establish a first design direction.

Focussing on the newly introduced constraint (designing an interactive lighting façade), the team first aimed at exploring a design direction for the lighting aspect of the final installation. Ideas were

rooted in the qualities that emerged from the previous phase. Ideas that emerged for the façade revolved around *resonant* dynamic patterns.

As making had been a central activity in the previous weeks, this direction was explored through a series of prototypes, in which the (opportunities for) lighting effects created were continuously reflected on with the lenses of the three experiential qualities.

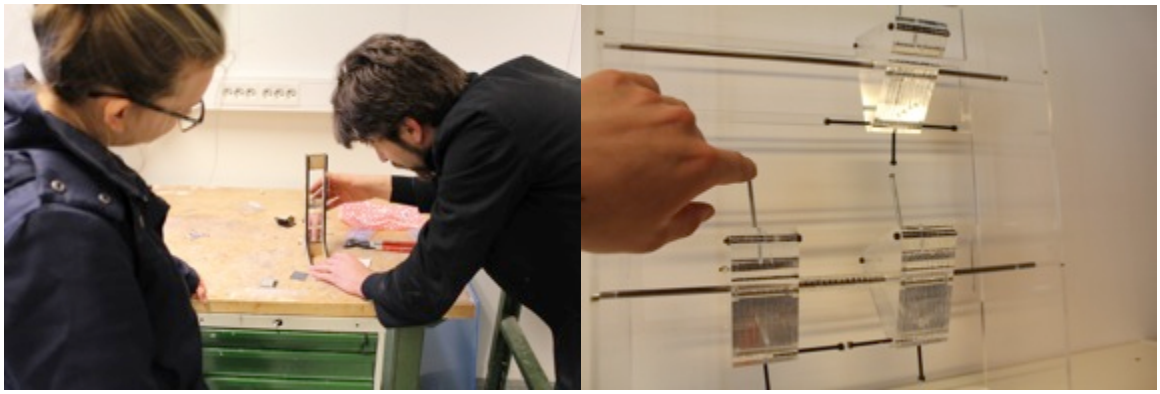

Figure 9: The design direction around dynamic patterns was immediately explored through various iterations of mock-ups and working prototypes. The search here was to find ways in which a collection of physical elements that affected natural light in the environment, could acquire dynamics that reflected the qualities that emerged from the earlier phases. Experiments were conducted on various scales, working with subtle, small mirror surfaces and bigger prisms.

Having explored and established a clear design direction for the façade, the next step was the design of the actual interaction. Building upon the rocking, subtle movements that were explored in the façade prototypes, the interaction mechanism was inspired on the same grounds to establish a clear connection between input and output.

The interaction revolved around visitors rocking one of two interactive surfaces back and forth with their hand. Developing an interaction mechanism based on small, subtle movement reflected the subtle, micro-scale quality of friction. The movement of the interactive surface is electronically transferred to an actuator that influences the dynamic pattern of light objects. The movement of this actuator is slowly but surely transferred to the whole matrix, creating a *resonating* effect. To reflect the *guidance* theme, the two interactive surfaces are interconnected: the movement of one is transferred to the other, allowing two people to feel and see each other's manipulations of the surface, inviting them to shape the movement together as they let each other *guide* one another.

6. FINAL PROTOTYPE: DIFFRACT ME!

The third phase explored, through an iterative process of making, a concept for an interactive and dynamic façade formed by a matrix of prisms. The final result of this phase were a number of prototypes and a detailed design for both the dynamic façade and the way in which visitors could interact with it.

In the weeks after the workshop, part of the workshop's team continued with this concept to create a full-scale working prototype to be placed in public space. This process required a substantial amount of engineering to create a fully functional installation that accurately transposed the experiential qualities that were present in the final concept that emerged from the workshop.

6.1. Description of Diffract Me!

The final installation consists of a large frame that houses a matrix of transparent prisms, mounted on horizontal axis. Each prism can move independently, rocking on its axis. Sunlight is diffracted and reflected by the prisms, projecting a shimmering pattern onto and into the environment. Visitors control a row of trigger prisms by manipulating a surface with their hands. All of the prisms are mechanically coupled, allowing the movement to transfer from one prism and be slowly but surely distributed to all the others in a ripple-like, resonating effect.

Spectators are immersed in a shimmering, responsive space of coloured light. As they come closer, they are enticed to engage with the installation. By placing their hand on mobile surfaces and rocking them back and forth, they create a subtle, resonant effect that moves through the lighting pattern. This has a directly perceived, and profound, effect on the surrounding environment. As they interact with the installation, they tactually and visually perceive others doing the same.



Figure 10: The final DiffractMe! Installation, showing the matrix of prisms in the centre, and the two interaction columns left and right.

6.2. Experiential Qualities in the Final Design

The qualities that emerged from the first week of the workshop as defined in the mapping were *friction*, *resonance* and *guidance*. The qualities were integrated and reflected in the interaction of the final design, Diffract Me!.

Visitors feel the subtle and tactile experience of friction, as they rock the movable surface back and forward. Small motors create a slight feeling of resistance as they mimic the movement created by another visitor on the adjacent column. As visitors feel each other's movements, they start to let each other *guide*, rather than *obstruct* their movements in an intimate dialogue experienced haptically. The result is a continuous, *resonating* series of movements, in which the visitors move the surface back and forward in harmony with each other. This results in a *resonating*, ever increasing ripple-like effect that moves throughout the matrix of prisms.

7. REFLECTIONS

Reflecting on the workshop and its different results, there are a number of points of interest that emerge and shed some light onto the opportunities and pitfalls that this approach presented in this context. Below we present a number of reflections around the process on different levels, responding to the three goals of the workshop.

7.1. Understanding of Experiential Qualities

One of the most salient aspects in our reflections relates to all three of the phases during the workshop. By extracting a salient aspect of our skills and immediately applying this aspect in lo-fidelity experiential prototypes, we increased our grip on this experiential quality. General notions of concepts such as friction or resonance seem straightforward, but by exploring their meaning through continuous prototyping and discussion, their richness becomes apparent. This allows these concepts to become more and more a tool to work with when designing interactions. For example, friction has very different meanings, with many different experiences than one would think of at first glance; E.g. it can relate to the unpleasant experience of a grinding gear that is misaligned, or be a way of sensing traction with one's eyes closed.

We clearly noticed an increased sense of awareness for the complexity or richness that sometimes hides behind the deceptively simple sounding concepts such as "friction" or "resonance". Sketching in hardware and reflecting through various different media, we were able to explore the meaning and subtlety involved in materializing these experiences. It is important to note here, that this increased understanding relates to both individual perceptions of these notions, and a mutual, shared understanding. In the explorations we were sensitized to the experiential qualities from our own perspective, but were also able to communicate, and build on, a shared understanding of these qualities that developed between us.

7.2. Reflecting on Artefacts

From our experience, it is imperative to reflect on the experiential qualities in direct relation to artefacts. The full richness of the qualities becomes apparent through reflections on, and discussions of, our experience *with* prototypes. This creates a physical, experiential dimension to the explorations, and discourages discussions moving into abstractions.

The first phase of the workshop, building directly onto the steps of the *DiS* framework, made this an explicit point. Reflecting upon the later part of the workshop, where the gained understanding was transferred into the design process of an entirely new interactive installation, it became clear that this element is important in sustaining the richness of these qualities. When artefacts that enabled direct reflection were absent, it was difficult to share each other's understanding of how a certain quality would become evident in an idea. It required us to resort to drawings or elaborate oral examples to refer back to the shared understanding of these qualities and communicate them.

With the lack of concrete physical examples to base discussions on, ideas often drifted back to the abstract, and became removed from experience. This suggests that despite having a shared understanding of the qualities, physical prototypes or other techniques could benefit the process of moving from this shared understanding into the formation of a clear design direction.

The requirement for reflections on these qualities to be rooted in physical prototypes remains relevant throughout the design and prototyping process. In later stages, a hi-fidelity installation was created and activities shifted from exploration to engineering. We needed to “shift gears”, and jump back and forward between two different ways of thinking: imaginative in terms of the qualities embedded in the prototypes, and problem-solving in terms of creating complex, working materializations of these prototypes. This requires a subtle, but profound shift in approach towards design-led engineering. When moving through various, increasingly complex, mechanical iterations, the objective is not just to make an element move, but to make an element move in a certain, specific way, so that it best reflects the sought after experiential qualities.

Reflecting on the design process, it is also clear that experiential qualities need to be strongly evident in the first design directions, in terms of being experiencable in consistent prototypes. The qualities can easily be mis-expressed between one iteration and the next, and it becomes difficult and time-consuming to repair such mis-expression, especially in later stages.

7.3. Our Relation to the World

Expanding upon this increased sensitization towards the many, often very subtle, experiential qualities that exist in the ways we interact with the world, there is also a clearly discernable influence of this process on our relation to the world. Exploring these three particular concepts in depth and through continuous iterations of making, clearly expands our perceptive abilities in day-to-day life. Understanding a little bit more of the depth of experience in our interactions with the world, seems to last beyond the specific timeframe and scope of the design process. We feel we have become more aware of the qualities that exist even in the most mundane of interactions with the world, and how these can be further explored and leveraged within our own design practice.

For example, the theme of friction emerged from the skill of rolling a cigarette. Through the workshop, it was explored and materialized as a subtle, small-scale, haptic interaction that felt pleasant and irresistible. Months after the workshop, one of the authors picked up a hand-powered flashlight during a holiday. Playing with the crank that is used to wind-up and power the flashlight, certain richness in this interaction revealed itself. The resistance felt when turning the crank, was reminiscent of the explorations around friction: a subtly captivating rotating motion, irresistible through its haptic qualities. However, upon further reflection, it also revealed very different qualities than those explored during the workshop. Small, ticking steps were felt through one’s fingertips, rather than a continuous, smooth rotation. Also, the momentum of hidden mechanical parts provided a subtly forceful feedback when one stopped manipulating the crank, pushing back and providing an echo of the rotation.

This is just one of the examples in which we can express how this approach, starting from our own skills and increasing our sensitivity, has provided us with an increased awareness of the richness that exists in our interactions with the world. Moreover, through experience, we developed a cross-medial vocabulary to communicate and transfer these findings, as well as the tools to implement them into our design work.

8. CONCLUSIVE REMARKS

In this paper we have presented the *Designing in Skills* framework, and have described how we have applied this skills-based approach in a workshop to explore its potential for design practice. In our reflections, a number of key points emerge that shed light on the opportunities and potential difficulties of this approach on different levels.

On an individual level, we have acquired an increased awareness of experiential qualities, and have acquired insights and techniques in order to communicate and leverage this potential in our designs. On a shared level, we have found the workshop to facilitate the development of a deeper, mutual understanding of these qualities, allowing for the integration of our points-of-view.

In addition to our own experiences of this approach and its effect on our design process, another point of interest is to reflect on how the experiential qualities we have explored and materialized are perceived by the outside world. The next step within this research is therefor to evaluate, through making the DiffractMe! installation publicly available, in what sense these explored qualities are evident and valuable for the general public.

ACKNOWLEDGEMENTS

We would like to thank Interactive Institute Swedish ICT and the Artistic Development fund of the Umeå Institute of Design for their support in realising the DiffractMe! prototype. Moreover, we thank the City of Eindhoven for financially supporting the Civic Forges: Weaving Neighbourhoods project.

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BIOGRAPHY

Jeroen Peeters studied Industrial Design at RMIT in Melbourne (Australia) and the Eindhoven University of Technology in the Netherlands, receiving his Master’s degree (Cum Laude) in 2012. In his graduate work, Jeroen was involved in the design of an interactive exhibition aiming to sensitise visitors towards contemporary issues of Human Rights in Siena, Italy. In 2010, he co-founded the interactive lighting design studio De Bende. In 2012, Jeroen joined Interactive Institute Swedish ICT, and started a PhD project at Umeå University, Sweden. In his current work, he explores how to design for profoundly engaging and meaningful aesthetic interactions in various domains.

Stoffel Kuenen studied Industrial Design Engineering at the Technical University of Delft, graduating in 2002 on a wearable, tangible social interaction product. Stoffel has worked as a strategic, conceptual and technical designer, and has led design and development projects for various interaction and communication products for the consumer market. In October 2010 he joined the design research group at Umeå Institute of Design. His PhD research focuses on the physical side of social interactions. Through designing tools for people to get a grip on their social context he is researching how to create products that result in complex systems and the emergent behavior of groups of people that use them.

Ambra Trotto is currently a senior researcher at Interactive Institute Swedish ICT and a senior lecturer at the Umeå School of Architecture, Sweden. She closely collaborates with the Designing Quality in Interaction group of the Eindhoven University of Technology. Graduated with honors in

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Caroline Hummels has a background in Industrial Design Engineering, is full professor Design Theory of Intelligent Systems at the department of Industrial Design (ID) and heading the Designing Quality in Interaction group at the Eindhoven University of Technology. She is co-founder and member of the steering committee of TEI, and has run numerous workshops on designing and skills at TEI-like venues, and for industry and academia. Her activities concentrate on developing theories, frameworks and tools to support designing towards transformation. Her activities address e.g. aesthetic interaction, craftsmanship, phenomenology, research-through-design, multi-stakeholder design processes, new educational approaches, and disruptive innovation.

Message in a Bottle

The use of intermediary objects to convey future emotional intentions during a multi-disciplinary design project

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Abstract: In this paper we describe a recent design research investigation, highlighting ways in which a designer attempts to communicate to others their intentions regarding users' emotional responses to future artefacts through the use of intermediary objects during design activity. We follow the interactions of a jewellery designer engaged in a project in partnership with an electrical engineer, a software developer, and museum curators. The overall design goal is to create an aesthetically desirable electronic object for use in a specific museum context, allowing the generation of personalized labels. This paper embraces an ethnomethodological approach to uncover ways the jewellery designer attempts to translate an intended emotional state (appeal and desire) towards the designed artefact in the future context, through intermediary objects, which are interpreted differently by different people across the trajectory of design activity. The use of intermediary objects during sociotechnical interactions in engineering design activity is well documented (Vinck and Jeantet, 1995, Boujut and Blanco, 2003, Eckert and Boujut, 2003) but our research suggests more work is required to understand the role that these types of devices play in intending and interpreting future emotional content, which is seen as a significant goal within product design disciplines. We discuss the concept of difference, and how it is managed during design activity involving various actors and actants, leading towards a better understanding of intention and interpretation during design.

Keywords: design activity, design process, affective design, design intention, designer interaction

1. INTRODUCTION

This paper provides an account of a group of creative professionals involved in a design project aimed at developing and prototyping an ornamental technical device for a museum context. The technical device is part of a system that enables the custom generation of exhibit labels as visitors walk through a museum exhibition visiting different artifacts on display. The aim of this research paper is to build a better understanding of how a designer makes use of physical prototypes to share her intentions and interpretations regarding

overall affective and emotional attachments to a final artifact intention, which is yet to be developed, in partnership with a wider creative team. The researchers observed the interactions between the group directly involved in the design assignment to determine how boundary objects are deployed, used and interpreted in different ways amongst different team members.

All project partners observed, to varying degrees, considered themselves designers: the academic Co-Investigator, responsible for project management of product design development; the jewellery designer, with responsibility for the design and plan of the circuit casing; the electrical engineer, responsible for the design and delivery of the technical circuit; a software developer responsible for development of a mobile application which connects to the server side application responsible for generating the customized labels throughout the museum exhibit; and finally, the ethnographic design researcher who is involved in field testing of the system in the wild in various museum contexts. Outside of this core group are the museum curators and directors who have been invited to participate in a focus group towards the end of the project to provide feedback on the robustness of the technical platform, the value of custom labeling to their relevant museums, and their overall aesthetic appeal the artifact presents as a museum souvenir structured around the interactive gallery experience.

The majority of the team has not worked together before. There is no significant history of this group being collectively engaged in design activity together. This suggests that there are no preconceptions, or shared experiences with team members, and thereby no prior knowledge or understanding of each other's intentions, or approaches to working. Assembled in this way, the team is required to explain or detail decisions to the rest of the team early in the design processes, in order to ensure a common approach can be found. This scenario is ideal for the research observation, since it is not clear how any particular member of the team will respond to the set brief, and explicating personal understanding will be required.

The co-investigator responsible for product design development is also the lead author of this paper. It was established early in the project that product design activities would be delegated to the jewellery designer, but it remained the responsibility of the co-investigator to retain project management in partnership with the lead project team. All design project partners were made aware of the research focus of the co-investigator as a design observer. Project partners were also enlisted as observation participants at the early stages of the design project, to solicit their responses to the product design intentions of the jewellery designer in response to the overall project brief established by the Principal Investigator prior starting the design activities. The design brief does not contain any explicit suggestions about product design development, and the jewellery designer was asked to provide prototype samples that addressed colour, material and finish (CMF) as she understood would be relevant to the project intentions.

1.1. Boundary objects in the design process

The prototypes and samples presented by the jewellery designer are considered here to be boundary objects (Star and Griesemer, 1989) within the overall process of design activity, where the prototype possess a clear identity for individual actors, but remains flexible and ambiguous enough in their identity to accommodate a variety of interpretations across multiple actors working together across networks. We refer to two types of boundary objects observed in this project. Conscription devices (Henderson, 1991) are seen as artifacts used during design activity which enlist participants to think and work towards a common goal in a participatory environment. Intermediary objects (Vinck and Jeantet, 1995) are artifacts which work as representations of final, absent object at an intermediate state. They are understood as objects used to communicate and exchange ideas and intentions between partners involved in design activity about future states, as well as foster co-operation within design teams working on common goals concerning future states (Eckert and Boujut, 2003, Boujut and Blanco, 2003).

Conscription devices and intermediary objects can take a variety of forms, including drawings, sketches, models and prototypes. We argue that physical artifacts, when presented as prototypes, can be understood as boundary objects of both types described

above, but are unique from other forms of boundary objects in that they are simultaneously representational artifacts concerning future intentions, while also being non-representational by virtue of their presence during design activity. This dual nature of physical prototypes is also related to their intended (and presented) social, technical and material affordances. It remains unclear in what ways a physical prototype, when operating as a boundary object regarding a future intention, is able to represent intentional future affective attachment, in relation to an object that is not yet realized.

1.2. Project overview: Talisman

Talisman is the name of the design project under observation. The overall intention of the Talisman project is to enhance the visitor experience to a non-specific museum exhibition through the generation of custom digital labels at artifact displays.

Talisman is a small wearable device that contains an integrated circuit that utilizes Near Field Communication (NFC) through a Bluetooth protocol, to enable communication and notifications with devices using Apple's iOS7 operating system. As the visitor approaches an artifact in the exhibition context, the Talisman device notifies an iOS device of its presence, and the iOS device communicates with a server side application that generates descriptive label text using an algorithm based on natural language processing. Descriptive labels are returned to the iOS device for presentation, and are customized according to the route each visitor takes in engaging or visiting various artifacts, creating the impression of a degree of personalization. The experience is intended to work automatically without the use of buttons or other physically interactive media.

The overall intention of the Talisman is to be both a passive technical device, interacting with computer hardware behind the scenes, while also being an aesthetically pleasing and a positive reminder of the visitor's experience engaged in the museum exhibition. As a result, the project was structured into three key areas: hardware development, responsible for the Talisman circuit design; software development, responsible for the technical code for information exchange between Talisman, the iOS device and the server side application, and; product design development, responsible for the hardware casing and the overall aesthetic of the Talisman device.

It was clear that any smartphone would be capable of fulfilling all functional and technical requirements outlined in the design brief. A secondary design intention was to create a "heads up" experience, preventing the need for visitors to make use of their own phones, but rather to immerse themselves fully in the museum experience. In early project discussions, it was believed that the affective experience of the museum visit might be enhanced if the Talisman device were described as a wearable item, which might also serve as a souvenir, a memory of the event that had created some sense of value through the experience. For this reason, it was decided to invite a jewellery designer to participate as a member of the overall design team, since it was anticipated that a jewellery designer might possess a degree of expertise regarding wearable objects that held value.

The structure of the project suggests that two key indicators of Talisman's performance will require assessment during overall development; namely, the technical performance of the hardware and software during use, and the affective, aesthetic performance of the Talisman device when engaged by the user, ensuring it remains an object that creates a positive and pleasing means to deliver the technical functions.

There is a degree of overlap of team members across these three areas of activity; for instance, one member of the software team works closely with the electrical engineer involved in the circuit design to ensure signals from the circuit correctly interface with the server software, while the electrical engineer also works closely with the jewellery designer to discuss dimensions, technical restrictions, and other necessary knowledge impacting development of the casing structure. All team members are involved in weekly meetings to update the full project team on the respective progress of their activities.

1.3. Affective Design, multiple views

This paper is intent on describing how the project team involved in the various design activities intends to share their understanding regarding a positive affective experience for each museum visitor using the final designed product through physical prototypes as boundary objects during intermediary stages of design activity.

Norman (Norman, 2005) describes three levels of affective design responses that people normally exhibit when interacting with objects. At a rational level, people are able to discuss the concepts behind the artifact, to describe their understanding of the intentions that the designers were attempting to address in the overall product design and development. At a behavioural level, people generally respond to the overall performance or utility of the object, describing how well an object serves its suggested purpose. At the visceral level, responses are generally pre-cognitive, and people display a more emotional response to the overall form and shapes, exhibiting their personal preferences or tastes prior reflective analysis of their understanding of the object.

The author engaged participants in the early phases of project work, in an attempt to uncover how each team member, each with different backgrounds and experiences, would understand the proposed product direction when engaged with the early prototypes at the rational, behavioural and visceral level of interaction. The research observations form part of a separate research project outside the scope of Talisman, reported here as a case study. Capturing initial thoughts from all team members before any significant interactions occurred between them was considered advantageous in understanding individuals' initial understandings of the project, prior input from other team members, while also capturing how each individual participant interpreted the overall design trajectory in regards to its affective intentions through presented prototypical artifacts.

The jewellery designer was asked to interpret the design brief and provide some prototypes and samples that would start to communicate her design intentions surrounding the final design specifications. The jewellery designer was informed that she was able to interpret the brief as she felt necessary, and given creative control and direction of the aesthetic decisions. She was trained in a programme that has a strong emphasis on materiality, and her area of expertise involves technical processes of casting simple materials, such as resins, polymers, epoxies. For this particular project, a new material called Jesmonite® was selected for use.

2. RESEARCH METHODOLOGY

Typically, an affective design methodology requires a large sample size in order to construct a meaningful understanding of the affect participants describe concerning an artifact (Nagamachi and Lokman, 2011). The use of large sample sizes is to ensure that any deviation, or individual differences, might be minimized or made irrelevant. Collecting data in such a way is most relevant to very large design projects, such as automotive or consumer electronics. Many design projects, particularly those involving small and medium enterprise, rely on small design teams to deliver results quickly, and often the affective dimension is interpreted through the experience of the designers involved. Deadlines for production are short, volumes for production are small, and access to the final target group can be difficult.

As a design project, Talisman fits the latter description, involving a small design team that has limited access to the final end user and limited time in order to develop the final product. However, the aim of the research observation described in this paper was not whether the designer captured the affective dimension intended in the final product delivered; rather, how a designers' intentions during design activity are conveyed to others in the network through the use of physical objects and prototypes. With respect to Talisman, it remains unclear how a designer can successfully convey a positive affective experience regarding a future state through an ambiguous boundary object.

The design research observations were structured around methods involving participant observation and semi-structured interviews. All interactions were recorded using standard video recording equipment, and a stand-alone audio recorder was also employed for backup purposes. Each discussion with relevant team members lasted approximately 15 minutes in total. All audio recordings were transcribed and analyzed in textual format.

Rather than constructing Likert scales for understanding the semantic differential space (Snider and Osgood, 1969), each participant was encouraged to speak freely about their experiences with the artifacts presented to them. A corpus was created and analyzed structured on ethnomethodological techniques associated with conversation analysis

(Hutchby and Wooffitt, 2008) using an appropriately constructed and validated coding scheme in order to identify key themes emerging from each participant's individual account, and compare any commonalities or differences in perception and interpretation.

Our research observations began with the jewellery designer presenting her intermediary prototypes. She described what she believed was an appropriate response to the design direction set in the brief. She was asked to describe the objects presented, to outline her intentions regarding the final design specifications, and how she understood these artifacts to be representative of jewellery objects. The objects presented to each of the participants are captured in Figure 1.



Figure 1: Boundary objects used to elicit an affective response

The objects presented were of various dimensions, but all could be described as being hand held, or wearable, each no more than approximately 100 cm3.

Following the designers descriptions and rationale for presenting the collection of objects, individual team members were asked to interact with the same series of intermediary prototypes created by the jewellery designer, prior any meetings with other team members. Three questions were asked of the remaining team members while interacting with the intermediary prototypes:

- Could you describe the objects in front of you?
- Could you describe the designer's intention regarding these objects?
- Would you describe these objects as pieces of jewellery?

2.1. Results

The jewellery designer described her intermediary prototypes as studies in material. She outlined her design intention was to generate an artifact that resembled a pebble or stone, which had the circuit design embedded into the Jesmonite® material which has a tactile quality similar to stone. In her description, she outlined that she had interpreted the design brief into the pebble artifact because of the affective experience that she perceived most people had with pebbles, particularly found during walks on beaches. She believed that the affective quality of "finding the right stone", feeling it, and holding it in the hand were affective elements she wanted to capture which maintained the "heads-up" approach to the project. She also outlined that in attempting to understand what affective elements were related to desirable souvenirs, she felt that pebbles, once found, were often kept and collected for their affective quality and value , rather than their economic or functional value.

At a later date, the same intermediary prototypes were presented to the electrical engineer. The total discussion time was over 17 minutes. The research observation team asked the three questions outlined in the research methodology above. In response to the first question, the engineer immediately began to discuss perceived functions associated with the objects: *"…that feels like something you use, to keep something in your wrist, like a remote kind of thing …* " (0:00:38/0:17:20). Continuing with the various objects presented, the engineer continues to describe the artifacts relating to perceived function, rather than material or mode of construction: "*…I'd have to say pencil holder, I dunno, that's just what*

comes to my mind when I see this." (0:00:57/0:17:20)*; "…I'm sorry, I'm thinking of common objects again and this reminds me of a chopstick holder…"* (0:02:11/0:17:20)*; "…this kind of reminds me of a tea cozy…"* (0:02:36/0:17:20). When asked if the objects presented to him could be described as jewellery, the participant responded: *"…well I don't see why not. Uhm, though they are kind of, they feel a little bit on the boundary of … so like, some of these are not obvious how they would be used as jewellery. So they don't have the kind mode of attachment, if you like…"* (0:09:29/0:17:20). When asked about the designer's intentions regarding the artifacts, the participant noted: *"… in some sense it seems like an exploration of the boundaries of the traditional concepts of jewellery…"* (0:15:57/0:17:20), and continuing: *"…it's not obvious how these would be used as jewellery. Though with this ones, uhm, I mean they have this kind of similarities to something, like, a lot of people like having a stone that they've picked up at the beach…"* (0:16:15/0:17:20).

The same artifacts were presented to the lead software developer, and the same three questions were asked as outlined above in the research methodology. Total length of this discussion was just over 8 minutes. In this instance, the participant in question was quick to identify the material as a strong salient feature, but only after mentioning the lack of technical functionality present in the artifacts: "…*I guess I see a collection of different objects, shaped objects. They all seem to be, uh, inert. Don't seem to be any kind of electronics or anything. Some of them seem to be made of stone-like material…"* (0:00:33/0:08:38). While physically engaging with a number of the artifacts, some other elements are discovered which clearly generate a positive affect with the participant: *"…oh, look, that's actually – oh hey, magnets. That's obviously trying to do something functional, but I can't quite work out what it is though…"* (0:01:43/0:08:38). Eventually, the participant decides to cluster the artifacts into categories that allow him to build a deeper understanding of the task he's involved with*: "…they certainly look like, I guess these look like stones. That one looks like a bit of worked stone…"* (0:02:05/0:08:38). When asked if the objects presented to him could be described as jewellery, the participant immediately responded: *"…uh, I wouldn't. But then my view of jewellery is very narrow.*" (0:03:49/0:08:38). When asked to speculate on the designer's intention of the prototypes presented, the software developer replied: *"…I find it easy to speculate on the intention of these. These seem to be trying to, uhm, take qualities that you associate with a natural stone …"* (0:05:37/0:08:38).

The ethnographic design researcher was also asked to participate in the study, since she would be involved in field trials with the artifacts at identified testing gallery sites at a later date on the project. Total discussion time was approximately 9 minutes. In attempting to describe the objects, her immediate response was*: "…a mixture of pebbles, and black artifacts …*" (0:00:29/0:08:52). Slightly later, prior being asked the third question, she also states *" … they also slightly remind me of jewellery.*" (0:01:48/0:08:52). At a later time, the researcher asked the participant to expand on this statement, and describe why she felt the intermediary prototypes reminded her of jewellery. She states: " *… ehm, I think cause they're all kinda like pretty, in a way…I guess it's like the smoothness of them, that makes me think they'd be quite good as wearables. But I think it's cause I like jewellery and I sort of see everything as 'Oh, I could wear that'…"* (0:04:46/0:08:52).

When asked to describe what she understood the designer's intention to be, the design researcher states: *"…it looks the ultimate aim is to make something that you can hold in your hand and is quite tactile…they don't really look as if they are just meant to be looked at… they look as if they are supposed to be held … "* (0:06:15/0:08:52).

3. DISCUSSION

Though our research findings make evident that the rational intentions associated with the pebble concept initially outlined by the jewellery designer was clear to all participants, the transcriptions suggest that there are other considerations that need to be taken into account when working with boundary objects during design development that are intended to represent ambiguous future states. We discuss below four particular issues relevant to an affective design project involving inter-disciplinary teams. Notably, all four issues involve the role of difference across various elements within the interactions between participants and prototypes.

3.1. Differences among participants

In the interdisciplinary team we describe in our project, the differences between participants, both in their personal world views and their individual biographies is significantly accentuated, due to the small sample size of the group. One key difference is that the jewellery designer and the design ethnographer are women; our two engineers are men. The descriptions provided suggest that a difference in understanding and interpretation is evident between the women and the men. We suggest that this difference is amplified by the presence of the intermediary object, but the intermediary objects presented also enable participants to manage difference since clarification of interpretation and intention is made readily possible through concrete means.

3.2. Ambiguity of intermediaries: differences in interpretation

The traditional approach involved in an affective design methodology is to engage a large sample size with artifacts and objects that are fully formed. The objects normally presented are precedent objects, already in fully formed existence on the consumer market. Design researchers involved in affective design methodologies will normally place restrictions upon the survey target they are addressing in determining the affect in order avoid unnecessary confusion in their analysis (Nagamachi and Lokman, 2011). Such an approach may provide insight into how a target audience of consumers necessarily feels about an existing product, which is clearly defined, categorized, and not ambiguous. Intermediary prototypes used across design teams are not full manifestations of the final design intention, but an incremental representation between the precedent state and the final design intention (Boujut and Blanco, 2003, Vinck and Jeantet, 1995). Intermediary objects are highly ambiguous, open to differences in individual interpretation, as the intermediary object reveals and implicates particular information relevant to the interpreter (Eckert and Boujut, 2003). Our analysis reveals that the ambiguity would appear to emerge as a result of variety of interpretations possible in the presence of the objects and other designers. In attempting to ascertain the designer's intentions, our three participants were clear on the rational intentions that the prototypes were trying to convey (stones and pebbles), but less clear on the behavioural intentions (how does one interact with or use the pebble as an electronic device?). It is not clear how the visceral responses reported by all participants are related to the artifact presented, or anticipated concerning the future manifestations which are intended to emerge later in the design trajectory.

3.3. Semantics and meanings – differences in understanding

Across the Talisman project, a standard definition of jewellery was not provided in relation to the final design decision regarding final artifact development. In early briefing meetings, it was suggested that the final device should be considered a souvenir, create a sense of "value" and also be "wearable". This was collectively interpreted to fit within a scope of jewellery, in its widest sense, and to this end, an expert designer of jewellery was invited to participate. What appears in our reports is difference in collective understanding of what "jewellery" is. The designer interpreted the brief to be about value of experience, and attempted to parallel the gallery experience to the act of collecting pebbles on the beach. From that, the designer suggested that "wearable" could be also understood as "handheld", and interpreted jewellery not as a brooch, pendant or bracelet, but rather a handheld device, which addressed the designer's understanding of facilitating a "heads up" experience in the museum context.

The electrical engineer, and the software programmer reported having difficulties in understanding the intermediary objects presented as subscribing to a definition of jewellery for different reasons. The engineer made extensive use of analogy in describing the intermediary objects, none of which were related to jewellery. The software programmer was not able to categorize the intermediary objects as electronic devices, outlining that they seemed too "inert", while also professing that his view of jewellery was "very narrow". In the conversations with the design ethnographer, her early response of viewing the intermediary objects as jewellery was predicated on her view that she interprets many things as potential types of jewellery.

3.4. Shared affective experience – differences in connections and relations

All participants were quick to understand the metaphorical connotation of pebbles through the intermediary objects presented by the designer. The rational understanding of the experience of walking along a beach and collecting stones considered aesthetically pleasing to both eye and hand, was mutually agreed. However, this analogy was not necessarily transferred to the intended activity of the end user in the final design intention; that is, no participants were able to articulate an understanding of the desired transference of visceral experiences from one activity (walking along the beach and collecting precious stones as souvenirs) to the intended activity (walking through a museum with a precious electronic stone, which is a souvenir). Thought the boundary object was able to operate effectively at a rational level, it remains unclear whether it does so equally well at a visceral level.

4. CONCLUSIONS

This paper highlights that communicating affective intentions presents challenges in small, interdisciplinary design projects, because difference plays a prominent role across the project team, both at the individual level and the level of understanding and interpreting intentions of other group members. Intermediary objects, shown to facilitate communication and cooperation across design teams, are ambiguous by nature, and we suggest that their ambiguity is a result of differences in interpretation by individual actors. Difference occurs on three distinct levels, following from Norman (Norman, 2005): difference at the visceral level (the object's affect); difference at the behavioural level (the object's performance); and difference at the rational level (the concepts relating to the object). However, difference also occurs when participants are not clear on which level (visceral, behavioural, rational) other team members are interpreting the intermediary prototypes, since affective responses can occur across all three, and individuals place differing levels of importance on each of these levels.

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2B - Kansei Design in Taiwan 2

Applying Fuzzy Linguistic Preferences to Kansei Evaluation

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Abstract: Kansei engineering has been developed as an effective methodology to deal with customers' feeling and demands and further translate them into the design elements of a product. It is very important to determine and substantiate the measure of Kansei preferences before its utilization and performance. Kansei evaluation plays a vital role in the implementation of Kansei engineering; however, it is difficult to quantitatively evaluate customers' preferences on Kansei attributes of products as such preferences involve the human perceptual interpretation with certain subjectivity, uncertainty, and imprecision. This study presents a fuzzy linguistic preference approach for Kansei evaluation. The proposed approach is based on fuzzy linguistic variables associated with the fuzzy weighted average techniques for aggregating Kansei preference information. A case study was conducted to illustrate the implementation of the proposed approach.

Keywords: Kansei Evaluation, Fuzzy Linguistic Variables, Kansei Preferences, Aggregation, Fuzzy Weighted Average.

1. INTRODUCTION

In today's highly competitive and uncertain market environment with short product life cycles, companies have to develop every aspect of the quality of products to satisfy customers' requirements as well as to guarantee their market success. Kansei engineering has been developed as a consumer-oriented technology to deal with customers' emotional responses and further translate them into the design elements of a product (Nagamachi, 2002). It has been widely employed in various design fields during the past few decades (Fukushima et al., 1995; Jindo & Hirasago, 1997; Nakada, 1997; Tanoue et al., 1997; Chang et al., 2006; Huang et al., 2011). Kansei evaluation is an important process to determine and substantiate the measure of customer preferences prior to the utilization and performance of Kansei engineering. Many studies have

conducted Kansei evaluation (KE) in the literature in which statistical analysis associated with semantic differential (SD) method is widely employed to quantify human perception for an understanding of Kansei preferences (e.g., Hsu et al., 2000; Mondragón et al., 2005; Llinares & Page, 2007; Smith & Fu, 2011; Lin et al., 2012). Conventional statistical analysis methods suppose that customers' preferences increase or decrease linearly as Kansei attributes improve or get worse. However, in many cases these attributes can be a non-linear pattern with imprecision and vagueness of meanings, where the attributes perceived as satisfactory are not the same as those perceived as dissatisfactory. This non-linear behavior requires special analytical techniques to identify the different effects which variations in Kansei attributes may have on the customers' preferences. To deal with the quantitative measures of perceptual information, a number of non-linear inference techniques have been developed and used for modeling KE systems, including neural networks (Ishihara et al., 1997; Lai et al., 2006), fuzzy logic (Fukushima et al., 1995; Shimizu & Jindo, 1995; Tsai & Hsiao, 2004; Lin et al., 2007; Yan et al., 2008; Huang et al., 2011), and genetic algorithm (Tsuchiya et al., 1996; Hsiao & Tsai, 2005; Hsiao et al., 2010).

Kansei evaluation (KE) is a systematic determination of significance of customers' preferences using criteria against a set of Kansei attributes. A basic principle in KE is that valid results depend on establishing priorities for the Kansei attributes and priorities for the preferences with respect to each attribute, and synthesizing the priorities for the evaluated alternatives. Kansei attributes refer to a bipolar pair of Kansei words expressed with adjectives of emotional connotations such as beautiful, romantic, fantastic, comfortable, etc. The semantic differential (SD) method is often used as a measure to quantify Kansei attributes. In KE studies, respondents are customarily asked in a questionnaire to indicate their perceptual scales from a set of adjective descriptors. Such responses are fuzzy because the preference options often cannot be objectively and uniformly differentiated by all the respondents (Das, 2002). Many researchers consider the psychometric labeled scales as ordered-categorical data rather than interval-level data since one cannot assume that respondents perceive all pairs of adjacent levels as equidistant. However, often the wording of response levels clearly implies a symmetry of response levels about a middle category; at the very least, such a scale would fall between ordinal-level and interval-level measurement. Information efficacy may be lost when Kansei preferences are merely treated as ordinal data. Kansei preference data can be regarded as integer-level scales which have an ordered set of responses that are whole numbers. The respondent magnitude of "very comfortable", for example, is more than that of "comfortable" but by how much is not known. Kansei preference data are thus better treated as semantic variables for measuring human perceptual interpretations.

Kansei preferences refer to a non-quantifiable, subjective, and affect-based process and involve the human perceptual interpretation with some uncertainty and imprecision. Previous research indicated that the main problem in constructing customer preference models with a good predictive performance is how to deal with nonlinear correlations between product attributes (Shimizu & Jindo, 1995; Park & Han, 2004). Fuzzy set theory offers a powerful tool for dealing with concepts and rules with uncertainty and non-linearity, especially in real-life situations where absolute precision has little relevance and a robust representation of relative trends is valuable. It launched a scientific revolution based on the premise that the key points in human thinking are not numbers, but linguistic terms (Bellman & Zadeh, 1970). The linguistic approach is an approximate technique which represents qualitative preferences as linguistic values by means of linguistic variables (Zadeh, 1975, 1976; Herrera & Herrera-Viedma, 2000). For KE situations in which the customer preferences cannot be assessed precisely in a quantitative manner but may be in a qualitative one, the use of linguistic evaluation is very appropriate (Delgado et al., 1992; Ruan & Zeng, 2004; Martínez, 2007;

Zeng et al., 2008; Yan et al., 2008; Huang et al., 2011). Accordingly, the present paper offers a Kansei evaluation approach based on fuzzy linguistic preference techniques. The aims of this study are (1) to model Kansei preferences based on fuzzy numbers for the priority analysis; and (2) to aggregate priority information and rank the order of decision alternatives by means of the fuzzy weighted average operation. An empirical study is presented to illustrate the implementation of the proposed approach. Concluding remarks are also drawn in the last section.

2. KANSEI PREFERENCE MODELING BASED ON FUZZY NUMBERS

The use of fuzzy sets is central to computing with words or labels as they provide a means of modeling vagueness underlying most natural linguistic terms (Zadeh, 1996; Lawry, 2001). A Kansei word is an adjective of emotional connotations describing customers' feelings towards a product. It can be regarded as a fuzzy set *A* defined by its membership function, μ_A, in a universal set *X*, which is expressed as $\mu_A: X \rightarrow [0,1]$, where [0,1] denotes the interval of real number from 0 to 1, inclusive.

Kansei preferences are defined as customers' preferences on a specific Kansei attribute of a product. As shown in Figure 1, a Kansei preference *K* in the semantic space *S* is characterized by a triangular membership function that associates each semantic element *s* of *S* with a real number, $\mu_K(s)$, in the interval [0,1]. It can be thought of as containing the real numbers within some interval to varying degrees, and is expressed as $K = \{s, \mu_K(s) | s \in S\}$, where

$$\mu_K(s) = \begin{cases} \dfrac{s-a}{b-a}, a \le s \le b \\ \dfrac{s-c}{b-c}, b \le s \le c \\ 0, otherwise \end{cases}$$

The value of membership grade, $\mu_K(s)$, indicates the degree of the customer preferences close to the Kansei attribute. The Kansei preference *K* can be classified as a fuzzy number as it is a convex and normalized fuzzy set whose membership function is piecewise continuous defined on $\mathcal{R}$.

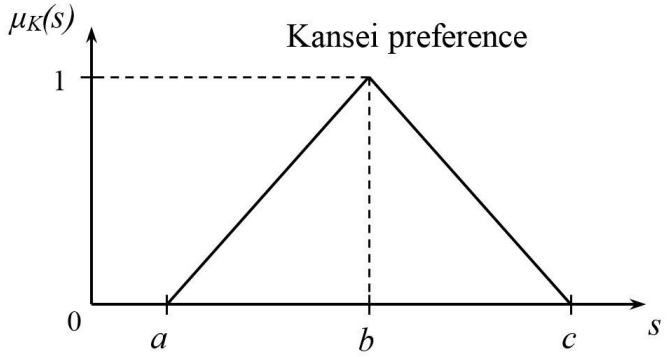


Figure 1: Kansei preference modeling based on a triangular membership function

Kansei attributes refer to a bipolar pair of Kansei words (e.g., inelegant/negative feelings–elegant/positive feelings) which involve different levels of adverb intensity descriptors for quantifying customers' preferences (e.g., very inelegant, inelegant, medium, elegant, and very elegant). Since triangular membership functions are a uniformly distributed ordered set of Kansei preferences in a semantic space, they provide a relatively simple way to capture the vagueness of Kansei information. Each Kansei attribute can be defined by piecewise continuous membership functions and comprises 7 semantic sets as shown in Table 1 and Figure 2. These semantic sets are

allowable to describe with customers' Kansei preferences and can be quantified with corresponding triangular fuzzy numbers.

Table 1: Semantic sets of Kansei attributes

Semantic label	Semantic element (Perceived intensity/Perceived importance)	Fuzzy number	Crisp number
VL	Very low Kansei preference Very low importance	[0, 0.167]	0
L	Low Kansei preference Low importance	[0, 0.333]	0.167
ML	Medium low Kansei preference Medium low importance	[0.167, 0.5]	0.333
M	Medium Kansei preference Medium importance	[0.333, 0.667]	0.5
MH	Medium high Kansei preference Medium high importance	[0.5, 0.833]	0.667
H	High Kansei preference High importance	[0.667, 1]	0.833
VH	Very high Kansei preference Very high importance	[0.833, 1]	1

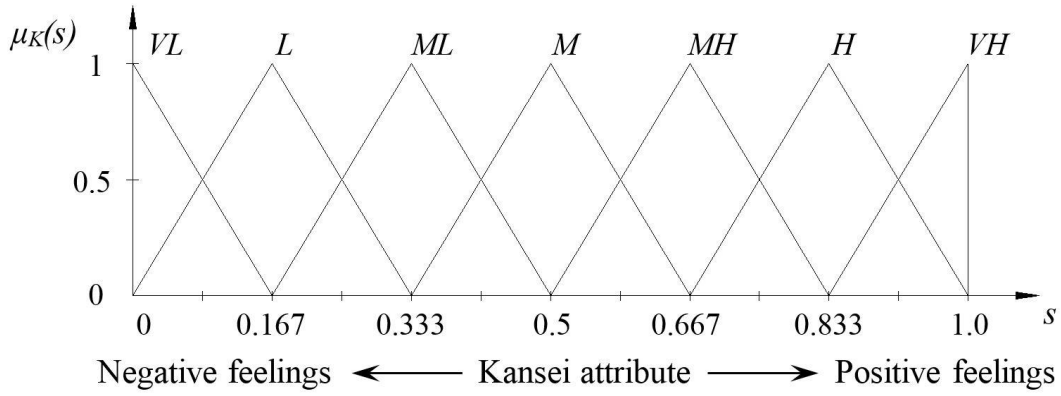


Figure 2: Triangular membership functions of Kansei attributes

The concept of α-cut is a means to convert a fuzzy set into a crisp set, which is very significant in the relationship between fuzzy sets and crisp sets and is also useful for defining the arithmetic operations on fuzzy numbers. The α-cut of Kansei preference *K* is a crisp set $K_{\propto}$ that contains all the elements of the semantic space *S* that have a membership grade in Kansei preference *K* greater than or equal to the specified value of α ($0 \leq \propto \leq 1$). The Kansei preference *K* can be a crisp number at $\propto = 1$. In establishing priorities of preference relations, fuzzy numbers are used as interval type-2 fuzzy numbers for aggregation operations that allow the incorporation of uncertainty on the Kansei evaluation.

3. AGGREGATION OPERATION ON FUZZY NUMBERS

Aggregation operations on fuzzy numbers are operations by which several fuzzy numbers are combined to produce a single fuzzy number (Klir & Folger, 1988). The fuzzy weighted average (FWA) is an aggregation operator used in situations where the arguments are inexact numerical variables (Dong & Wong, 1987; Kao & Liu, 2001). More specifically, it is a combination of extended algebraic operations to be used in the Kansei evaluation of alternatives when their corresponding

ratings (Kansei preferences) and weights (importance) of criteria (Kansei attributes) are represented by fuzzy numbers. The operation of FWA is formularized as follows (Vanegas & Labib, 2001):

$$D_j = \frac{\sum_{k=1}^{m} w_k \cdot r_{jk}}{\sum_{k=1}^{m} w_k} \tag{1}$$

where
D_j represents the overall desirability of alternative *j*;
r_{jk} represents the preference of the kth attribute of alternative *j*; and,
w_k represents the importance (weight) of the kth attribute.

Variables D_j, r_{jk}, and w_k are fuzzy numbers. Based on the extension principle, the fuzzy arithmetic operations have been defined to manipulate fuzzy numbers (Zadeh, 1975, 1976). Any fuzzy number can be completely defined by its family of α-cuts, while extended algebraic operations can be defined based on arithmetic operations in intervals assuming that fuzzy numbers are represented by continuous membership functions. According to Klir and Yuan (1995), an arithmetic operation on fuzzy numbers A and B on $\mathcal{R}$ can be reduced to operations on intervals $A_\alpha = [a, b]$ and $B_\alpha = [c, d]$, respectively. The four arithmetic operations on closed intervals are defined below:

Addition:

$$(A + B)_\alpha = A_\alpha + B_\alpha = [a, b] + [c, d] = [a + c, b + d] \tag{2}$$

Subtraction:

$$(A - B)_\alpha = A_\alpha - B_\alpha = [a, b] - [c, d] = [a - d, b - c] \tag{3}$$

Multiplication:

$$(A \times B)_\alpha = A_\alpha \cdot B_\alpha = [a, b] \cdot [c, d] = \left[min[ac, ad, bc, bd], max[ac, ad, bc, bd]\right] \tag{4}$$

Division (provided that $0 \notin B_\alpha$ for all $\alpha \in (0,1]$):

$$(A \div B)_\alpha = \frac{A_\alpha}{B_\alpha} = \frac{[a, b]}{[c, d]} = [a, b] \cdot \left[\frac{1}{d}, \frac{1}{c}\right] = \left[min\left[\frac{a}{c}, \frac{a}{d}, \frac{b}{c}, \frac{b}{d}\right], max\left[\frac{a}{c}, \frac{a}{d}, \frac{b}{c}, \frac{b}{d}\right]\right] \tag{5}$$

The result of the four arithmetic operations is a crisp set (interval) that represents the α-cut of the fuzzy set obtained by operating on fuzzy numbers *A* and *B*. Through the arithmetic operations, the family of α-cuts defined as the resultant membership function of the evaluated alternative can be presented as a membership function curve and classified as a fuzzy number. In order to obtain a quantitative value of the resultant membership function, the center-of-gravity (COG) defuzzification method is used in this study. The formula of the COG method is expressed in Eq. (6). The higher the $\bar{s}$ value, the better is the evaluated alternative.

$$\bar{s} = \frac{\int_u^v m(s) \cdot s ds}{\int_u^v m(s) ds}$$

(6)

where

$m(s)$ represents the resultant membership function of the evaluated alternative;

u and *v* are the respective lower and upper limits of the support of the fuzzy number.

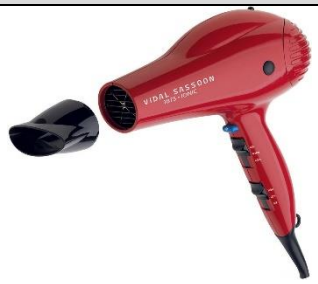
4. AN ILLUSTRATIVE CASE

This section conducts an empirical study to illustrate the implementation of the proposed approach. The aim of the case study is to assess the most desirable alternatives from a set of selected products in terms of customers' Kansei preferences.

4.1. Selecting a set of product alternatives for evaluation

A hair dryer is an electromechanical device designed to blow cool or hot air over wet or damp hair, in order to dry the hair by speeding up the evaporation of water from the hair's surface. Six branded hair dryers were selected as product alternatives to conduct the Kansei evaluation. The specifications of the product alternatives are listed in Table 2.

Table 2: Product alternatives for Kansei evaluation

Alternative 1	**Alternative 2**	**Alternative 3**
 Brand: VIDAL SASSOON Model No.: VS547	 Brand: Conair Model No.: YB075W	 Brand: Panasonic Model No.: EH-NE11-V
Specifications: Dimensions: 27.9 x 10.2 x 22.9 cm Weight: 0.636 kg Wattage: 1875 Watts Color: Red	**Specifications:** Dimensions: 22.9 x 8.9 x 20.8 cm Weight: 0.908 kg Wattage: 1875 Watts Color: Yellow	**Specifications:** Dimensions: 17.2 x 7.3 x 21.8 cm Weight: 0.45 kg Wattage: 1200 Watts Color: White/Purple
Alternative 4	**Alternative 5**	**Alternative 6**
 Brand: PHILIPS Model No.: HP8213	 Brand: REVLON Model No.: RVDR5092	 Brand: JOHN FRIEDA Model No.: JF1
Specifications: Dimensions: 16 x 9.3 x 28 cm Weight: 0.636 kg Wattage: 1500 Watts Color: White/Purple	**Specifications:** Dimensions: 25.4 x 10.5 x 27.9 cm Weight: 0.908 kg Wattage: 1875 Watts Color: Pink/Black	**Specifications:** Dimensions: 21.6 x 9.8 x 29.2 cm Weight: 0.545 kg Wattage: 1875 Watts Color: Silver

4.2. Collecting a set of Kansei adjectives as semantic elements for Kansei evaluation

The trend of product development is moving towards incorporating customers' affective needs into design elements that deliver customers' Kansei preferences. In establishing a product's attractiveness, the use of perceptual scales can provide a qualified approach for evaluation purposes. The question for measuring customers' perceptual scales is "What kind of feelings do you stress when purchasing a hair dryer". There were 7 pairs of adjectives selected as the Kansei attributes for evaluating hair dryers. According to the Kansei preference modeling given in section 2, the perceived intensity and perceived importance of these Kansei attributes are listed in Table 3.

Table 3: Perceived intensity and perceived importance of the Kansei attributes (KAs)

Semantic label		***VH***	***H***	***MH***	***M***	***ML***	***L***	***VL***	
Fuzzy number		**[0.833, 1]**	**[0.667, 1]**	**[0.5, 0.833]**	**[0.333, 0.667]**	**[0.167, 0.5]**	**[0, 0.333]**	**[0, 0.167]**	
	Positive feelings	←						→	Negative feelings
KA_1	Handy	□	□	□	□	□	□	□	Awkward
KA_2	Elegant	□	□	□	□	□	□	□	Inelegant
KA_3	Stylish	□	□	□	□	□	□	□	Styleless
KA_4	Fashionable	□	□	□	□	□	□	□	Unfashionable
KA_5	Simplificative	□	□	□	□	□	□	□	Complicated
KA_6	Convenient	□	□	□	□	□	□	□	Inconvenient
KA_7	Novel	□	□	□	□	□	□	□	Ordinary
Weight	Important	□	□	□	□	□	□	□	Unimportant

4.3. Establishing priorities for obtaining Kansei preference variables

According to the Kansei attributes, evaluators establish priorities for the Kansei attributes and priorities for the Kansei preferences corresponding to each product alternative. The evaluation scales are semantic labels of fuzzy numbers shown in Table 3. After completing the priority analysis, two sets of Kansei preference variables are obtained as follows.

$$R = [r_{jk}] = \begin{bmatrix} ML & L & M & L & H & M & L \\ L & L & MH & M & H & ML & MH \\ H & M & H & MH & M & H & H \\ VH & M & H & H & MH & H & H \\ M & MH & H & H & MH & MH & M \\ MH & M & MH & MH & H & MH & M \end{bmatrix}$$

$$= \begin{bmatrix} [0.167, 0.5] & [0, 0.333] & [0.333, 0.667] & [0, 0.333] & [0.667, 1] & [0.333, 0.667] & [0, 0.333] \\ [0, 0.333] & [0, 0.333] & [0.5, 0.833] & [0.333, 0.667] & [0.667, 1] & [0.167, 0.5] & [0.5, 0.833] \\ [0.667, 1] & [0.333, 0.667] & [0.667, 1] & [0.5, 0.833] & [0.333, 0.667] & [0.667, 1] & [0.667, 1] \\ [0.833, 1] & [0.333, 0.667] & [0.667, 1] & [0.667, 1] & [0.5, 0.833] & [0.667, 1] & [0.667, 1] \\ [0.333, 0.667] & [0.5, 0.833] & [0.667, 1] & [0.667, 1] & [0.5, 0.833] & [0.5, 0.833] & [0.333, 0.667] \\ [0.5, 0.833] & [0.333, 0.667] & [0.5, 0.833] & [0.5, 0.833] & [0.667, 1] & [0.5, 0.833] & [0.333, 0.667] \end{bmatrix} \quad (7)$$

$$W = [w_k] = [VH \quad H \quad MH \quad H \quad H \quad MH \quad H]$$

$$= \begin{bmatrix} [0.833, 1] & [0.667, 1] & [0.5, 0.833] & [0.667, 1] & [0.667, 1] & [0.5, 0.833] & [0.667, 1] \end{bmatrix} \quad (8)$$

4.4. Aggregating the priority information and rank the alternative products

Substituting the above two sets of Kansei preference variables into Eq. (1) to perform the FWA operation, the resultant membership functions of the evaluated alternatives can be derived which are presented in membership function curves as shown in Figure 3.

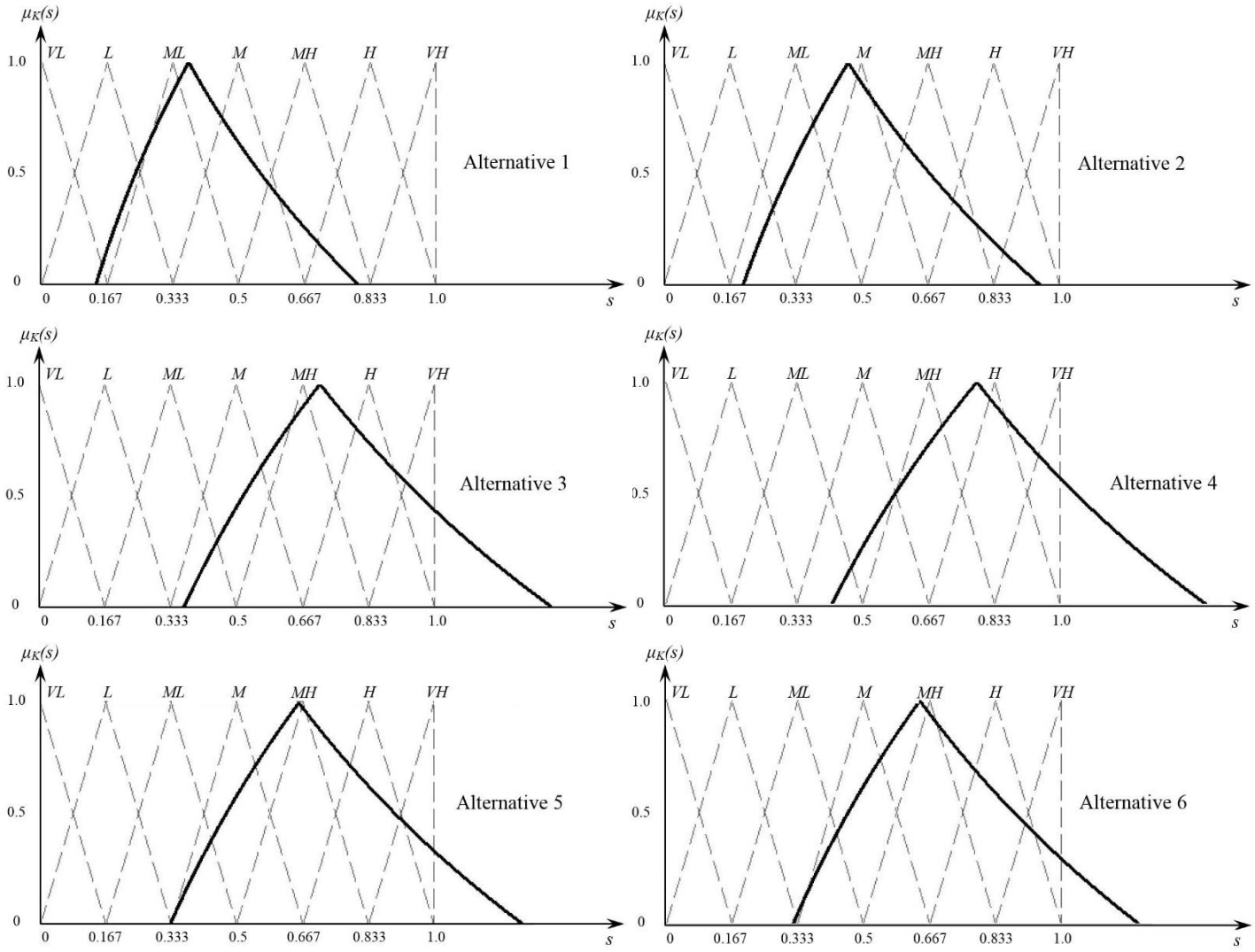


Figure 3: Resultant membership function curves of the evaluated alternatives

By using Eq. (6), we can defuzzificate these fuzzy numbers and consequently rank the alternative products by the quantitative values. The final results are listed in Table 4. According to the Kansei evaluation results, the best product is Alternative 4 while the worst is Alternative 1.

Table 4: Final results of the Kansei evaluation

	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Quantitative values	0.421	0.521	0.77	0.839	0.718	0.7
Rank	6	5	2	1	3	4

5. CONCLUDING REMARKS

Kansei evaluation (KE) plays a vital role in the implementation of Kansei engineering; however, it is difficult to quantitatively evaluate customers' preferences on Kansei attributes of products as such preferences involve the human perceptual interpretation with certain subjectivity, uncertainty, and imprecision. This paper presents a Kansei evaluation approach based on fuzzy linguistic preference techniques. Fuzzy linguistic approach deals with Kansei preferences and attributes through natural language instead of numbers. It emulates human cognitive processes to improve solving processes of problems dealing with uncertainty, imprecision, and subjective vagueness.

In the proposed approach, Kansei preferences are modeled by using fuzzy numbers to establish priorities for the Kansei attributes and priorities for the customer preferences with respect to each attribute. Since fuzzy numbers are interval scales derived from the evaluators' linguistic judgments, evaluators feel more confident about giving their perceptual interpretations in the form of semantic sets. Moreover, the preference variables are aggregated by means of the FWA method. The use of FWA allows the evaluators to incorporate unquantifiable information, incomplete information, non-obtainable information, and partially ignorant facts into a decision model; hence, this approach is capable of capturing evaluators' appraisals of ambiguity and is valid for dealing with Kansei evaluation problems. Kansei clustering is an important step to justify that a set of much fewer selected Kansei adjectives can be used to represent the whole meaning of all the Kansei adjectives collected from the customers. Based on the proposed approach, further research could focus on developing a cluster analysis method for classifying Kansei attributes.

ACKNOWLEDGMENTS

This research was financially supported by the National Science Council of Taiwan under grant number NSC 102-2221-E-214-041.

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BIOGRAPHY

Jyh-Rong Chou is a professor and Chairman of the Department of Creative Product Design at the I-Shou University, Kaohsiung, Taiwan. He received his M.S. and Ph.D. in Industrial Design from National Cheng Kung University in 1994 and 2004, respectively. His major research interests include application of fuzzy set theory and gray theory, product design, ergonomics, human perception measure in interface design, and usability engineering. He has published a lot of papers in the International Journals in the above-mentioned areas. Professor Chou is also an Assistant Editor of the ***International Journal of Organizational Innovation*** and an Editorial Board Member of ***The Scientific World Journal***.

Understand user-device relationship in multiscreen exercise activity

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Abstract: The emergence of a variety of different technical devices has changed the ways we manage things, live our lives, gain new knowledge, or maintain a healthy lifestyle. According to Manhattan Research (2012) multiscreen health activities are on the rise. More and more exercise related equipment or gadgets are being adopted for the purposes of tracking, enhancing or facilitating our physiological state. Research in this field have addressed issues in the type of interaction, usage pattern and information perspectives, to explore the mechanisms between intrinsic issues (individual differences, content and device), and extrinsic issues (environmental context and culture implications). Less attention has been paid to deal with the relationships between the users and their devices during exercise activities. Some reports have shown why and how people utilize multiple devices in their daily lives, as well as what those devices mean to them in general, but it may not be the same while applying to the context and purpose in the domain of physical health. Mobile devices like smartphone, tablet or exercise gadgets provide specific functions and convey different messages when used in the context of exercise. The goal of this study is to explore the kind of devices people use during exercise, the usage context, and the emotional reaction derived from multiple devices by understanding the role of each device and how it can affect users' perception to the content and the motivation to the goal from a user-centered point of view. The findings of my study ascribed roles to the investigated devices through in-depth interviews. This study is to propose a conceptual structure of the user-device relationships in exercise activities, and provide a basic understanding on how we could map out the content, strategies or different ways of interaction with the characteristics of devices to maximize the effectiveness of the outcome.

Keywords: exercise, user-device relationship, multiscreen, product attachment, motivation

1. RESEARCH BACKGROUND

Technology has gone through a number of technological advances driven by the innovation of new technical phenomena and/or influenced by the evolution of human lifestyle. The Internet phenomenon made activities and communications possible without geographical and timely constrains. Things that we encounter in our daily lives have turned from tangible to intangible online materials and people nowadays receive information mostly from online search engines, email, blogs or all kinds of electronic platforms. Internet has become the main source of information provider, and enables information synchronization in all kinds of devices that are able to access the Internet. As the Internet ecosystem converged, Internet penetrates into our daily lives and reaches users across all touch-points and devices. According to the 2013 survey conducted by the International Telecommunication Union, 40% of the world's population are online and the percentage is growing each year (ICT, 2013). Internet builds up the communications between two and up to several entities, and changed the ways of how a single individual to a large enterprise communicate, collaborate and innovate. The trends of multiscreen, crowdsourcing, e-learning, online medical consulting services are a few examples that demonstrate the impact of Internet phenomenon. Internet made it easier for people to connect with each other through various platforms, it also strengthen users' attachment toward multiple devices and result in different sets of relationship.

With the latest mobile technological advances in smartphone mobility, multimedia and ubiquitous computing, the mobile phenomenon has emerged rapidly with the mass adoption of smartphone. While the always-on connected devices increased, 90% of the media are consumed through variety of screens including smartphone, laptop, tablet and television as compared to 10% with non-screen interaction on radio and paper-based artifacts as according to Google's research on multiscreen (Google, 2012). The increase in device mobility enables people to access data anytime anywhere which have added more mobility into our lifestyle. From desktop computer to smartphone and tablet, the usage context has broken its boundaries and have been expanded everywhere. Mobile devices are not used only for the purposes of communication, but have also become the vehicle for interactive audiovisual contents that are always-on, context-aware, and are being viewed, transferred, retrieved and distributed on the go. People start to establish significant relationships with their devices, such as mobile phone, tablet or PDAs which contain private personal information and often employed with a more active attitude, and used as primary or secondary screens (Cesar, Knoche & Bulterman, 2009).

Before multiscreen phenomenon emerged in recent years, the user-device relationship have been referred to as how users interact with a single device, and research in this area have provided valuable insight into subjects like user emotion, human behavior, attitude and motivation mainly dealing with single device interaction. However, in the era of multiscreen world, people no longer interact with with only one device, instead they interact with multiple devices in sequence or in conjunction with one another to extend device possibilities within a broader context. More interactive experiences appeared as user behaviors get more complex, the role of technology becomes versatile, and there is a need of reassessment to explore the interplay between users and their multiscreen. This study proposes that the potential of Internet and device mobility have made devices integrate seamlessly with one another while users are no longer restricted to using a single device but are able to choose the right kind of devices that suit their current usage and needs.

2. MULTISCREEN STUDIES

Multiscreen phenomenon has yielded research opportunities in various academic disciplines dealing with how we interact and connect with multiple devices, as they have gradually become a great part of our lives. Technological convergence led to media divergence, and resulted in different kind of devices and forms of content to serve users' various needs (Roscoe, 2004). For example, ESPN (Entertainment Sports Programming Network) fans are exposed to multiple devices everyday in various contexts. *"The ESPN fan who watches "SportsCenter" as he gets ready for work, listens to (radiocast of the television show) "Mike & Mike" on the way to work, uses ESPN.com to keep up with sports news during the day, and either watches ESPN on TV at home or goes out and uses ESPN mobile* (Assael, 2011). The adoption of several screens to perform related or unrelated tasks represent that every screen has its own benefits which people are able to use alone or together to create smarter and elevated user experience (Caras, EMEA & Microsoft Advertising, 2010). The technology has changed and so do other aspects that have been influenced by this kind of phenomenon: interaction goes from single to multiple, system usability goes from emphasizing on reliability to flexibility, services goes from linear to non-linear. Even information management takes into account the communication switching and mobility (Oulasvirta & Sumari, 2007). The multiscreen phenomenon has changed how we interact, think and learn; therefore, it is relevant to say that our relationship with screen is no longer limited to single screen interaction. According to Manhattan Research (2012) multiscreen health activity is on the rise. However, less attention has been paid to deal with the relationships between the users and their devices during exercise activities. Some reports have been showing why and how people utilize multiple devices in their daily lives, as well as what those devices meant to them in general (Matthews, Pierce & Tang, 2009), but it is not the same while applying to the domain of physical health.

People formed close relationship with mobile phone and PDAs, which are considered to be "personal accessories" (Wehmeyer, 2008), and described as an extension of one's self (Pertierra, 2005). Most of the researches in user-device attachment are done from mobile phone perspectives, and it is worth probing into such nature of relationship that it might shed light on the relationships with multiple devices that this study is going to investigate. This close relationship was defined as product attachment that illustrates the emotional experiences between product and its user (Schifferstein, Mugge & Hekkert, 2004). The relationship with modern technology has become tighter for the past decade, and the role of technology in human's lives has transformed from dominating, facilitating, and influencing to the extent of changing the perception and cognition aspects of human. Mobile device is considered hybrid with its voice and data features (Sarker and Wells, 2003). Devices are perceived with different meanings and functionalities according to the context and time of use, while the form size and lightweight make them possible to be carried around and thus the relationship between users and devices become even more complex and diversified. For example, tablet is interpreted as a multimedia station during leisure time, as an on-the-move professional assistant in formal business hours and as a entertainment device for socializing (Zamani, Giaglis & Nancy, 2012). The role of device is changing interchangeably, and perceived with various expressive meanings. People refer to device as their companion, which is reflected with personality and defined beyond its instrumental power (Turkle, 2007). Understand the relationship with multiscreen enables further prediction between multiscreen behavior and users' expectations.

Under this circumstance, the roles and functions of device is required to be redefined and generate with new sets of meanings. This study aims to explore the relationship people developed

with multiple devices during exercise activities. To explore the kind of devices people adopt during exercise, the activity types by device, and the user-device relationship by clarifying the role of each device, the emotional mapping and how its characteristic could affect users' reaction to the content and motivation to the goal from a user-centered point of view.

3. METHOD

The purpose of this study is to explore the user-device relationship in exercise context; therefore, it is important to know the kind of devices people adopt, and the emotional bond and insights that are elicited from the interaction with multiscreen. This study conducted in-depth interview with three participants (two males and one female; average age 28), whom are students and have been actively using multiple devices in exercise activities for approximately one to two years. Participants were selected to have been using those devices for a long period of time to avoid early adoption issues like technical or acceptance problems, and to make sure that their experiences are stable and reliable for research. The in-depth interview were conducted for approximately 1.5 hours each, and each participants were informed before the interview to bring the devices which they utilize during their exercise for demonstration. In these interviews, participants were asked about their exercise goals, types of exercise they perform, situations of where and how they used their devices, and also what kind of devices they use during exercise. They were also asked to describe their connections to those devices through usage patterns, and emotional bonds. Interviews were used as a way to elicit participants' emotions as to how they felt while using those devices and how they would give certain role for each device without the need to observe them in action or to ask them to fill out questionnaires. The results were analyzed and aggregated to create significant implication on users' relationship with multiscreen during exercise activities.

4. FINDINGS AND DISCUSSION

The participants used their devices mostly at the gym, school track and sidewalk. The differences in location impacted the kind of devices being used. The devices utilized by the participants include smartphone, laptop, television and other screens such as pedometer and weight scale.

4.1. The role of devices

Devices that were originally designed for one specific feature, now possesses more than one role. For instance, mobile phone transforms from merely a communication tool to what we considered a hybrid tool (Sarker & Wells, 2003), which can be used for navigation, data searching, socializing, entertaining and so on. Most often the roles of the devices in exercise activities can be categorized to indoor and outdoor settings. The influencing factors that determine how devices mean to users are exercise goals, activity types, motivation, and technological characteristics such as network capability, mobility and content design.

4.1.1. Smartphone

Participants described smartphone as a communicator, a recorder, an entertainer in indoor exercises, and a coach in outdoor exercises. It is the main device that is being utilized the most in exercise activities by participants. Smartphone's small size makes it easier to carry around, to manoeuvre with one hand and to fix on exercise equipment. This study analyzed smartphone usage in two phases: before exercise and during exercise, to demonstrate how the role of devices

shifted with user needs and changing context. Participants have stated that before exercise, smartphones were used as communication tools to contact exercise pals through phone calls and sending online or offline messages. As one participant said, "*I contacted my exercise buddies to make sure that everyone is going to the gym tonight*". Communication beforehand acts as a trigger for the activity to take place as several research studies have proved that social interaction in physical activities result in increased motivation (Biddle & Mutrie, 2001). The role of smartphone shifts with the change of contexts. During exercise, smartphone plays interchangeably different roles and establishes distinct connections and relationships with its owner, holding specific meanings for each participant. "*Smartphone is the best tool I can think of to record and store my personal data, I don't need to memorize the numerical data and then go home and key in onto my laptop*, it saves me time" Two participants described smartphone as a secretary that helped them to record their fitness data such as the kind of fitness equipment they used, exercise duration, and calories burnt, which are considered personal data. The use of smartphone made it easier for them to manage data digitally instead of paper-based recording. The management of personal information is part of what people need to pay attention to in the multiscreen world as to manage personal information across multiple devices. Also, since smartphone contains personal data, this result in people seeing smartphone as an extension of self (Zimmerman, 2009). This reveals the needs for users to store their private data in secured place while it is also reliable to manage data across multiple devices. The relationship between smartphone and exercise is intense and it is reflected through user's emotional attachment to their smartphones. "*I feel anxious if I forget to bring my smartphone because I might not be able to keep record*", stated one participant. The fear of losing data accurately showed the need of people to keep track of personal data and to synchronize data across devices. Other exercise-related smartphone usages that influenced participants' emotion were also discovered from the interview. Smartphone was also considered as an entertainer, providing recreational functions such as music, movies, e-newspaper or games, which may or may not be related to exercise itself, but serve personal enjoyment. "*When I felt low in physical strength and will power, I start to watch TV or use my smartphone to distract myself from paying attention to my sore muscle and bodyache*", "*You never feel bored with smartphone by your side, it possessed the powers of multi-sensory, vividness and richness that provides endless entertainments*". Such multifunctional features often bring extra motivation for the current task. The role of smartphone is diversified and can be assigned to meet user need and use context. In outdoor exercise situations like school track and sidewalk, the small and light-weightiness of smartphone possesses more advantages than any other devices with Internet access. "*I use a fitness application called RunKeeper on my smartphone to track my running distance, and this application provides me with instant feedback (through my headphone) on how far I have run and whether I have reached my goal. It is like having a coach by my side. I feel both motivated and inspired.*" This shows that users like to feel in control of their exercise progress while being given prompt feedback. These will help them reach their goal in an easier way with more pleasant experience.

4.1.2. Laptop

Laptop is less mobile than other hand-held devices. Its medium size and weight make it not as easy to operate in motion; therefore, it is often used in stable locations such as coffee shops, offices or at home. In the context of exercise, laptop usage occurred most often both before and after exercise for various purposes as opposed to during exercise. Participants in the interview portrayed laptop as their long-term partner. Laptop acted as a gateway toward knowledge, insight, sharing and self-reflection. Some quotes from participants stated that: "*I used laptop a lot for*

exercise-related information seeking. I found the right kind of fitness equipment for muscle building as well as how to prevent myself from exercise injuries", "*I searched for opinions and experiences online from people whom have the same problem or exercise goals with me, and see how I can learn from them*". Laptop serves as a quick and convenient first priority tool for information gaining. The knowledge absorbed through searching process also affects later decision-making and how people accomplish their goals. As one participant said "*It was until I knew that cardio exercise worked best with weight training for losing fat, did I start to change my exercise plan*." Exercise evaluation was conducted through fitness service websites (participants used RunKeeper in this case), which participants synchronized their exercise data from their smartphones to their laptops. "*I checked the website on a weekly basis to see my exercise records, and evaluated whether I have achieved my weekly goal. Seeing the number of running miles increasing was the greatest motivation to me*." Users employed laptop to manage their scattered exercise data, evaluate exercise performances, display history exercise record or share with friends their goal achievements. The results from the interaction with laptop show that a great amount of time are spend on self-reflection and awareness in relation to the exercise performances, which are indicate to be crucial factors to increase motivation (Ronda & Brug, 2001).

4.1.3. Television

The relationship with television in domestic contexts is like being with an old friend, it is casual, laid-back, and just like being with a friend (Microsoft, IPSOS & BBDO, 2011). Televisions in the gym may not have a direct influence to exercise itself, but they do have emotional and motivational attributes to the participants. As they mentioned, "*TV is like an companion which accompanied me throughout the exercise, it made me feel less bored and let me forget how hard I am working right now", "If there is a chance, I often choose the fitness equipment with embedded TV in them*". Sometimes exercise requires repetitive physical and emotional commitment and watching television is a way to distract people from paying attention to the exercise itself and put mind at ease. Interestingly, as participant said, "*I am not always paying attention to the television program content, instead I play games, check some social networking websites or read my email at the same time.*" Smartphones thus can be used like a secondary screen while watching television, and this multiscreen behavior was found in other research studies as to enrich TV watching experience (Cesar, Bulterman & Jansen, 2008). However, in the context of exercise, TV watching is not the primary task, but as an aid to help people complete their exercise routine. It is believed that the complementary use of smartphone as the second screen experience is perhaps inherited from people's daily interaction with television.

4.1.4. Other screens

Pedometer and weight scale are part of the devices participants adopted during their exercise activities. Pedometer is used during ambulatory activities like walking and running for counting the number of steps and the distance travelled. "*I carried my pedometer in my pocket everyday with me to almost anywhere. My pedometer have an internal 7-day memory, so I usually checked the number of steps I have walked at the end of the day, and adjusted whether I need to walk more tomorrow*" as stated by one participant. Its hardware and software design make pedometer simple and easy to use without any set up beforehand; therefore, it is accessible to a wild range of population (Bravata et al., 2007). Participants refer to pedometer as simple, invisible and friendly, and described it as a soundless friend who stays by their side everyday. Weight scale is more like a ruler that participants used as a device to measure whether they have achieved their desired weight. However, participants did not feel any connection or emotional reaction with the weight scale mostly due to the short interaction time and limited content provided. Screens without

Internet access functions like pedometer and weight scale usually operate alone and have less interactions with other devices, but they have been proven to be easily adopted and utilized as self-monitoring tools (Lubans, Morgan & Tudor-Locke, 2009) as well as motivational tools (Kang et al., 2009) for promoting physical health.

Table 1: Overall usage and device role by activities

Activity	Device	Usage	Device Role
Indoor Activity (Gym, Home)	Smartphone	• Used for social connection, which acts like a trigger. • Easy and convenient for users to carry around and used as a main device to connect with their other devices. • Used for personal purposes such as managing personal exercise data, or dealing with unfinished works. • Most of the time, it is utilized to kill time or serves for personal enjoyment, which also adds motivation and increases exercise sustainability.	Communicator Recorder Entertainer
	Laptop	• Quick and convenient first priority tool for exercise information gaining. • May affect later decision-making and ways to accomplish the goals. • A better device to manage scattered exercise data, evaluate performances, and display history records. • A great amount of time are spend on self-reflection and awareness in relation to the exercise performances.	Long-term partner
	TV	• Provide additional emotional and motivational influences to the users. • Used to distract users from paying attention to their sore muscle and bodyache while also sustain their exercise behavior. • Usually used in conjunction with smartphone as a secondary screen.	Old friend
	Other screens	• Pedometer is accessible to a wild range of population since it is easy to use, lightweight and no pre-set up is required. • Weight scale and pedometer are easily adopted and utilized as self-monitoring tools as well as motivational tools for promoting physical health.	--
Outdoor Activity (Track, Street)	Smartphone	• Small and light-weightiness of smartphone possesses more advantages than any other devices for outdoor locomotor activities. • Users like to feel in control of their exercise progress while being given prompt feedback.	Coach
	Other screens	• An easy and immediate tool to grab for tracking outdoor activities.	--

4.2. Usage based on time

This study analyzed usage of multiscreen devices through time intervals: before, during and after exercises. Exercise setting (indoor and outdoor), behavior path, and usage modes (sequential and simultaneous usage) and considered in relation to the utilized devices. The result revealed how multiscreen are utilized the second screen effect and specific usage in relation to the exercise context. These results provide a basic understanding on how people react to the multiscreen phenomenon.

Result from indoors setting in Figure 1 showed that before exercise, laptop and smartphone are used simultaneously: communication and searching for exercise-related information are both done prior to going to the gym, but communication takes a more important role at this stage. In behavior path, contacting friends from smartphone acts like a trigger for the exercise activities to take place, and the presence of trigger often indicates motivation. Previous research has stated various strategies for motivation, such as social support, feedback and rewards (Fogg, 2002). Therefore, it is important to know how people use their multiple devices in different stages as a basic standpoint for motivational strategies or other services to be added on. Participant used smartphone, pedometer and TV all together during exercise for different tasks but at the same time complementing with each other. Television and smartphone are used like secondary screens to enrich exercise experience and to distract attention on physical and psychological tiredness, while

it is also noticeable that complementary usage of television and smartphone indicate users' multitasking behavior and the nature of being engaged at all time (Microsoft, Flamingo & OTX, 2013). The emotion derived from using devices has an influential factor to its users on the kind of devices they choose to be used with one another to enhance exercise experience. Participants tend to select TV programs that suit their exercise type in the gym. "*Part of my purposes of going to the gym is to relax, so I will choose to watch movies with more positive mood and avoid watching tense movies which will affect my emotion*", "*When I am using the elliptical machine, I like to watch sport competitions like NBA since they have similar pace and motivates me to work harder*" Therefore, content and emotion are two influential factors when devices are chosen to be used solely or in conjunction with one another to meet user needs or completing a task. Smartphone, in particular, is used sequentially throughout the whole exercise process, showing that its technical capability and content availability are both mature enough to conform to all kinds of contexts.

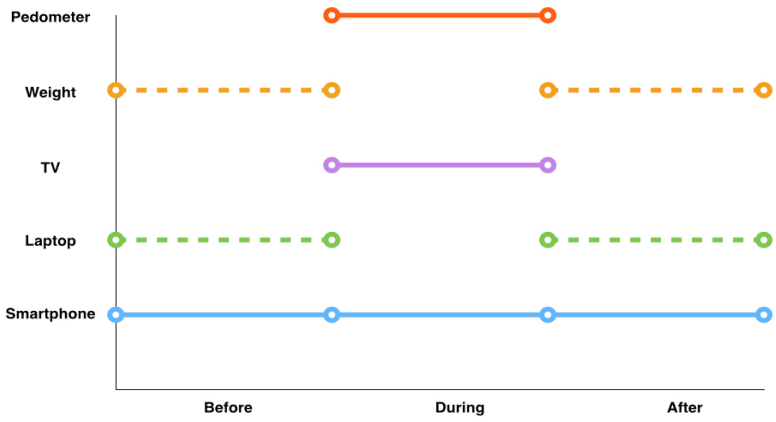

Figure 1: Indoor exercise (The adoption span of different devices before, during and after exercise)

The relationship with multiscreen in outdoor situations shown in Figure 2, occurred mostly after exercise, and this is due to Internet availability, form size and device mobility. Participants often transfer exercise data such as step counts and distance travelled onto their other laptop or smartphone for later retrieval and evaluation after exercise. Data synchronization is a critical issue since it saves time for data transferring and participants feel more motivated if their devices are able to sync with their other devices easily. During outdoor exercise, participants used pedometer and smartphone for keeping track of their exercises, while smartphone is sometimes used as secondary devices for listening to music.

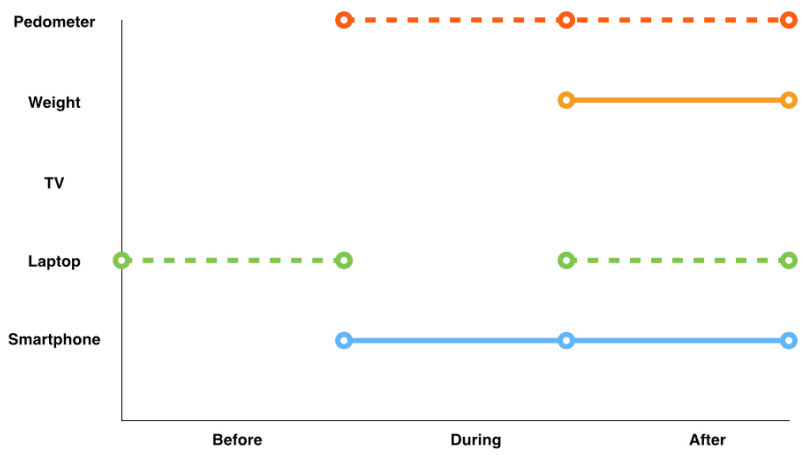

Figure 2: Outdoor exercise (The adoption span of different devices before, during and after exercise)

Defining the devices through time interval clearly demonstrated what device are suitable for current stage of use and how the interplay between content and emotion come to affect the sequential and simultaneous usages that may reflect in users' decision making.

4.3. Goal setting

From the interview we also found that goal setting plays an important determinant in revealing participants' action pattern, behavior path and emotional reaction. People exercise for the purposes of fulfilling their goals or hoping to accomplish certain results. No matter it is to maintain a healthy lifestyle, improve performance or for relaxation, users take different approaches to fulfill their desires, and the actions they take may determine the kind of devices being adopted and their relationship with those devices.

One participant reported having set up specific goals for losing weight on a periodic basis (weekly and monthly goals) and before an important event like travel. He mentioned that goal setting encouraged him to keep exercising, and act as an indicator for him to reflect back from time to time on how far left he had to work on to accomplished his goals. He used both the smartphone and laptop to keep track of his goals. He mentioned in the interview that setting exercise goals have two effects: in short term, goals motivated him to continue pursuing exercise and keeping track of the numbers (weight, calorie intake, calories burnt, body fat) that helped him compare exercise results on daily basis and reminded him on whether more exercises were needed. In the long term, the overall goal records portrayed as an inspiring milestone that increased his self-image as he proudly said *"In the past two years, the distance I have ran by foot is equal to the distance of circling the earth once."*

On the contrary, the other two participants did not set up any specific goal but are hoping to get "in shape" and to increase muscle strength. One participant reported that in the beginning, he actively kept exercise records using his smartphone, but after a while he does not exercise as frequent as before. The participant mentioned that the lack of a clear definition of "in shape" made him less motivated to go exercise. Moreover, keeping exercise record became boring and troublesome for him after a while as he said "*I think the application needs more variation such as adding some group competition function or other features that motivates me*". In addition, he felt exercise did not interest him as much as before and he did not know when he could achieve his

desire of being “in shape”. There is a decline in positive emotion with the number of exercise taken, as participants start to feel bored. At the time of Interview, both participants said that even though they didn’t set up any specific exercise goals, they still went for exercises now and then because they believed that they would slowly get closer to getting “in shape” and increased muscle strength.

The above situation is similar to Hassenzahl’s research in usage situation, which he defined into goal mode and action mode. Goal mode means goal fulfillment is the key to all actions, while individual describes themselves with terms like “serious” and “planning”, but in action mode, taking action is the key while users feel playful and spontaneous (Hassenzahl, 2005). Drawing from this point of view, we can argue that having specific goal or having volatile goal plays vital role in exercise activities since it influences users’ behavior, and the adoption of the devices and thus reshaping the relationship between user and the multiple devices.

5. CONCLUSION

The emergence of multiscreen, which has been a prominent phenomenon for the past few years, has changed people’s lives and how they interact with their devices. This study explored the user-device relationship in exercise activities. It mapped out the changing relationships between user, context, usage modes and the roles of device. Knowing these relationships could help explain how multiple devices are adopted during exercise activities and how can they be utilized to achieve desired goals or enhance exercise experiences. Device constraint, mobility of device and users’ body movements split exercise into two categories: outdoor and indoor exercises. The differences in context also resulted in the kind of devices people choose to adopt.

Based on in-depth interviews with three participants, this study showed that smartphone, laptop, television, pedometer and weight scale are used interchangeably throughout exercise processes. Among all of the devices, users developed a stronger sense of attachment with their smartphone, which is often being adopted as the primary device. The role of smartphone transformed from communicator, secretary, coach to entertainer through different stages of exercise. The personal physiological data being recorded is viewed as private assets, so much that users refer to smartphones as an extension of self. Therefore, the feelings of security and reliability are what users look for in the relationship with smartphone. Moreover, the multifunctional feature of smartphone broadens the user-device interaction and is being perceived by the users as a device with multi-sensory features, vividness and rich characteristics. The role of laptop in indoor context is like a device for investigation and knowledge seeking. It is used the same way in exercise context as it is being described as a long-term partner. However, in the context of exercise, users employed laptop to manage their scattered exercise data, evaluate exercise performances, display history exercise record or share with friends their goal achievements. Therefore, the relationship with laptop is mainly based on self-reflection and awareness that have significant influences for motivation. Television is one of the devices that users refer to as companion during indoor exercise. Even though using television may not have a direct influence to the exercise itself, but it does have emotional and motivational influences to its owners such as decreasing tensions derived from exercises and sustaining exercise behavior. TV watching is often being complimented by the use of smartphone for dealing with personal tasks such as checking email or playing games, which demonstrates that users like to multitasking even during exercise because they want to keep one single device for their personal use (Oulasvirta & Sumari, 2007). Other devices like pedometer and weight scale do not show prominent attachment with the users and it is due to their hardware characteristics that promote minimum interactions. However, it is found that the low technical

barrier made them easy and simple to adopt, especially pedometer that is often being implemented as a motivational tool to improve physical health for the general population (Mansi et al., 2013; Bravata et al., 2007). This paper also discusses the user-device relationship in time intervals. The complementary usage of smartphone and television shows how users like to be engaged at all time, and emphasizes on the importance of the interplay between content and emotion to enhance positive mood. The technical constraint and content availability of the devices and the contexts and types of exercise also direct how users define each of the devices and adopt them for sequential or simultaneous usages. Moreover, through exploring the relationship between users and devices, we found that the differences between having specific goal and having volatile goal determine the action approach users' take, their behavior path as well as the adoption of the devices.

This paper investigated the user-device relationship from multiple perspectives: how users characterize the role of each device as well as through exercise context and user behavior, to get a holistic understanding of how use-device relationship is constructed. This study stands at the beginning of possible discussion and further research on the concept of user-device relationship in the multiscreen world. The concepts raised in this study will have further development while more empirical studies will be conducted.

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BIOGRAPHY

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

The study on playability of toys for children based on different temperaments

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Abstract: Children gain knowledge through internalization, adjustment, and construction of individually contact with surrounding environment. During infant phase, a game is life, and life is a game. Toys have become a powerful tool to facilitate children's growth and learning. Besides, Children are born with their natural style of interacting with or reacting to people, places, and things—it is their temperament. Children with different temperaments need different teaching aids in their development. To promote effective learning and in order to stimulate their interest in games, it is important to select appropriate toys for the children with different temperaments. It would help to improve learning effects if adults timely provide children with help and guide. To achieve the above targets, this study aims to builds the relationship between child temperament and toy categories in order to discuss the playability of toys for children based on different temperaments. Study steps are as follows：(1)Classify preschool children by temperament test, and pick up representative toys as the experimental samples according to Piaget's game theory.(2) Discuss with experts in EGM and extract the possible playability of toy from it. Classify and arrange data with Factor analysis. (3)When observing the preference of children picking different sort of toys, confirm the attractive factors for playing games continuously by arranging the possible playability with experts.(4)The operating time and frequency of playing toys would be recorded in the experimental procedure.(5)Study if there was preference of different temperament children for toy categories, and built the connection between the playability of toys and temperament of children. This study builds the relationship between child temperament and toy categories in order to discuss the playability of toys for children based on different temperaments. It provides childhood educator a reference to choose toys, but also a design guideline for toy designer.

Keywords: temperament, toy, preference

1. INTRODUCTION

With improvement of technology and the trend toward fewer children, requirement of children have been taken seriously gradually. Various kinds of expensive toys are there in the market, but not all of them are good for stimulating children's ability development. Some of the toys are only even decoration, or they are only designed with a couple of ways to play with which will lose players' curiosity soon. Under the circumstance of not long enough of playing time, children will not be able to develop different type or level of game content through deep exploration. (Johnson,Christie, & Peckover,1988)

Thus, for adults, especially for preschool education workers like kindergarten teachers or babysitters, they should pay more attention on the principle of the right age, the right ability, and the right personality between children and toys when they are picking toys for children. According to Piaget's game theory, (Piaget, 1962) Children who are at different phase of cognitive development will play games with different ways, and, in turn, games simultaneously reflect children's level of development at the moment. Besides of the cognitive development differences, each child was also born with different kinds of temperament. The definition of temperament is that it is a natural born, unique behavior pattern that stimulates internal or external reaction. It has nothing to do with IQ or future achievement, but it will affect infants' personality development.

2. LITERATURE REVIEW

2.1. Game theory

According to Cognitive-developmental theory of Piaget, children gain knowledge through internalization, adjustment, and construction of individually contact with surrounding environment. However, during infant phase, a game is life, and life is a game. Toys have become a powerful tool to facilitate children's growth and learning.

Piaget had divided children's cognitive development into 4 phases, which are sensorimotor, preoperational, concrete operation, and formal operation phase. By explaining toys with perspective of cognitive development, he thought that cognitive development would affect children's games playing behaviors and divided those behaviors into three phases which are Practice play, Symbolic play, and Game with rules. After that, Smilansky, based on Pisget's categorization, revised cognitive games into four types. He changed Practice play with Functional play, and added Constructive play between Practice play and Symbolic play. He also changed symbolic play with Dramatic play. The last one remained Game with rules.

The four phases which cognitive development would experience are kind of gradual and continuous ones. Performance of each phase will be different depending on individual difference, but order of each phase will maintain the same.

2.2. Developmental theory of Vygotsky

Infants are born with independent performance and assisted performance during their growing process. In Vygotsky's scaffolding theory, he points out that children are able to stimulate their learning potential during the process of learning through games playing if there are adults aside to offer proper resource and assistance. For children of kindergarten level, the media that can stimulate learning potential is through adults offering proper games and toys.

2.3. Temperament of Children

The infants-temperament meter used in the present research takes this version as a revising standard. After evaluating grade of each dimension according to the infants-temperament meter, we are able to understand children's behavior reaction trend within each dimension. The present research will use the infants-temperament meter to evaluate children's performance, and divided children into different temperamental groups to discuss their preferences and durability toward toys.

2.4. Categorization of toys

There are various kinds of toys, and so are categorizing standards. The present research will categorize toys according to Piaget's game theory of cognitive development.

The present research will utilize Piaget's game theory to divide toys into 5 categorizations and pick out the most typical toy of each categorization to be our experimental sample according to experts' opinion.

3. LITERATURE REVIEW

3.1. Participants

Participants are 23 students from advanced and intermediate class of kindergarten of Taoyuan County Ben-Gang Elementary School. Their age range is between 4 and 6 years old. Carers of the students, which are kindergarten teachers, are required to fill out questionnaire of children temperament.

3.2. Experimental sample

We take Piaget's game theory as the basis of toys categorization and consult experts' opinion to choose the most typical toy of each categorization to be the experimental samples that are listed below:

1. Sensory action game: Game set that physical ability is integrated by senses, and hereafter it is defined as a physical toy.

2. Symbolic role-playing game: Game set of kitchen role-playing, and hereafter it is defined as a role-playing toy.

3. Structural construction game: Building blocks, and hereafter it is defined as a building block toy.

4. Fluid construction game: Wheat clay and clay tools, and hereafter they are defined as a clay toy

5. Number-symbol game: Number board and pokers, and hereafter they are defined as a number toy.



Figure 1: Experimental samples

3.3. Experimental environment

We decorate a kindergarten classroom as an experimental game zone and call it a “happy corner” in order to match up our activities which proceed in the corner. 5 experimental sample toys that represent Piaget’s game theory are placed in the corner, and toy amount of each categorization must be enough for participants. Jigsaw mats of different color are used to separate playing space of each game. Taping equipment are set in the classroom to record experiment process which is convenient for data collection and data analysis afterward.



Figure 2: Happy corner

3.4. Observation and recording

6 to 8 children are arranged to enter the experimental game zone- happy corner. Corner staying time for each group is around 40 minutes. Toys that are picked by children and their playing time length are recorded on experimental data sheet. Total experimental number of times is 23. Experimental data of 7 times for each participant are obtained.

The purpose of this phase is to utilize the decoration of happy corner to allow children to pick games and toys according to their preference. Through recording toy playing time as quantitative analyzing data, we discuss whether different kinds of toy will have different level of durability toward children.

4. DATA ANALYSIS

4.1. Analysis of participants

Through result of the questionnaires, we utilize cluster analysis to sort out children's temperament clusters. The sorting results are listed as below:

Extrovert type: 4 children, their activity level is higher than approach, their attention span is a little too short, and they are easy to be noticed

Unique type: 4 children, their activity level is high but short on attention span, and their persistence and adaptability are comparatively lower. Hyperactive children, schizophrenia, slow learners of learning and language are included in this type.

Serene type: 4 children, their activity level, approach, and intensity of mood are low, but their persistence is the highest. They are more focused to deal with their own business and rare to express their opinion or thought.

Ordinary type: 11 children, their adaptability is the highest among all clusters, but they perform ordinarily on the rest dimensions. The most children are in this type.

4.2. Durability analysis of experimental sample

The analysis of the present experiment is to individually measure playing time from the first to the seventh experiment. Our purpose is to understand whether differences of durability exist or not among toys through the toys choice every time from the beginning to the end of the experiment.

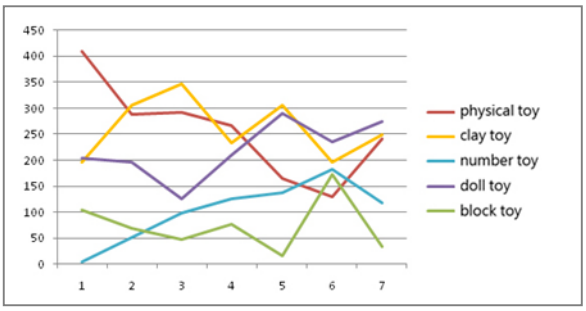

Figure 3: Durability analysis of experimental sample

At first, the toy types children chose were not consistent. Playing time of physical toy is obviously higher than other toys. During mid-later phase of the experiment, children's choices of toys were more consistent which means that the phenomenon of obvious longer playing time of particular toy did not exist. As increasing of experimental number of times, the playing time of physical toy gradually decreased; On the contrary, no one picked number game at the beginning, but its playing time obviously increased during later phase of the experiment which anticipates that different level of durability do exist among different toys.

This phase also utilize regression curve estimation to draw out durability curves of 5 experimental toy samples during 7 times of experiment. Analysis purpose is to judge whether, as a whole, experimental samples have durability or not according to the trend of the regression curve.

4.2.1. Physical toys

The curve regression mode of physical toys corresponding to the N time of experiment is a log curve. When the number of times of experiment gets higher, the time that children play with physical toys gets shorter. In other words, physical toys will be less and less attractive to children as the experiment is approaching toward its end. As for the result of the present research, physical

toys do not have durability.

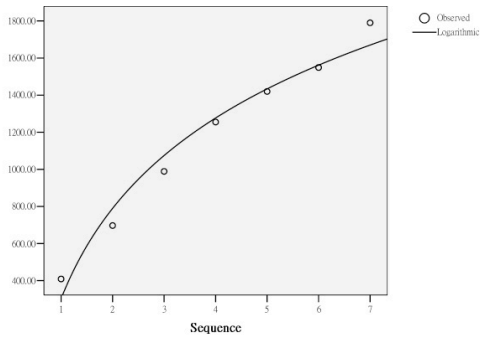

Figure 4: The curve regression mode of physical toys

4.2.2. Clay toys and number toys

No matter during early or later phase, the time that children play with clay toys and number toys remains stable which means that these two toys have a certain level of durability.

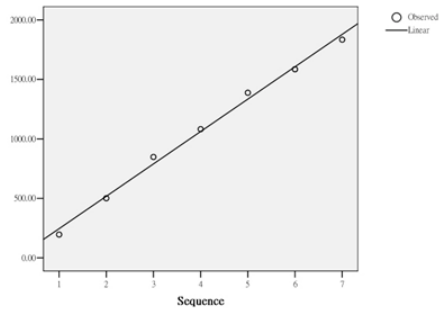

Figure 5: The curve mode of clay toys

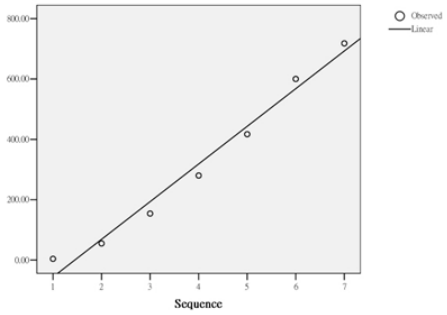

Figure 6: The curve mode of number toy

4.2.3. Role-playing toys and building blocks toys

As for the time that children play with role-playing and building blocks toys, its increasing amount of later phase is larger than early phase that means that role-playing toys have the durability which can attract children continue to play with.

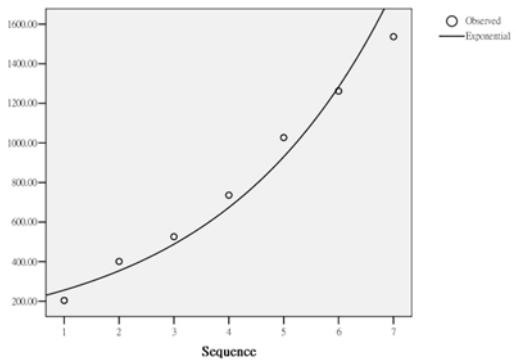

Figure 7: The curve mode of role-playing toys

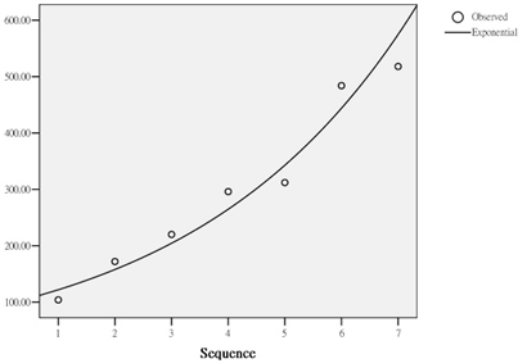

Figure 8: The curve mode of building blocks toys

According to the analysis above, we can find out that among the 5 chosen toy samples, the playing time of building blocks and role-playing toys at the beginning is comparatively shorter but increasing during the later phase. However, the playing time of clay and number toys approximately remains the same. The above 4 toys

persistently attract children to keep playing with. Nevertheless, as for the physical toys, although it has the specialty to attract children and its playing time is the longest during the early phase of the experiment, however, as the number of times of experiment increases, its playing time becomes shorter and shorter which means that physical toys do not have durability among these experimental samples.

4.3. ANOVA analysis of temperament clusters toward toys playing time

According to the analysis result in the last chapter, physical toys are less durable to children in the present experiment. Thus, we will only discuss clay, number, role-playing, and building blocks toys. The present research utilizes one-way ANOVA to analyze playing time of children from different temperament clusters toward different toys:

Role-playing toy has significant p value for children from different temperament clusters ($P=0.011<0.05$), and building blocks toy has near significant p value ($P=0.056<0.1$). From Scheff's multiple comparison we can find out that the playing time of role-playing toys for children of unique type is obviously longer than children of ordinary type. Moreover, from the result of LSD multiple comparisons, the playing time of role-playing toys for children of unique type is obviously longer than other children. However, the playing time of building blocks toy for children of serene type is obviously longer than children of extrovert type.

Table 1: the analysis result of ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Clay toy	Between Groups	4663.705	3	1554.568	.329	.804
	Within Groups	89754.295	19	4723.910		
	Total	94418.000	22			
Number toy	Between Groups	7444.327	3	2481.442	1.333	.293
	Within Groups	35372.977	19	1861.736		
	Total	42817.304	22			
Doll toy	Between Groups	28558.120	3	9519.373	4.885	.011
	Within Groups	37024.750	19	1948.671		
	Total	65582.870	22			
Block toy	Between Groups	1778.705	3	592.902	3.014	.056
	Within Groups	3737.295	19	196.700		
	Total	5516.000	22			

From Scheff's multiple comparison we can find out that the playing time of role-playing toys for children of unique type is obviously longer than children of ordinary type. Moreover, from the result of LSD multiple comparisons, the playing time of role-playing toys for children of unique type is obviously longer than other children. However, the playing time of building blocks toy for children of serene type is obviously longer than children of extrovert type.

4.4. Characteristic extraction from toys

Through in-depth interview and observation on children's game playing, we could list some characteristics of toys, and sum up the characteristics by using Evaluation Grid Method. Upper level is the psychological receptivity of children playing games. Middle level is the description of gaming behavior. Lower level is the physical features of toy corresponding to play behavior.

There's not only one game characteristic on toy design. This study breaks the ordinary framework of single toy and extracts the game characteristics by using KJ method to sort the play behaviors (middle level) into seven game characteristics: (1) Activity of body movement (2) Various creating process (3) Playable created results (4) Application of the abstractive concept (5) Interaction with peer group member (6) Symbolic role-playing (7) Interesting tactility.

4.4.1. Activity of body movement

Table 2: Activity of body movement

Psychological receptivity	Play Behavior	Toys categorization
Push body to the limit The sense of equilibrium Restless Competition	It could make children move around Jump, creep, roll, shake, climbing high Sitting on it or lying on it Perform the regulated movement	Physical toys

4.4.2. Various creating process

Table 3: Various creating process

Psychological receptivity	Play Behavior	Toys categorization
Imagination Feel free Variety	Create shapes Assembled parts at will could become some shape easily It could be assembled from many different directions	Building block toy
Process of transforming into solid With practical result Self-fulfillment	Copy what he looks at Something could be added detail Create some similar things Create any objects Need no rules	Clay toy

4.4.3. Playable created results

Table 4: Playable created results

Psychological receptivity	Play Behavior	Toys categorization
Feel majestic Self-fulfillment Nervous<->Relaxing (cycled) Feel excited	It could become something large Sit on it The assembled item is playable It could be carried and movable The assembled item is playable	Building block toy
	It could become the slide or a seesaw Substitution of outdoor facilities	Physical toys

4.4.4. Application of the abstractive concept

Table 5: Application of the abstractive concept

Psychological receptivity	Play Behavior	Toys categorization
Self-ability Performance Operability	It needs to use formula Showdown, partnership, sorting, sequence Match game It could be arranged in a row	Number toys

4.4.5. Interaction with peer group member

Table 6: Interaction with peer group member

Psychological receptivity	Play Behavior	Toys categorization
Interaction Competition Interaction	Play with many people at the same time Competition for complete something well and quickly	Physical toys
	Play with many people at the same time Create stories	Role-playing toy
	Competition	Number toys

4.4.6. Symbolic role-playing

Table 7: Symbolic role-playing

Psychological receptivity	Play Behavior	Toys categorization
Imitation behavior Sound effect Satisfy	Imitate adults Play roles in fairy tales Play animal roles Imitate the cooking behavior Play something forbidden in ordinary life	Role-playing toy

4.4.7. Interesting tactility

Table 8: Interesting tactility

Psychological receptivity	Play Behavior	Toys categorization
Feeling Movement	Feel the tactility on clay It could be nip, rub or stab Love to cut clay It could be shaped by model Feel the tactility on clay	Clay toy
	Touch stimulation	Physical toys

This study focus on children's behavior and content in games and record the operating time when they play games with different characteristics, for example:

Table 9: Take Building block toys for example

Categorization of toys	Game behavior	Game characteristics
Building block toys	Create shapes Assembled parts at will could become some shape easily It could be assembled from many different directions It becomes fastness after assembling	Various creating process
	It could be assembled as a big object It could become something large Sit on it The assembled item is playable	Playable created results

4.5. Analysis of the playability relationship between game characteristics and children's temperament

Based on the children's scores in temperament dimension, we sort these scores into 3 groups (high, middle and low). ANOVA analysis would be used to study if children with different temperament dimension have corresponding operating time on different game characteristics.

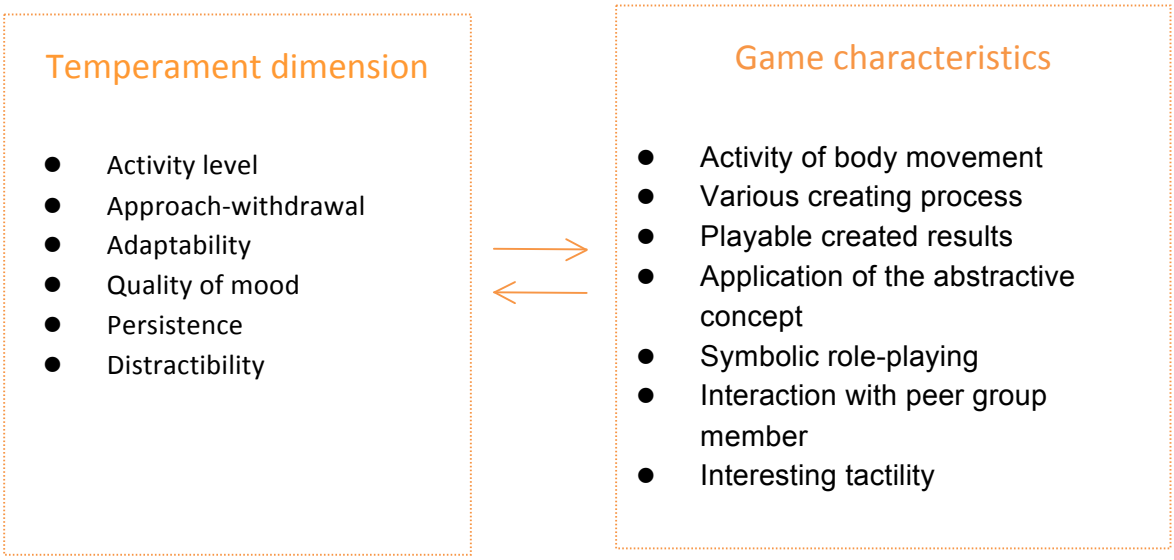

Figure 9: Analysis of relationship between game characteristics and children's temperament

Research result shows as below:

It shows significant difference on children with different Persistence when they play game with these two characteristics: "Symbolic role-playing" & "Playable created results"

In the characteristic "Symbolic role-playing", the mean value of low-persistence children is 131.00. It's more than mean value of middle-persistence children (36.91), P=0.017<0.05 (significant). It shows that "Symbolic role-playing" has more playability

for low-persistence children than middle-persistence children. In the characteristic “Playable created results”, the mean value of high-persistence children is 9.57. It’s more than mean value of middle-persistence children (0.00),P=0.007<0.05 (significant). It shows that “Playable created results” has more playability for high-persistence children than middle-persistence children.

It shows significant difference on children with different Distractibility when they play game with the characteristic: “Symbolic role-playing”. The mean value of high-distractibility children is 135.50. It’s more than mean value of middle-distractibility children (39.6), and low-distractibility children (44.44), P=0.011<0.05 (significant). It shows that “Symbolic role-playing” has more playability for high-distractibility children, than middle-distractibility children and low-distractibility children.

It shows a trend close to significant difference on children with different Approach-withdrawal when they play game with the characteristic: “Application of the abstractive concept”

In the characteristic “Application of the abstractive concept”, the mean value of middle approach-withdrawal children is 67.5. It’s more than mean value of low approach-withdrawal children (7.75), P=0.087, 0.05 <p<0.1 (close to significant). It shows that “Application of the abstractive concept” has more playability for middle approach-withdrawal children than low approach-withdrawal children.

It shows a trend close to significant difference on children with different Quality of mood when they play game with the characteristic: “Interaction with peer group member”

In the characteristic “Interaction with peer group member”, the mean value of children with middle quality of mood is 119.91. It’s more than mean value of children with high quality of mood (55.85), P= 0.078, 0.05 <P<0.1 (close to significant). It shows that “Interaction with peer group member” has more playability for children with middle quality of mood than children with high quality of mood.

There’s no significant difference on children with different Activity level or Adaptability when they playing games with varieties of characteristics.

5. CONCLUSION

Role-playing toy is categorized as a “symbolic game plaything” in children development. This type of toy can facilitate children’s social behavior and improve individual ability to efficiently deal with problems of interpersonal relationship. Unique type children’s playing time of role-playing toy is obviously higher than ordinary type children, and Its possible reason is that the integration level among groups of unique type children is easily decreased by their physical and mental status factors. Due to lower level of socialization, children are more easily attracted by symbolic game plaything and fulfill their cognitive and personality developmental expectation and imagination through behaviors of role-playing. During the symbolic role-playing game, children’s preference of concrete toys is in inverse proportion to their socialization level which means that the younger or lower socialized the children are, the more they will be attracted by concrete toys.

Ways to play building blocks toys belongs to a experience of solving problems. From the perspective of cognitive motivation construction, as infants solve problems or have breakthrough, it means that the infants have obtained cognitive function of higher level. It requires higher attention when playing with building blocks toys, thus, it is easier to attract serene type children whose activity level is lower, attention span is shorter, and persistent level is higher.

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Products as Poetry: A Case Study of the Sun-Crow Teapot Design Based on Traditional Chinese Poetic Aesthetics

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Abstract: The concept of emotional design has become the main focus in the current trend of perceptual consumption. After reviewing the historical development of Eastern and Western art, we determined that traditional Chinese art emphasizes subjective expression. Moreover, classical Chinese aesthetics favor poetics, whereas classical Western aesthetics focus on rationalism. Poetics are image based, and personal perceptions are used to analyze and understand external objects. These perceptions are expressed implicitly through symbols or metaphors. Classical Chinese poetic aesthetic theory is based on nearly 2,000 years of history and, thus, comprises a myriad of valuable ideas. The artist of the sun-crow teapot has extensive experience researching and creating Chinese art, and drew on these experiences and knowledge to craft the teapot. However, the purpose of the design was to achieve Donald A. Norman's reflective level of emotional design. In addition, the teapot was designed to exhibit traditional Oriental charm while conforming to modern style aesthetics. Design strategies inspired by traditional Chinese aesthetics include the concept that humans are an integral part of nature, wonder derived from opposing similarities and dissimilarities, the theory of the emptiness-solidity relationship, the concept of meaning that is retained when images are forgotten. To modernize the teapot, the design strategy was derived from the theories of Cezanne. Thus, the teapot was crafted using both spherical and cylindrical shapes to create a contemporary and fashionable abstract minimalist style. Case evaluation results indicate that a poetic design based on traditional Chinese artistic techniques can be implemented.

Keywords: Chinese Classical Aesthetics, Emotional Design, Poetic Design, Bionic Design, Product Design.

1. INTRODUCTION

Lope de Vega, in one of his sonnets, uniquely referred to two famous contemporaries: he called the Italian poet Marino “a great painter for the ears,” and the Flemish painter Rubens “a great poet for the eyes.” Six hundred years later and 6,000 miles away, a similar concept was expressed in a parallel situation. In one of his poems, the Chinese poet Su Shih (1036-1101) praised a poet and a painter: “Tu Fu's poems are figureless paintings, Han Kan's paintings are wordless poems.” In both poems, a special relationship is established between poetry and painting in that they are considered parallel, comparable, interchangeable (Frankel, 1957).

However, this type of relationship is not exclusive to poetry and painting; Chu (2003) stated that “poetry and other arts all are the outpouring of emotion.” In addition, Heidegger (1993) believed that “all art is essentially poetry.” Similarly, current industrial design is free of the shackles of functionalism and instead focuses on consumer emotional satisfaction. Thus, the concept of emotional design has become the main focus in relation to perceptual consumption, and “poetic design” has become an emergent topic.

2. RESEARCH PURPOSE

The artist of the sun-crow teapot has extensive experience researching and creating Chinese art, and drew on these experiences and knowledge to craft the teapot. However, the purpose of the design was to achieve Donald A. Norman's reflective level of emotional design. The teapot was designed to express traditional Oriental charm while conforming to modern style aesthetics.

3. LITERATURE REVIEW

3.1. The features of poetry

The Collins English Dictionary (2003) defines a poem as “a composition in verse, usually characterized by concentrated and heightened language in which words are chosen for their sound and suggestive power as well as for their sense, and using such techniques as meter, rhyme, and alliteration.”

The Oxford Advanced Learner's Dictionary defines the term “poetic” as “like or suggesting poetry, especially because it shows imagination and deep feeling.” Webster's Dictionary states that the term means “having or expressing the qualities of poetry (as though aesthetic or emotional impact).”

Based on these concepts, we can consider aesthetics and emotional presentation as features of poetry. Although perceiving poetry is a complex process, we believe that aesthetic feeling is primarily derived from rhyme and emotion is induced by the imagination through the suggestive power of poetry and the senses.

Beatty and Ball (2010) suggested that the process of poetry composition is derived from the inherently ill-defined nature of the task. Ill-defined problems are those in which the goals are vague, the optimal solution is unknown, and the limitations of the problem space are not fully specified (Ormerod, 2005). These problems produce numerous uncertainties and, therefore, create a listener when trying to understand, thereby generating a mind that “seems to be, but it cannot be completely sure.” This ambiguity sparks the imagination. In traditional Chinese paintings,

impressionism and empty spaces constitute the method used to promote the poetic imagination.

In addition to the uncertainties of ambiguous poetry, the theme or story of a poem provides crucial sources of inspiration for the reader's imagination. Poetry can be divided according to the nature of the content as narrative or lyric poetry. Narrative poetry tells a story and lyric poetry typically expresses personal (often emotional) feelings. In ancient China, because of the theory that humans are an integral part of nature, poetry was often created by referring to nature. Therefore, the development of lyric poetry occurred much earlier and more extensively than Western poetry did, and to a greater extent involved the use of symbolism based on scenery or objects to convey ideas and moods.

3.2. Emotional design

The purpose of poetic design is emotional expression, which can be regarded as a component of emotional design. Kolko (2007) considered that the interaction between emotions and poetry occurs in the conceptual space between a person and an object: “It is at once physical, cognitive and social. A poetic interaction is one that resonates immediately but yet continues to inform later—it is one that causes reflection, and one that relies heavily on a state of emotional awareness. A poetic interaction is one that is nearly always subtle, yet mindful.”

Reflection is a feature of a poetic interaction. Donald A. Norman defined it as the third level of emotional design. His three levels of design include visceral, behavioral, and reflective design (Norman, 2005). Visceral design focuses on appearances, behavioral design emphasizes the pleasure and effectiveness of using a product, and reflective design involves considering the rationalization and intellectualization of a product.

Klegin and Caldwell (2012) summarized 11 methods for enhancing emotional performance by empathizing with people and helping them perceive and express their feelings, including leaving space, considering relationships, designing personality, telling stories, maintaining traditions, and imitating nature.

3.3. Traditional Chinese artistic techniques

After reviewing the historical development of Eastern and Western art, we determined that traditional Chinese art emphasizes subjective expression. Moreover, classical Chinese aesthetics favor poetics, whereas classical Western aesthetics focus on rationalism. Poetics is image based, and personal perceptions are used to analyze and understand external objects. These perceptions are expressed implicitly through symbols or metaphors. Giambattista Vico (1668–1744) called this philosophical concept “poetic wisdom.”

Classical Chinese poetic aesthetic theory has developed over nearly 2,000 years and, thus, comprises a myriad of valuable ideas, such as the concept that humans are an integral part of nature (天人合一), the theory of the emptiness-solidity relationship (虛實相生), the concept of meaning that is retained when images are forgotten (得意忘象), and wonder derived from opposing similarities and dissimilarities (妙在似與非似之間).

We can associate these concepts with several design techniques or concepts:

a. Bionic design: the concept that humans are an integral part of nature.

b. Impressionistic performance: wonder derived from opposing similarities and dissimilarities.

c. Leaving space, contrast and harmony: the theory of the emptiness-solidity relationship.

d. Ornamentation: the concept of meaning that is retained when images are forgotten.

4. DESIGN STRATEGIES

Beatty and Ball (2010) interviewed five expert poets and discovered that they all seemed to be heavily inspired by what was “familiar” to them and, therefore, what was “ordinary,” “mundane,” or “everyday.”

One of the authors of this paper conducted a comprehensive study on the Gui tripod and subsequently published a book entitled *The Secret of the Bronze Jue Tripod and Jia Tripod: From the Prehistoric Gui Tripod to the Origin and Dating Problem of the Xia and Shang Cultures* (Lu, 2007). This book revealed that the Gui tripod symbolizes the sun crow, which is related to ancient sun worship. The historical and cultural importance and outstanding performance in the plastic arts of the Gui tripod indicate that it is one of the most representative objects of prehistoric China.

The author considered the Gui tripod (Fig. 1) to be a familiar vessel and similar to a teapot in function. Therefore, the Gui tripod was used as a reference for shape in the development of a sun-crow teapot (Fig. 2) with excellent functionality that can exhibit the qualities of poetry. Additionally, design strategies inspired by traditional Chinese aesthetics and emotional design methods were used.

Furthermore, to modernize the teapot, the design strategy was derived from the theories of Cezanne, the father of modern art. Thus, the teapot was crafted using both spherical and cylindrical shapes to create a contemporary and fashionable abstract minimalist style.



Figure 1: The pottery Gui-tripod

4.1. Visceral level

4.1.1. Focusing on proportions and contours to create an aesthetic form

Classical Greek aesthetics emphasized harmonious proportions, and involved the creation of the “golden ratio” relationship. Traditional Chinese art also attaches importance to proportion, but emphasizes intuition and learning experience. In addition, in contrast to Western geometric modeling, Chinese art involves organic modeling and linear expression. Regarding the “poetic” performance, the form of traditional Chinese art is characterized by uncertainty and facilitates the expression of imagination.

In Chinese calligraphy, a single line is created by determining the proportion and the manner in which an abstract structural relationship can be constructed at the moment the brush touches the paper. In addition, the brush strokes are not required to be smooth or exhibit harmonious

proportions; including crucial variations may produce works that incorporate emotional elements. The author has been committed to learning and creative calligraphy, which were useful in determining the optimal proportions and emotional lines used to create the sun-crow teapot.

4.1.2. Emphasizing personality style to enich emotional experience

A survey conducted by the American Research Center on popular colors indicated that the "seven seconds law" is used in the selection of goods: when presented with an assortment of goods, people require 7 seconds to determine whether they are interested in the commodities. Therefore, the purpose of modern design that emphasizes creative performance is to appeal to consumers based on the first impression. In addition to the advantages of the consumption process, unique products can reflect the distinct taste of users, and be personalized to meet their emotional needs. The sun-crow teapot, consisting of three legs and a beak-shaped spout, is completely unique compared with other works and has become the focus of attention.

4.1.3. Defining the current environment to conform to fashion trends

Aesthetic fashion has changed throughout history, and constructing a fashionable Gui tripod was a major goal in this design case. As mentioned previously, Cezanne's theory, “treating nature by means of the cylinder, the sphere, the cone,” was the basis of the author's design concept. The author successfully integrated the past and present, and used digital technology to complete the teapot.



Figure 2: The Sun-crow teapot set

4.2. Behavioral level

4.2.1. Considering vessel function to provide enjoyment of use

Socrates stressed that, in the relationship between beauty, good, and use, considering function and conformity as the primary objectives is the basic premise of beauty. Muneyoshi Yanagi (1941), a leader of the Japanese folk art movement, indicated that "One big mistake people make in modern times is being confined to visual beauty only, and do not care about use.” Practical function provides pleasure in the process of use, thereby reflecting the aesthetic qualities of the product.

The various functions of the sun-crow teapot have been recognized by tea experts.

4.3. Reflective level

4.3.1. Implementing a bionic design to reflect nature

Bionic design has become a crucial creative tool in the age of “perceptual consumption.” Klegin and Caldwell (2012) said, “Borrow cues from the natural world. If people get even the slightest hint that something is alive, they are instinctively drawn to it.”

The Gui tripod, which was the design basis of the sun-crow teapot, was originally considered a bionic masterpiece in ancient China; it was constructed freehand, and it is both simple and dynamic. Consequently, subsequent works are considered subpar compared with the Gui tripod. Therefore, the sun-crow teapot features a basic bionic design that is inherited from the excellent form of the Gui tripod.

4.3.2. Emphasizing impressionistic performance and leaving space to inspire imagination

Inspiring viewer imagination is another purpose of creating a poem. n ancient poem stated that “there's an end to the words, but not to their message.” Chinese paintings emphasize poetry; painters who use "impressionistic performance" and who "leave space" successfully convey the mood of poetry.

The design of the sun-crow teapot emphasized the effect of “impressionistic performance” and “leaving space.” Therefore, a beak-like spout, a three-legged structure, and tilted momentum effectively symbolize a bird's physical characteristics and vitality.

4.3.3. Changing the shape and characteristics to emphasize the essential connotation

Traditional Chinese painting focuses on invoking form to convey spirituality. Modern Japanese animation employs exaggeration, metaphor, and symbolism to emphasize the characteristics of an object and, thus, obtain a concise form. This method is similar to that employed when writing short poems: the essence of the visual image is extracted, providing additional charm and appeal.

4.3.4. Linking the object to a situational story

Both the sun and the moon were once thought to be pulled by a flying bird. Therefore, the author designed a tea set with two teapots. One symbolized the sun and the other symbolized the moon. Contrast was achieved by using strong and gentle shapes. Yin and yang and hardness and softness reflect the basis of traditional oriental philosophy, Tai Chi, as well as convey Oriental aesthetics, wonder derived from similarities and dissimilarities.

The tea set includes matching cups in the shape of bird eggs. The three-legged element was incorporated into the cups to symbolize chicks. Pouring the tea from the teapot into the cup represents a parent feeding a child. This conveys the image of a happy family and symbolizes generations and an endless cultural heritage.

4.3.5. Incorporating traditional symbols to enhance the cultural characteristics

In semiology, a traditional pattern is a decorative form of beauty that incorporates symbolism. The German philosopher E. Cassirer (1874–1945) asserted that humans should be defined as an animal symbolicum (a symbol-making or symbolic animal), and sought to understand human nature by exploring symbolic forms in all aspects of a human being’s experience.

The sun-crow teapot, with the lid knob symbolizing the crest and the pinch handles representing wings, was completely decorated with Yun Wen (cloud pattern). Yun Wen is a Chinese traditional decorative pattern and can be traced back to the vortex pattern (渦旋紋), a type of prehistoric

painted pottery decoration, the Yunlei Wen (雲雷紋) pattern exhibited between the Shang and Zhou dynasties (1562–221 B.C.), and the cloud scroll patterns (卷雲紋) that were prominent during the Warring States period (475–221 B.C.).

The cultural connotation of the cloud pattern is "Yuan Qi" (元氣, the origin of the heavens and the earth and all things), which combines spirituality and auspicious meaning.

4.3.6. Reviewing traditional philosophy to climb overlooking the future

Analyzing the development of history reveals that the symbolism and modeling techniques used to create the Gui tripod reflects the development of Chinese philosophy and artistic expression. The purpose of constructing the sun-crow teapot, inspired by the Gui tripod and the theories of Cezanne, was to incorporate elements of traditional philosophy and adapt to contemporary trends.

5. EVALUATION OF THE WORK

Two questionnaire surveys on the sun-crow teapot were administered. In addition to related attributes, both questionnaires comprised an overall performance evaluation based on three indicators: “attractiveness to people,” “sophisticated design,” and “craft masterpiece.” Regarding personal preference, add an option of the favorite product. The results are shown in Tables 1 and 2, and indicate that the teapot was evaluated favorably (Lu, 2013; Lu & Lin, 2014).

Kolko (2007) said, “A poetic interaction is one that is nearly always subtle, yet mindful.” This feature of poetic interaction was included in one of the questionnaires for the evaluation of poetic attribute. The teapot received a high score for this item, ranking second among all bird-shaped teapots.

The teapot was entered into competitions and received two major awards: Taiwan's Golden Pin Design Award and the “Most Creative Award” in the Chinese Craft Excellence Award.

Table 1: User's preference and overall evaluation scores and ranking for questionnaire 1

No	Image	preference		attractiveness		sophisticated design		craft masterpiece	
		Percentage	Ranking	Mean	Ranking	Mean	Ranking	Mean	Ranking
1		19.5	2	3.13	4	3.71	3	3.71	1
2		9.8	6	2.88	8	3.56	5	3.20	5
3		13.5	4	3.02	5	3.29	6	3.13	6
4		**17.3**	**3**	**3.56**	**2**	**3.78**	**2**	**3.66**	**2**
5		22.6	1	3.44	3	3.63	4	3.54	3
6		2.3	8	2.98	6	2.90	9	2.90	7
7		11.3	5	3.64	1	3.88	1	3.41	4

8		3.8	7	2.92	7	3.21	7	2.90	7
9		0	9	2.67	9	3.01	8	3.76	9

Table 2: User's preference and overall evaluation scores and ranking for questionnaire 2

No	Image	preference		attractiveness		sophisticated design		craft masterpiece	
		Percentage	Ranking	Mean	Ranking	Mean	Ranking	Mean	Ranking
1		6.3	3	3.37	6	3.73	3	3.45	7
2		2.1	9	3.26	8	3.57	7	3.43	8
3		0.7	11	3.07	11	3.36	10	3.07	11
4		**16.7**	**2**	**3.73**	**2**	**4.06**	**2**	**3.92**	**2**
5		2.8	8	3.33	7	3.64	5	3.48	5
6		52.1	1	4.46	1	4.35	1	4.25	1
7		0.7	11	2.91	12	3.04	12	3.05	12
8		2.1	9	3.08	10	3.26	11	3.19	10
9		3.5	7	3.48	3	3.64	5	3.47	6
10		4.2	5	3.47	4	3.65	4	3.61	3
11		4.2	5	3.22	9	3.47	9	3.4	9
12		4.9	4	3.45	5	3.55	8	3.55	4

6. CONCLUSION

Chinese traditional thinking involves “poetic wisdom,” which was termed by Giambattista Vico (1668–1744). He emphasized humanistic social thought and was opposed to the natural sciences. The concept of emotional design appeared in the twentieth century, and was derived from humanism. Abraham Harold Maslow (1908–1970), a humanistic psychologist, proposed the hierarchy of needs, which has become the theoretical basis of emotional design.

The concept of emotional design has become the main focus in the current trend of perceptual consumption. Consequent theories, concepts, and related methods have emerged and have been used to promote the development of creative design. These ideas can be explored by analyzing

traditional Chinese philosophy or art theory.

Although Western knowledge is widely accepted, Chinese descendants inevitably inherit the culture of poetic thinking. Therefore, Chinese artists have numerous advantages in achieving the goal of emotional design. Although numerous methods can be used to engage in creative design, traditional Chinese art must be learned and understood because it can offer artists countless ideas.

The strategy used to construct the sun-crow teapot can be associated with the following traditional Chinese ideas:

1. The concept that humans are an integral part of nature (天人合一) was expressed through the bionic design to convey a sense of nature.
2. The theory of the emptiness-solidity relationship (虛實相生) was presented by using the shape and characteristics to emphasize the essential concepts. In addition, impressionistic performance was used and space was left to inspire imagination.
3. The concept of meaning that is retained when images are forgotten (得意忘象) was achieved by emphasizing impressionistic performance and leaving space to inspire imagination. The incorporation of traditional symbols enhanced the cultural aspects.
4. The concept of embodying a spirit in a physical form (以形寫神) was conveyed by using the shape and characteristics to emphasize the essential concepts. In addition, impressionistic performance was used and space was left to inspire imagination.
5. The concept of wonder derived from opposing similarities and dissimilarities (妙在似與非似之間) was conveyed by using impressionistic performance and leaving space to inspire imagination.

The Taiwanese government has recently been dedicated to promoting cultural and creative industries, primarily focusing on industrial applications that involve converting traditional cultural relics into creative designs; however, Chinese cultural relics are diverse and exhibit distinct characteristics. This sun-crow teapot case is a type of art that transforms relics into creative designs. The case evaluation results indicate that the poetic design based on traditional Chinese artistic techniques was successfully implemented.

ACKNOWLEDGMENTS

This study was partly sponsored by the National Science Council of Taiwan through grant NSC99-2622-H-144-002 -CC3.

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2C - Transportation

Exploring the cognitive structure of aircraft passengers' emotions in relation to their comfort experience

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Abstract: Emotion descriptions were elicited from participants' written accounts of their comfort experience and grouped according to the emotion model by Ortony, Clore, and Collins (OCC). The cognitive structure and specific appraisal patterns of passengers were explored on three levels of passenger's concerns (goals, standards, and aspects), their focus during the flight (including the mediating cabin elements) and the resulting emotions. Four emotion groups were highlighted as relevant to flight comfort. Wellbeing (e.g., joy, distress) emotions were the most frequently mentioned group by participants when focused on the consequences of interaction with cabin features such as seat, IFE and service, pertaining to participants' personal goals (e.g., security, calmness). The cognitive underpinning of prospect-based (e.g., satisfied) emotions included similar goals except that participants evaluated the consequences of their interaction with the seat, legroom, IFE and service relevant to their expectations and anticipations. The emotions in wellbeing/attribution compound group were elicited upon evaluating the consequences of the actions of agents (e.g., service, neighbors). Thus emotions anger and gratitude emerged when those actions yielded pleasing or unpleasing consequences for participants. Attraction (e.g., liking) emotions were generated once passengers developed liking or disliking for certain aspects (e.g., aesthetics, physical fitting) of the seat and legroom. Subsequently, a model of cognitive structure of passengers' emotions was constructed for the flight context highlighting the seat and services as the central (most frequently regarded) features to passengers' emotional experiences. The proposed model enables designers to recognize the types of experiences that should be delivered to ensure that passengers feel comfortable.

Keywords: Comfort, Emotion, Experience, Aircraft, Passenger.

1. INSTRUCTION

Passengers' reaction to the aircraft interior environment has always been a concern for the aerospace industry. While research concerning prevention of passengers' bodily discomfort has attracted a lot of attention, the subject of emotional reactions to the aircraft environment has not inspired much research. In recent years, studies on user experience have shown that positive

emotions generated in response to product use provide pleasurable and positive experiences (Desmet et al, 2005; Desmet, 2012). Similarly it could be argued that designing for passengers' comfort and wellbeing should follow the same trend and go beyond the mere prevention of physical issues (Ahmadpour et al., 2014). This paper presents a study on the emotional reactions of passengers to the cabin environment and their relation to comfort. The aim is to uncover the nature and type of emotions as well as their attribution to environmental (cabin) elements.

There is evidence in the literature to suggest a link between comfort and emotions. For instance De Looze et al. (2003) demonstrated that emotional reactions to products such as being relaxed, improves the comfort experience. Scherer (2005) regarded comfort and discomfort as affective states, changes in which influence one's emotions, while Ortony, Clore and Collins (1988) categorized the feeling of discomfort as an emotion related to one's wellbeing. These arguments highlight the relationship between perception, emotions and comfort, although any causal relationship among them has never been established. Nevertheless, all these authors emphasize the highly subjective and personal nature of comfort. It must be noted that the concept of comfort in this document refers to all levels of comfort which also entails discomfort. Differentiating comfort and discomfort, although acknowledged as an important argument (De Looze et al., 2003; Helander, 2003; Kuijt Evers et al., 2004), is not in the focus of this paper.

Among several models of emotion, Ortony, Clore and Collins' (1988) model aimed to elucidate emotional responses through structured logic. Their model, based on a bottom-up approach, considers the nature of emotion to be determined by the eliciting conditions when people experience a positive or negative affective reaction upon appraising an object, event or agent respectively beneficial or harmful to their concerns. According to Ortony et al., events are perceived to 'happen', objects as "qua object" , and agents are characterized in terms of their "instrumentality in causing or contributing to events" (Ortony, Clore and Collins, 1988, pp.18).

Ortony and his colleagues distinguish 22 emotion types (e.g. joy, distress, pride) based on their cognition patterns, categorized into six groups. These are wellbeing (e.g. joy, distress), attribution (e.g. pride, reproach), wellbeing/attribution compound (e.g. gratitude, anger), prospect-based (e.g. satisfaction, fear), attraction (e.g. like, hate) and fortune-of-others (e.g. resentment, gloating). Each emotion group descends from a unique cognitive pattern depending on the person's focus at the time and appraisal of the situation relative to their concerns. Focusing on consequences of events and evaluating their desirability relative to one's goals, results in an affective reaction of being pleased or displeased. Upon evaluating these consequences for others, fortune-of-others emotions are elicited while wellbeing and prospect-based emotions are generated when consequences for self are examined. A focus on actions of agents and evaluating their praiseworthiness relative to one's standards brings about an affective reaction of approving or disapproving and elicits attribution emotions. The co-occurrence of those two conditions, i.e., evaluating consequences of events particularly caused by agents, yields wellbeing/attribution compound emotions (this is to say that not all events in the world are necessarily caused by an agent). Finally focus on aspects of objects and evaluating the appeal of their aspects (e.g. aesthetics aspects) gives rise to an affective reaction of liking or disliking, leading to attraction emotions. This logic incorporated into the model referred to as the OCC model throughout this document. This paper employed the model in a case study of emotions in relation to passenger comfort experience and to explore the underlying cognitive patterns of passengers' reactions.

2. METHOD

A questionnaire was distributed by email to 158 participants once they were back from their summer vacation. They were asked to describe a comfortable experience inside the aircraft cabin. They were asked to describe the trip in a casual manner and include as much detail as possible. Responses from three participants were discarded prior to the data analysis because of incomplete data, yielding a sample of n = 155 (98 males, 20-61 years of age, M = 38, median 35 years). All participants had at least 5 flight experiences prior to the survey.

3. RESULT AND DISCUSSION

Content analysis was performed on the reports, identifying all emotion words that respondents used in their descriptions of comfort experience. Adopting a definition from Ortony, Clore, and Foss (1987), emotion was defined as *internal, mental states that are elicited in reaction to an ongoing situation and focused primarily on affect where affect is the perceived goodness or badness*. The data were compiled and emotion types were grouped according to the OCC model. This part of the analysis examined whether or not emotions played a role in passengers' comfort experiences as well as identifying the types of the resulting emotion groups. Furthermore, respondents' descriptions were used to isolate cabin elements that were central to each emotion group in order to identify the relationship between emotions and external eliciting factors (stimuli),

During the analysis, the emotion type "feeling uncomfortable", characterized as a wellbeing emotion in the OCC model, was not considered because it was impossible to distinguish its affective nature and because the questionnaire was inquiring about comfort. As Clore, Schwarz, and Conway (1994) mentioned in their review of emotion theories, eliciting emotion words empirically is challenging due to the lack of control on whether respondents are reporting "feeling something" or "being something". For instance, while feeling uncomfortable is an affective state, being uncomfortable is an experience that may not necessarily be affective in nature. One may experience an awkward posture but this does not necessarily lead to feeling an emotion.

A total of 92 comfort-related emotion words were identified as per the definitions given earlier. Interestingly, some respondents included descriptions of uncomfortable situations to highlight certain experiential aspects. Consequently 27 (29.35%) of the emotion words were negative. For instance one passenger described how she hates it when she does not have access to enough storage space at her seat. Since these words did exemplify an emotional component of the comfort experience, they were included in the analysis. In total, n=57 (36%) participants used at least one form of emotion-related description in their report; the term 'feeling' was used very frequently in the experiential comfort descriptions.

Finally, cabin elements that generated these emotions were categorized (one per each emotion type) including seat, legroom (the pitch between the seats of two consecutive rows), In-Flight Entertainment (IFE), service, neighbors, turbulence, etc. Once the emotions had been grouped and their associations with cabin elements established, the results were summarized as shown in Table 1.

Table 1. Summary of the results from the online questionnaire (n=155 participants)

	Wellbeing	**Prospect -based**	**Attribution**	**Wellbeing/ attribution**	**Attraction**	*Total*
N respondents	31	14	2	16	21	
%participants (n=155)	20	9	1	10	14	
N comments	35	18	2	16	21	92
%comments	38%	20%	2%	17%	23%	
Seat	14	4		1	8	27
Service	3	1	1	5		10
IFE	6	1				7
Legroom	2	2			3	7
Neighbor	2		1	4		7

The number and percentage of respondents in each emotion group are displayed in the first two rows of Table 1, followed by the number and percentage of comments obtained for each group. The wellbeing group (e.g., joy, contentment, feeling good) received the most comments (35

comments) while the attribution group (e.g., pride, not being embarrassed) was used least often (2 comments). The Table shows only cabin elements that received at least 7 (8%) of all comments across the five emotion groups. This resulted in five elements among which the number of seat-related comments comprised the most frequently observed group with almost one third of all comments (27 comments, 29.35%) belonging to that group. It was followed by service-related comments (10 comments, 9.20%). Each group is discussed in more detail in the next section.

3.1. Emotion groups

Wellbeing - this group of emotions was the most frequently mentioned overall. Comments relating to wellbeing expressed the desirability (appraisal) of the consequences of an event that exceeds passengers' expectations, e.g., experiencing joy due to being served quality wine, as one passenger mentioned. The associated goals were feeling peaceful, relaxed, and mentally positive. The seat played a central role in mediating these emotions compared to other cabin elements. Other comments included the ability to sleep and relax, the entertaining aspects of the IFE unit and its potential to make the passenger pass the flight time pleasurably. The specific types of emotions stated frequently were joyful, pleasantly surprised and feeling good.

Prospect-based – here the passenger is concerned with the desirability of consequences of events for him/herself based on pre-determined hopes or fears, relevant to their concerns. The most frequently mentioned goals were feeling safe, secure and stress-free, and accomplished. Examples are satisfaction with high quality seat headrest. Other comments mentioned feeling relief due to fitting comfortably to the seat or legroom, not experiencing any pain or pressure on the body and not fidgeting. Satisfaction, disappointment and relief were the most common emotion types in this group.

Attribution - when the actions of human or product agents (in the flight context) were approved or disapproved based on passengers' tacit standards (e.g., things perform smoothly and uniformly), these emotions were mentioned. A respondent mentioned that having to call the flight attendant, who does not circle around the cabin often, is embarrassing (an emotion). Another emotion mentioned in this group was admiration for how the in-flight services were performed. This group was the least mentioned overall.

Wellbeing/attribution Compound – this complex group of emotions comprised standards (concerns) such as being responsive and attentive, as the basis for the appraisal process. For instance, one passenger mentioned that he appreciated that the flight attendant checked on him to see if he was alright after that he had complained about being cold and requesting a blanket. The experienced emotion in that example is appreciation, resulting from the attentive action of an agent (the flight attendant) that matched the respondent's standards of what constitutes good service and the passenger approving the consequences for himself (comfort and health). In this group, gratitude was mentioned in relation to services (e.g., making special consideration for travelling parents with infants) and anger towards neighbors (e.g. noisy and disturbing neighbors causing irritation and consequently discomfort).

Attraction – this group of emotions was based on liking or disliking the characteristics of objects, for example, finding the cabin design tasteful. After wellbeing emotions, this group received a considerable number of comments mainly focusing on the seat and the legroom. Apart from finding the visual aspects of the seat or the cabin to one's taste (e.g. liking the bright cabin), respondents mentioned the appeal of some physical design characteristics (e.g., well-stuffed seat). Finally respondents expressed a strong dislike for a lack of personal space either because of close proximity to neighbors (e.g., narrow seat width or shared space below armrest) or other design aspects (e.g., the legroom space reduced due to the side wall curvature).

3.2. Appraisal patterns

The major benefit of the OCC model is the framework it provides for understanding the underlying reasons for the expressed emotions in a systematic manner. This is accomplished via the identification of certain patterns characteristic for each emotion group. The discussion in this section focuses on the underlying patterns of emotion groups in the flight context in the same manner as the OCC model and revising it accordingly.

The results suggested that, in this dataset, the emotion group “fortune-of-others” (e.g., gloating, resentment, pity) was not relevant to the passengers’ comfort experience. This is not surprising given that comfort is a personal experience (De Looze et al., 2003) and the main concerns of aircraft passengers are how THEY feel and what THEIR physical and psychological state are (Dumur et al., 2004) rather than those of others. Furthermore, the emotion group “attribution” was apparently not strongly linked to comfort, judging by the fact that it received only two comments. This leaves four emotion groups that could be attributed to the passengers’ perceived comfort among which wellbeing emotions were found the most salient and occurring most frequently. These groups and their eliciting conditions are illustrated in the model shown in Figure 1. It depicts three levels of the appraisal process: passengers’ concerns (goals, standards, and aspects), their focus, and emotions that are elicited as the result of particular patterns of those two. In order to describe passengers’ focus in the context of flight, a number of cabin elements (based on Table 1) are introduced as mediating elements.

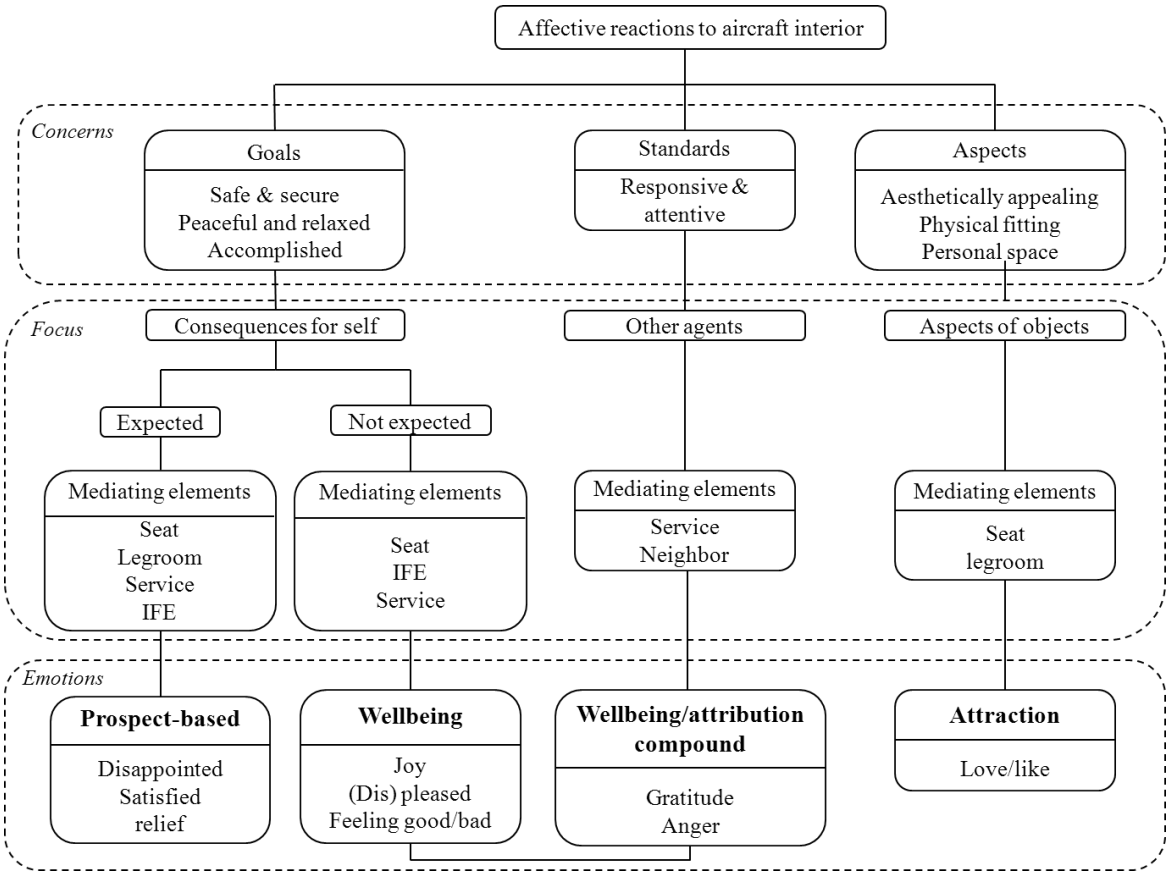

Figure 1. The cognitive structure of passengers’ emotions in relation to comfort, illustrating the appraisal patterns of passengers’ affective reactions to the aircraft interior during the flight (adopting and revising the cognitive structure of emotions by Ortony, Clore, and Collins, 1988).

Based on above model, Prospect-based emotions are evoked when passengers board aircrafts with certain expectations; when they encounter what they had hoped for, they experience satisfaction while disappointment results when hopes are not confirmed. They also have fears rooted in previous experiences or pre-flight experiences (e.g., airport, check-in procedures, luggage screening), which, if not confirmed, generate relief. These prospect-based emotions could be addressed in design on the basis of passengers’ expectations, considering different scenarios, and developing alternative solutions to prevent experience of these fears. For instance, a lot of passengers in this survey expressed their goal as wanting to feel secure and having access to their personal effects during the flight. Finding out the typical objects passengers bring along (e.g., bottle, glasses, headphones, etc.) onboard and designing appropriate built-in compartments in the seat to store those could potentially generate an emotion of satisfaction.

Wellbeing emotions, although related to goals, are not related directly to passengers' anticipations prior to a flight but rather to the influence exerted by unexpected events. When passengers are taken by surprise, for instance, two outcomes may be expected. First, an experience of joy due to being pleasantly surprised, and second, feeling distressed due to being negatively surprised. Given the importance of wellbeing emotions for the comfort experience, it is advantageous to study what constitutes a pleasant surprise for passengers. To that end, the survey showed that feeling calm, relaxed, and secure are common goals among passengers. Designing adjustable seat headrests such that it maximizes support for the neck and keeping it steady while sleeping in various postures is likely to generate a joyful and relaxed experience. Another means to deliver joy and pleasure is to provide passengers with access to an IFE unit similar to what they have in their home, for instance access to live TV or a remote control. A lot of passengers used the phrase "something that stands out" as a determinant of joy. This is usually a small serendipitous event such as receiving chocolate as a souvenir on a Swiss airline, being served wine on a domestic short flight or listening to music local to the destination country. As for security concerns, passengers' need for a small safe to store and lock in important belongings such as passports or money could create a pleasant surprise. One passenger mentioned the joy of removing the armrest to cuddle with his wife like they do on a couch at home. These parts of the experience provide that extra touch that is not necessarily expected, but stands out and makes passengers feel they are part of the experience and not merely cargo to dispatch, as one passenger put it.

Wellbeing/attribution compound emotions represent an interesting case in relation to comfort. The results of this study suggested that attribution emotions in isolation appear trivial to a sense of comfort, yet 15 (17%) emotion comments pointed to the co-occurrence of the eliciting condition for this group and wellbeing emotions allocated it. Attribution emotions are elicited when people react to the actions of agents (self or others) and evaluate them against their standards. An example of an in-flight agent is the service, with the action represented by the response of the crew to passengers' demands. If passengers approve of the crew's responsiveness (standard), an admiration emotion is elicited. The lack of implications of these emotions for the comfort experience, however, suggests that passengers' comfort does not depend on objects or human agents to "do things right". On the one hand, this is due to the somewhat passive position of passengers as self-agents in the aircraft, and on the other hand, their awareness of the limiting circumstances (for other human or object agents) during the flight. Meanwhile, when the actions of an agent yields pleasing or unpleasing consequences for passengers that meet or disturb their personal goals, the compound emotions, anger and gratitude in particular, emerge.

According to Frijda (1988), anger is the outcome of appraising frustration for which someone else, i.e., another agent, is to blame. Although the passenger is not actively concerned with what the agent does (e.g. the service), if the consequences of their actions frustrate or benefit the passenger, anger or gratitude is generated in return. In short, in the context of a flight, passengers are not primarily concerned with how things get done but what they mean or bring to them. In this study, the results implicate that serendipitous elements which generate joy, could also elicit gratitude if they deliver something significant for passengers. As mentioned earlier, the goal of most passengers is to relax. When preparing to sleep, if the cabin light is designed to automatically dim and project a calming environment of night time, this serendipitous action delivers a level of appreciation and gratitude that belongs to the wellbeing/attribution compound group.

Finally attraction emotions are elicited when passengers appraise aspects of appealing objects. These aspects constitute aesthetics aspects as well as design aspects such as the physical fit of the seat to passengers' body or their personal space, one respondent described as a "bubble of intimacy". The physical aspects might appear odd and perhaps similar to what one might consider standard (as defined earlier) rather than aspects. However, it must be noted that all respondents had several prior flight experiences. As a result of their familiarity with the seating area, they had developed a taste for it and assigned certain characteristics to the seat and the legroom; some appealing and some not so much. Upon appraising an appealing characteristic of the seat, the passenger develops a liking for it and a positive emotion (various degrees of "love") is generated. The OCC model also describes this situation by stating that objects do not refer exclusively to physical products but also to situations in which one is evaluating aspects and attitudes of

something including people. Indeed this situation arose in this survey as well where one respondent commented on liking the friendly attitude of flight crew.

The study presented in this paper and leading to the above model has some limitations. The method of studying emotions based on written self-reports often leaves some room for interpretation by the researcher regarding both the nature and intensity of the reported emotions. In-depth interviews could potentially overcome this limitation and provide an opportunity to inquire respondent's elaboration on the experience. Having established the significance of emotions for comfort, future research should attempt to validate the model and the inter-relationship between its components.

4. CONCLUSION

This paper showed that different types of emotions are related to passengers' comfort experiences. As mentioned in the introduction, opinions vary as to whether comfort per se is an emotion. Yet, the types of emotions emerging in this study shed light on how emotions may inform a sense of comfort. The appraisal patterns of the OCC model provide a good structure for those experiences and the model was successfully adapted for the aircraft interior context. The new model highlights passengers' concerns, focuses and the types of reaction that typically result from their interactions with the cabin.

The proposed model of the cognitive structure of passengers' emotions enables us to recognize the types of experiences that should be delivered to ensure that passengers FEEL comfortable. How is this achieved? The model identified four emotion groups that are closely related to comfort. First and foremost, these involve wellbeing emotions followed by prospect-based, wellbeing/attribution compound and attraction emotions. The particular appraisal patterns (concerns, focus and moderating cabin elements) for each of these four groups are highlighted in the model.

The cognitive structure of passenger emotions in relation to comfort experience presents an opportunity for improving the design of aircraft cabin elements to elicit positive emotions. The fact that some elements such as the seat and the IFE appeared in the model several times; in association with different emotions groups, it shows that there are various ways to manipulate the cabin design and induce positive emotions and comfort. It is up to manufacturers and airlines to work out how an appealing and pleasing balance of those can be reached to enhance passenger comfort.

ACKNOWLEDGMENTS

This study is part of a research project on passenger's comfort experience and wellbeing funded by an IIS (Industrial Innovation Scholarship) by *Fonds Québécois de la Reserche sur la Nature et les Technologies* (FQRNT), *Natural Sciences and Engineering Research Council of Canada* (NSERC), and Bombardier Aerospace. The authors would like to thank Bernard Pownall of Bombardier Aerospace for his support throughout the project.

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The Future Passenger Experience: A Shift from Physical to Virtual Design

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Abstract

The importance of passenger experience in aviation has become well understood in the last several years. It is now generally accepted that the provision of good passenger experience is not an option, but a necessity, from an aviation profitability perspective.

In this paper, we paint a picture of the future passenger experience by consolidating a number of industry and research perspectives. Using the future passenger experience as a starting point, we explore the components needed to enable this future vision. From this bottom-up approach, we identify the need to resolve data formatting and data ownership issues. The resolution of these data integration issues is necessary to enable the seamless future travel experience that is envisioned by the aviation industry.

By looking at the passenger experience from this bottom-up, data centric perspective, we identify a potential shift in the way that future passenger terminals will be designed. Whereas currently the design of terminals is largely an architectural practice, in the near future, the design of the terminal building may become more of a virtual technology practice. This of course will pose a new set of challenges to designers of airport terminal environments.

Keywords

Passenger Experience, Future, Vision, Travel, Design, Data, Airport

The “Airport Terminal of the Future” has been an important topic of discussion at aviation industry conferences in the last few years. In fact, the exploration of the future terminal and associated passenger experience are considered so paramount, that entire conferences have emerged dedicated to this topic alone. As an example, Future Travel Experience now hosts three conferences each year, namely FTE Global, FTE Asia and FTE Europe (Future Travel Experience, 2013a, 2013b, 2013c).

In the last year, there has been a convergence of ideas regarding what the future passenger experience will be like. The commonality across various stakeholder viewpoints can be attributed to several key trends, including: (a) the maturation and accessibility of technologies, (b) a shared need to reduce the cost and time associated with processing passengers through terminal buildings, and (c) a growth in the number of passengers travelling by air each year (IATA Corporate Communications, 2011).

In the first instance, technologies such as mobile devices, social media and the proliferation of wireless networks make the vision of a technology-centric airport technically feasible. Equally importantly however, the use of these technologies by the general public has reached a tipping point – a recent study by Lookout (2012) found that 58% of respondents check their mobile phone at least once an hour. It is now believed that the use of these devices has shifted from being conscious, to being habitual in nature (Carr, 2010). To an airport, this signals a customer base that is ready to embrace a more technology centric airport terminal experience (Grossman, 2006; IATA Corporate Communications, 2011; SITA, 2013).

The inevitable move to making the future passenger experience more technology focussed is partially driven by this increased adoption of technology in many aspects of our lives. Another key reason, however, driving the industry towards making the passenger experience increasingly automated is the global need to reduce passenger processing costs and increase processing speeds. The reduction of costs and processing speeds are vital in accommodating the projected growth on passenger traffic worldwide (IATA, 2012). As stated by Jager in his opening address at Passenger Terminal Conference in Vienna last year "…the creation of increasingly larger terminals is … economically, financially, operationally and environmentally unsustainable…" (Jager & Ofner, 2012). Creating a more technology focussed passenger experience is seen as a way to answer this industry dilemma.

In the remainder of this paper, we present an example of what the future passenger experience might look like. The example represents a consolidation of industry perspectives and research in the field. We then go on to de-construct the example into a set of components needed to make the vision of future travel a reality. We discuss the emerging challenges, and outline a potential approach to addressing them. Finally, we examine the impact that the vision of the future passenger experience will have on the design of future airport terminal environments.

Future Passenger Experience

It is generally accepted that the future passenger experience will be centred around interactions between passengers and various modes of technology (IATA Corporate Communications, 2011; Port Authority of New York and New Jersey, 2012; SITA, 2013). This scenario is inevitable due to the convergence of three critical factors, namely (1) the industry's need to reduce costs (IATA, 2013c), (2) a passenger preference for technology based solutions (SITA, 2013) and (3) the need to make passenger processing more efficient to accommodate projected global passenger traffic (IATA, 2012).

Although technology will unquestionably feature highly in the passenger experience of the future, the shape of what this future experience will look like remains largely unarticulated. In this section, we present an example of what the passenger experience might look like. The example, although fictitious, is based on a number of information sources, including:

1. The results of an industry workshop held in New York in 2012 (Port Authority of New York and New Jersey, 2012). Ninety-five invited industry participants brainstormed ideas for what the future travel experience would look like for each component of the trip: curbside, departure lobby, security checkpoint, concourse and gates. The group found that "…the largest leap will be in achieving an intuitive and seamless free flowing experience the customer can control, engage and enjoy in a manner and timeframe they control from the time they leave home to the time they arrive to their final destination".

2. The results of SITA's 2012 passenger survey and 2013 position paper "Flying into the Future" (SITA, 2012, 2013). In general, the reports present a very strong desire by passengers for a more seamless, personalised, technology intensive experience, not only in the terminal, but as part of the extended travel experience (researching and purchasing travel, notification of flight delays, personalisation of in-terminal retail, etc).

3. An analysis of the major programs currently underway at IATA (IATA, 2013a). These programs include the Checkpoint of the Future, Fast Travel, Passenger

Facilitation and One Stop Security initiatives (Copart, 2012; IATA, 2013b; IATA Press Release, 2011).

Consolidated Example: International Departures

In this section, we present an example of what the international departures segment of the future passenger experience may look like. The example is constructed from an analysis of the data sources described in the previous section. The example, illustrated in Figure 1, shows the experience of a fictitious passenger, “Anna” in her journey from the workplace to the boarding gate.

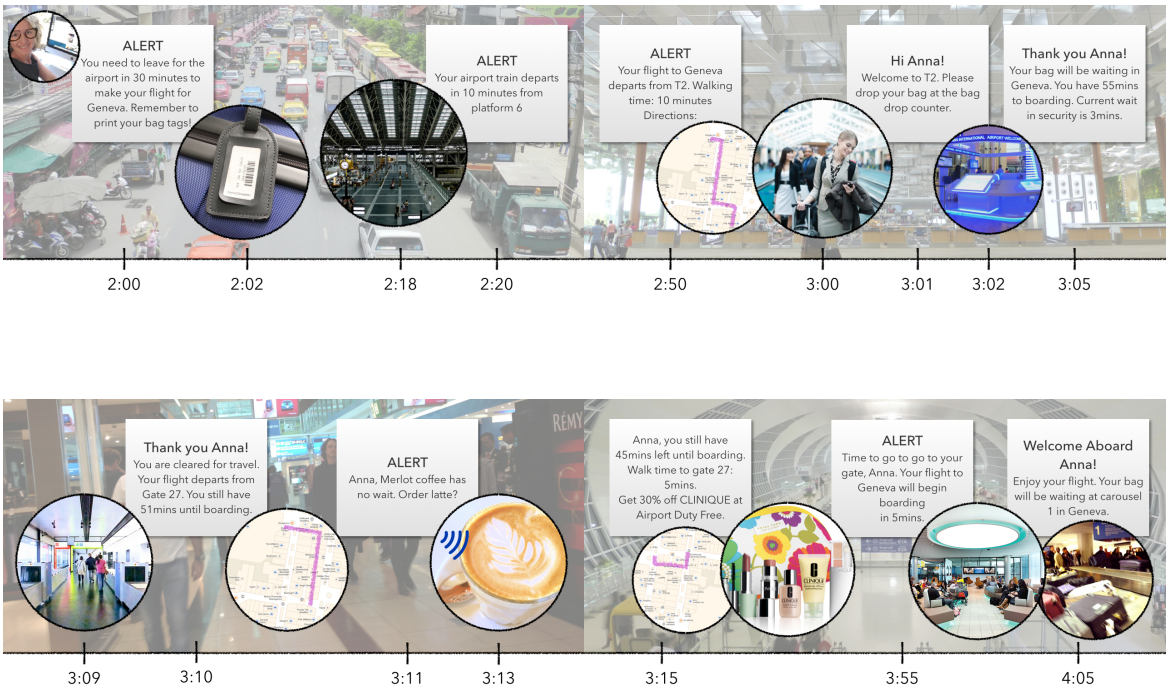

Figure 1: The future travel experience: International departures example

The example begins with passenger “Anna” receiving an alert while at work. The alert (2:00pm) informs Anna that she will need to leave work for the airport in 30 minutes, and reminds her to print her baggage tags. Clicking on the link, Anna prints her baggage tags and attaches them to her suitcase (2:02pm). Anna proceeds to the train station with her baggage (2:18pm). Shortly after arriving at the train station, Anna receives an alert telling her the platform and departure time of the next airport train (2:20pm).

Half an hour later, Anna alights from the train and is greeted by an alert informing her of the terminal her flight departs from and the walking time needed to get there. A map showing the fastest walking route is also provided (2:50pm). Upon entering the airport terminal building, an alert recognises Anna, welcomes her to the terminal and reminds her to drop her bags at the appropriate bag drop counter (3:00pm). After dropping off her bags (3:02pm), an alert informs Anna of the time she has left until boarding, directs her to the next step in the process, namely security, and informs her of the current wait in that processing zone (3:05pm).

Anna chooses to proceed straight through to the security zone, where she is identified and cleared for travel (3:09pm). Anna walks straight through the “green” pre-cleared security lane (3:10pm) and is greeted by a welcome alert informing her which of her favourite coffee vendors has the shortest wait (3:11pm). Anna clicks to order her coffee, proceeds to pick it up and pay for it using NFC technology embedded in her mobile phone (3:13pm).

After finishing her coffee, Anna is reminded that she still has ample time before boarding. Based on Anna's passenger profile, an appropriate retail lure appears, enticing Anna to spend some of her time and money in the airport retail outlets (3:15pm). At the appropriate time, Anna is reminded to head towards the boarding gate (3:55pm). After a short wait, Anna boards the plane. An alert greets her, and informs her which carousel her bag will be waiting at when she reaches her final destination (4:05pm).

Hurdles and Obstacles

The example presented in the previous section represents a significant departure from the current check-in, security/customs and boarding international departures sequence in use by most airports world-wide (Popovic, Kraal, & Kirk, 2009). Surprisingly however, the major obstacles to implementing this futuristic, seamless passenger journey through the terminal building are not the absence of underlying technologies. For the most part, the technology needed to enable each component in the above example has already been developed or is approaching readiness: secure Wi-Fi communications, mobile technologies, NFC technology, self-service bag-drop, check-in and boarding gates, one-stop security, the checkpoint of the future (Alliance, 2003; Harrison, 2012; IATA, 2013b; IATA Press Release, 2011; Madlmayr, Langer, Kantner, & Scharinger, 2008).

One of the key obstacles that prevents the above example from being realisable is the issue of data integration (Maurizio, 2002). In order to make the vision of future travel possible it is essential to resolve the issue of data integration and interoperability. This is critical, as the data required to enable each of the components shown in Figure 1 will necessarily come from multiple underlying sources, as illustrated in Figure 2. These data sources include airline reservation systems, airport mapping systems, passenger processing systems, flight information, government watch lists, passenger identification data, as well the numerous sources of "personalisation" information that can be sourced from "big data".

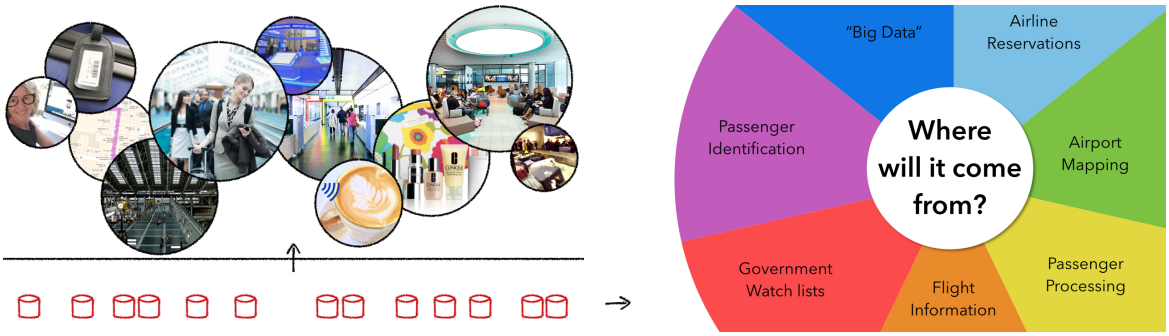

Figure 2: The vision of future travel is necessarily reliant upon the integration of data from multiple data sources, each one independently owned and operated

Integration of Data Sources

To illustrate the data integration issue, consider the following extract from the future travel example, as shown in Figure 3.



Figure 3: An extract from the future travel example, showing the various data sources that need to be integrated in order to create the two sample passenger alerts shown

In order for passenger Anna to receive the first alert reminding her of her upcoming flight, information will need to be assembled from, at least, the following data sources:

1. Airport databases: flight information (is the current flight scheduled to depart on time?), bag tag format.

2. Anna's information: calendar entry noting the flight details, existence of bags to be checked-in, preferred mode of travel to the airport.

3. "Big Data": Anna's current location, the travel time to the airport via the selected mode of transport, any issues in the selected mode of transport (such as train strikes, traffic jams, road closures, etc), a schedule of services for the selected mode of transport.

The second alert in the extracted example shown in Figure 3 will similarly require the assembly of information from various data sources, including:

1. Airport: a check of the flight status to ensure there have not been any changes.

2. Anna's info: the destination and desired time of arrival.

3. "Big Data": Anna's current location, schedule of services for the selected mode of transport, a map of the (train) station.

As is evident from this small extract of the future travel example, in order for each of the alerts and notifications to arrive "seamlessly" to the passenger's mobile device, data has to be integrated from a variety of different sources.

Formatting and Ownership

The data integration problem has been studied extensively in the fields of computer science and database design (Maurizio, 2002). Conceptually, the data integration problem can be broken down into two components, namely data formatting and data ownership.

To a large extent, the data formatting issues have been resolved. These solutions have progressed through various stages of development, and increasing complexity (Figure 4). The very early data integration problems revolved around reconciling physical differences in the storage format of data, for example, a person's name may be stored as a series of *characters* in a text file and a *string* in a database. In order for the text file to be imported into the database, the series of characters would need to be physically converted into a string data format.

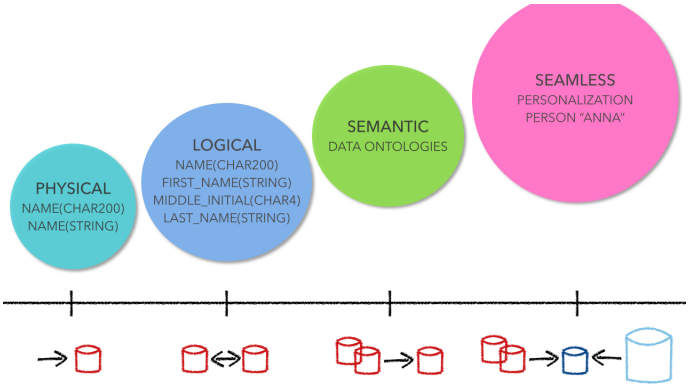

Figure 4: A historical perspective of the developments in data integration

The next development in data formatting was to reconcile logical differences between data stored in various databases. In the example in Figure 4, one database could store a person's name as a *name* field, while another database may store it as three separate fields, namely *first name*, *middle initial* and *last name*. In order for information about a person to be retrieved from the two data sources, the fields name and first, middle, last name would have to be logically mapped as being equivalent.

The next significant development in data integration occurred with the development of semantic ontologies and data dictionaries. This phase extended on the simple logical mappings defined in the previous phase by constructing taxonomies of concepts. In certain cases, these taxonomies have been developed to map out very complicated concepts – as in the example of the Snomed CT ontologies developed for the healthcare industry (Tun, Bird, & Goodchild, 2002). The development of semantic ontologies has allowed data to be shared globally between various stakeholders.

In contrast to the data formatting issues, the data ownership issues remain an open area of research. As shown in Figure 4, the next phase in data interoperability revolves around the integration of data sources needed to provide a "seamless" customer experience. The challenges in creating seamlessness, however, lie more in finding solutions to data sharing than data formatting.

In aviation, the data formatting issues have been addressed to a limited extent. There are numerous initiatives aimed at constructing industry standards or data communication formats. As an example, IATA has been developing a set of data formats under its Passenger Airport Data Interchange Standards (PADIS) initiative (IATA, 2011). The PADIS standards aim to define common industry data structures for passengers, flight information and boarding passes. Although these data standards need to be expanded into a comprehensive aviation data ontology, the key issue that IATA is facing, however, is not in the definition of common data formats, but rather in reaching an agreement between stakeholders about how data is to be shared once the standards are developed (IATA Fast Travel Working Group, 2012).

Approaches to Data Sharing

In order to overcome the data sharing problem, it is helpful to consider the reasons for why data sharing is not approached with favour. Traditionally, stakeholders have viewed their data as their competitive advantage (Smith, Grimm, Gannon, & Chen, 1991), and have therefore been reluctant to "share it". This is part of the reason why current attempts at resolving data integration issues in the industry are failing. Although data structures can be agreed on, the common (integrated) data source cannot be populated as the owners of the data do not want to share it. It is therefore necessary to think of alternate ways of approaching this problem.

One possible approach to overcome the issue of sharing data that is perceived as proprietary, or private, is to ask the owner of the data to "validate" the data, rather than to share the underlying data itself. As an example, a passenger already has all of their own details, such as name, flight information, in-flight preferences. A system could validate whether the passenger was a known traveller by matching the passenger's data against what is stored in the proprietary database. Instead of sharing data, the system could just provide a YES/NO validation against the passenger details. If the information was of a sensitive nature, it could be encoded using one of numerous appropriate technologies, for example using a cryptographic one-way hash (Naor & Yung, 1989).

Example: Using Tokens

Returning to the example of the future passenger experience, let's consider another extract, as shown in Figure 5. In the extract shown, in order for passenger "Anna" to receive a welcome alert when arriving at the airport terminal, a check needs to be made against the flight records to see whether Anna is an expected traveller for the given terminal. Passenger Anna's information can encrypted and sent to the airline's reservation system and the airport's passenger flight information system. If the records match, a *registered passenger token* can be returned to Anna.

A similar process can be applied to pre-clear the passenger for security – the passenger details can be checked against various known traveller and government watch list databases. If Anna is allowed to travel, she can be issued with a *security clearance token*, giving her access to the pre-cleared security lane. Naturally, if passenger Anna was not issued with a security clearance token, she would need to be processed through security by a staff member (or other fall-back mechanism for handling exception cases).

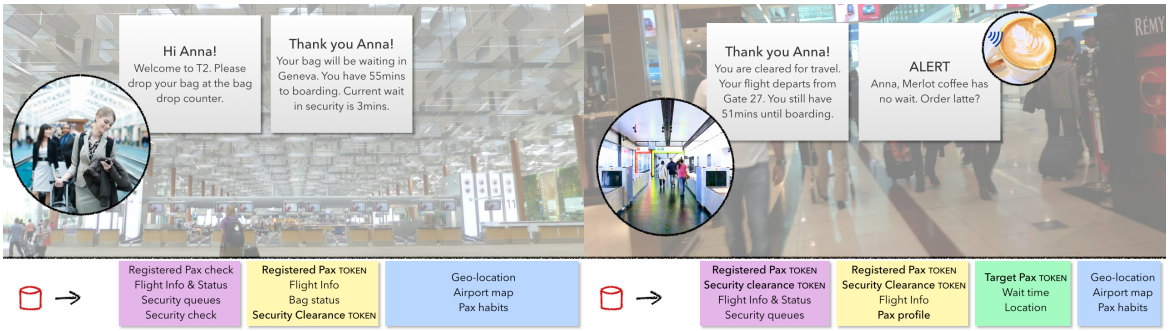

Figure 5: An extract from the future travel example illustrating an approach to data sharing which preserves data ownership and data privacy

Information can be exchanged in the same way between passengers and retailers. In the example in Figure 5, Anna's preferences for coffee are already known to her, and thus stored as part of her own data, as are her demographics. A particular coffee retailer need not have access to Anna's personal information – the only thing the coffee retailer is concerned about is that their message gets delivered to passengers who meet their target customer profile. Once again, Anna's data can be hashed and compared with the retailer's desired demographics. A token can be issued if there is a match.

It is important to note, that in the above example, the data sharing problem is avoided through the issuing and passing of tokens, rather than actual passenger data values. This element is important as it overcomes both data sharing and potential data privacy issues.

Looking Ahead: Opportunities

The approach to data sharing outlined in the previous section addresses one of the key obstacles that need to be overcome if the vision of the future passenger experience is to become a reality. By developing a comprehensive aviation data ontology, and making it available globally though a distributed virtual infrastructure, data can be integrated and leveraged to support a seamless passenger journey.

In addition to enabling seamless travel, an approach based on global data standards and data validation rather than data sharing would have two significant benefits to the aviation industry. Firstly, it would enable global passenger tracking – i.e. passenger Anna would be "known" to the arriving country's systems, instead of being treated as a new, unknown passenger. This of course would not only improve the passenger experience, but also improve world wide aviation security.

The second benefit would be the opportunity to realise global efficiencies though the use of standard data formats. Rather than each country solving the same problems individually from first principles, solutions could be developed and re-used worldwide. For example, instead of each airport developing their own "app", and each passenger needing a separate app for each airport they travel through, one global airport app could be deployed. This would make the passenger experience more simple (one app instead of many), and deliver savings to airports (one app is developed and maintained globally, rather than by each individual airport).

Design Implications: A Shift from Physical to Virtual

The future passenger experience example presented at the beginning of this paper is entrenched in technology (refer to Figure 1). The example, although fictitious, represents the convergence of thoughts and research outcomes from various industry and academic sources. As is evident, a significant part of this future passenger experience will involve interaction between passenger and some form of technology.

From a design perspective, this completely changes the nature of passenger terminal design from that of being a predominantly architectural practice, to that of being a virtual and technology practice. This of course raises an interesting question, namely, what will be the relative importance, or otherwise, of the passenger terminal building in the future passenger experience?

It will of course not be possible to research the answer to the above question until the passenger experience resembles the future vision more closely. However, based on the results of interviews conducted at an international terminal during 2011-2012 (Harrison, Popovic, & Kraal, 2013), there is suggestive evidence that the terminal building itself is not a significant factor in the passenger's overall experience.

According to the results reported by Harrison et al. (2013), passengers generally did not speak about the airport environment directly when recounting stories of their experience in the terminal building. In cases where the building environment was mentioned, it was always in the context of time perception – for example, a "light and airy" airport was equated with an absence of queues, and thus the prospect of faster processing, rather than an innate appreciation of architectural qualities or features. As stated by one participant, "…the airport is just a port to travel…". The airport is largely not considered as a destination, but an overhead that must be overcome in order to get to a desired destination.

In designing the terminal of the future, therefore, it is likely that problems of architecture will be superseded by problems associated with creating seamless virtual passenger

experiences. Of course, the architecture of an airport may still be important in communicating a city's status, or importance, but its actual form may be disconnected from the passenger experience itself. This potential shift in importance from architectural to virtual design would dramatically change the way in which future terminals are designed and built.

Summary

In this paper, we presented an example of what the future passenger experience may look like. The fictitious example was consolidated from various data sources, including industry workshops, surveys into passenger preferences, an examination of key industry initiatives.

By looking at the problem of future travel from the perspective of a grounded example, we were able to highlight some of the key components that need to be addressed before the vision of seamless travel can become a reality. In addition to the development of comprehensive global data standards to address data formatting issues, a system for overcoming data ownership issues will need to be developed. Resolving both formatting and data sharing issues is necessary in order to integrate data from various underlying data sources. This in turn is critical to providing a seamless travel experience.

By looking at the passenger experience from a data centric perspective, we identified a potential shift in the way that future passenger terminals will be designed. Whereas currently the design of terminals is largely an architectural practice, in the near future, the design of the terminal building may become more of a virtual technology practice. This naturally has significant implications for the way in which the design of these environments is approached in the future

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An Investigation on the Gender Differences of Taiwanese Youths and Middle Ages in Evaluating Motorcycle Appearance and Use

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Abstract: This study mainly used viewpoint of Kansei engineering to conduct survey of motorcycle shape cognition and usage evaluation among young (20-35 years) and middle-aged (35-55 years) males and females in Taiwan. Firstly, field observations and interviews were adopted to perform on-site shooting and recording of brand, model, purchase motivation, intended use, males and females' dressing style, etc. of 96 samples of 100-150CC motorcycle so as to know popularity of motorcycle in Taiwan and differences between generations and genders. Then, 10 representative motorcycle samples were selected. SD (Method of Semantic Differential) was used for shape cognition and usage evaluation survey among 114 interviewees and SPSS statistical software was used for factor analysis in order to understand young and middle-aged groups' relevance and gender difference in terms of motorcycle shape and usage evaluation.

Results of this study show young and middle-aged generations mainly consider factors such as brand, appearance, lightness, convenience and price when choosing motorcycle.Males and females purchase suitable brand and model as per personal height, body size, preference for shape, etc. Females mostly select light model of 100~115c.c and are in favor of relatively low horsepower and compact shape; males prefer to choose 125-150c.c sport motorcycle with strong horsepower and huge size. Factor analysis results of shape cognition and usage evaluation can be divided into three factors: (1) appearance, (2) sense of design, (3) operability. 125c.c models generally show a huge and steady sense while 100c.c ones feel small and light. Simple arc appearance looks natural

while complex and sharp appearances makes people feel unique. Curved design and small volume are suitable for females. These findings can provide a reference for subsequent relevant research development and future design development.

Keywords: Motorcycle, Generation Difference, Gender Difference, Semantic Differential method, Usage Evaluation

1. INTRODUCTION

1.1. Research background

Between 1930s and 1950s, motorcycle was a luxury for a few people. In 1960s, it evolved a function of transporting goods and making money. In 1970s, along with rapid development of Taiwanese economy, motorcycles were put into mass production and price was reduced. Students, office workers and housewives all streets and lanes ride motorcycles on streets and lanes. At that time, motorcycle became the most popular vehicle in Taiwan.

In Taiwan, popularity of motorcycle has lasted for more than half a century. Different groups have respective preferences for brands, types and styles. Generally, males and females are influenced by body size, physiological response and control abilities, fashion, etc when selecting and purchasing motorcycles. Also, people of different ages always choose types and styles suitable for them pursuant to various factors including intended purposes, operating requirements and use experiences. For example, among young populations, males tend to buy motorcycles featuring streamline and scientific sense while females prefer round and compact construction. Middle-aged men show a decreased demand on motorcycle and mostly of them own cars, so they generally choose cheap and simple-operation motorcycles. As a response to needs of shopping and picking up children, middle-aged women mainly select models with large storage space or comprehensive functions. Therefore, investigating differences or relevance between “different genders or generations” and “perception of motorcycle appearance design and evaluation of usage” is indeed an issue worth studying for industrial design field.

1.2. Research objectives

This study adopted cognitive evaluation viewpoint of Kansei engineering to implement survey of motorcycle shape cognition appraisal among young (18-35 years) and middle-aged (36-55 years) people from northern, central and southern parts of Taiwan. Firstly, individual interviews with 96 young and middle-aged males and females were accomplished to know consumers’ perceptions of motorcycle shape, brand preference and use demands as well as generalize and analyze young and middle-aged people’s generation and gender factors that influence motorcycle evaluation. Secondly, data about motorcycle quantity, brand and model were collected from five parking lots in northern, middle and southern Taiwan, popularizing rates were summarized for a subsequent cross contrast with sales ranking list, and 10 representative models were selected. 114 shape cognition and evaluation questionnaires of SD method were sent out for a survey. Through statistical analysis

and line chart and spatial distribution plotting, differences in shape cognition and usage evaluation caused by young and middle-aged people's different generations and genders were investigated. Results of this study will provide references for subsequent research development and designers' new product development in the future.

2. LITERATURE REVIEW LITERATURE REVIEW

2.1. Development and current condition of motorcycles in Taiwan

In 1930s, Taiwan introduced motorcycle from Japan. History of Taiwanese motorcycle development lasts 80 years and can be divided into three phases.

1. Rarity phase (1930-1963): during this phase, motorcycles were all imported and owned by wealthy people or male elites. Only a few females had the chance of riding on the motorcycle.
2. Transformation phase (1964-1976): in 1962, SYM cooperated with Japanese "Honda Motor Co., Ltd." to initiate motorcycle industry of Taiwan. Motorcycle riders gradually transformed from upper-level elites into lower and middle classes. For job and housework, more and more females became motorcycle users.
3. Popularity phase (1977-now): due to quick development of motorcycle industry, motorcycle popularizing rate goes up rapidly (Guan-Hong Lok, 2005). According to statistical data published by Ministry of Communications at the end of December 2012, number of motorcycles in Taiwan is 15,143,434. Top three manufacturers in terms of market share are KYMCO, YAMAHA and SYM in order, which collectively account for about 90% of total sales. In present Taiwan, owning a motorcycle is an easy and common phenomenon. Motorcycle is an indispensable vehicle for people to go working, relaxing and shopping.

2.2. Gender difference

Traditionally, males possess instrumental features: target-oriented, logical and aggressive. Females have emotional traits: tender, sympathetic and caring (Hort, Fagot, & Leinbach, 1990). Gender consciousness means: observe society, politics, economy, culture and environment from gender perspectives, perform gender analysis and planning, and thus prevent and overcome modes and measures bad for development of both genders (Ya-Hui Tang, 2000).

Gender viewpoint, based on cognition of gender consciousness, proposes statements on interpretation of tradition for traditional gender issues. Different genders play different roles. Gender role means individuals are taught to form values and behavioral norms suitable for their genders during their growth. Through role classification and setting, a person becomes a member of a category and presents a kind of role behavior, which should be proper and meet social expectations. These learning mechanisms include family, education, religion, society and all cultural communications (Mei-Hui You, 2001). This paper will find out differences through research and generalize elements that can provide design references.

2.3. Generation difference and cognition

Young generation refers to 18-35 years old teenagers who define “who I am” by joining in or identifying subculture or groups. If they fail to find acceptable subculture or group, they will feel like getting lost due to role confusion. Therefore, definite self-identification helps them blend in with social group to increase “sense of belonging”. Proper role confusion can establish personal “uniqueness” and thus enhance sense of presence.

Middle-aged generation refers to 36-50 years old adults featured by pursuing peak of achievement, career performance, social status and economic status. With long-term experiences, adults know more definite direction and development of life goal, become stable in work and social relationship, present better self-worth, esteem and creativity ability through well-established support network with colleagues and friends, and have a place in the society (Mei-Jun Wang, 2000). This definition is suitable for inter-generation differences in motorcycle use cognition and evaluation of this study.

2.4. Semantic differential method

Semantic differential method utilizes bipolar scale constituted by a pair of opposite adjectives to appraise product, brand, company or any concept. Two opposite adjectives of bipolar scale are often separated by a continuous set that is divided into 7 segments (or 5 or 11 segments) (Chun-Ying Huang, 1999), illustrates two common forms of semantic differential method. This study adopted a 5-segment scale, carried out word evaluation from -2 to 2, simplified data into explanatory factors by means of SPSS factor analysis and drew line chart and space coordinates, in order to know whether people of different genders and generations are different in cognition and evaluation of industrial products (Ching Yang, 2004) .

3. RESEARCH METHODS

3.1. Field observation and interview records

From 20 October 2014 till 22 November 2013, this study performed field observations and questionnaire interviews among different-gender young and middle-aged groups from five areas of Taiwan-Taipei and Miaoli in the north, Taichung and Yunlin in the middle and Kaohsiung in the south. On-site shooting was done to record information about 100-150c.c motorcycles such as brand, model, purchase motivation and males and females’ dressing style, so as to know popular phenomena among Taiwan motorcycle groups as well as generation and gender differences. Representative cases of young and middle-aged males and females were extracted from 96 samples as listed in table 1. According to results of interviews, youth’s primary use demand is for going to work; males mostly consider performance and distinctive appearance; females pay attention to light weight and storage space; middle-aged people use motorcycle for short distance, with males’ focus on price and brand trust and females’ emphasis on picking up children and storage space.

Table 1: Representative case of field observation and interview records

Gender	male			Female		
Young Generation	Number	Age	type	Number	Age	type
	B14	21-25	GP 125	B19	26-30	RS-Z 100
						
Middle-aged generation	Number	Age	type	Number	Age	type
	A01	41-45	Jeckey 125	B04	36-40	Smile 125
						

3.2. Survey of motorcycle popularizing rate in Taiwan

Between 9 November 2013 and 21 November 2013, this study investigated motorcycle popularity rate by means of shooting at motorcycle parking lots of New Taipei City Hongshulin MRT Station, Miaoli County Houlong Railway Station, Taichung Dacing Railway Station, Carrefour Douliu store (Yunlin County) and Carrefour Dingshan store (Kaohsiung City). A total of 622 motorcycles of 62 models were recorded and statistical results are shown in table 2.

3.3. Extraction of representative motorcycle models

A cross contrast was made between statistical results of popularity rate in table2 and sales data of January 2013 (www.eprice.com.tw，2013). 4 models of 100c.c motorcycles and 6 models of 125c.c. motorcycles were selected from top three domestic manufacturers and other factories and SD method was used for cognition evaluation of motorcycle samples. Numbers of questionnaire samples were arranged randomly as listed in table 3.

Table 2: Statistical sheet of motorcycle popularizing rate in Taiwan

No	Brand	Model	Quantity	Percentage	No	Brand	Model	Quantity	Percentage
1	KYMCO	Jockey125	44	7.07	32	KYMCO	CHERRY100	6	0.96
2	YAMAHA	JOG 100	34	5.46	33	PGO	BUBU	5	0.80
3	SYM	DUKE 125	31	4.98	34	KYMCO	Going 100	5	0.80
4	YAMAHA	CUXI	30	4.82	35	YAMAHA	CIAO115	5	0.80
5	KYMCO	EASY 100	29	4.66	36	SYM	TINI-100	5	0.80
6	YAMAHA	Forte 125	28	4.55	37	SYM	R1 125	5	0.80
7	SYM	X'pro 125	27	4.34	38	SUZUKI	Crystal 100	4	0.64
8	YAMAHA	CygnusX 125	21	3.37	39	SYM	JET-Power	4	0.64
9	KYMCO	GP 125	20	3.21	40	SYM	PARTY	4	0.64
10	KYMCO	Freeway 125	20	3.21	41	SYM	GR125	4	0.64
11	KYMCO	MANY	20	3.21	42	YAMAHA	BWS125	4	0.64
12	YAMAHA	RS-100	20	3.21	43	KYMCO	Herself125	4	0.64
13	SYM	GT125	18	2.89	44	KYMCO	CANDY	4	0.64
14	YAMAHA	Breeze 125	18	2.89	45	YAMAHA	Majesty125	3	0.48
15	SYM	SMILE100	15	2.41	46	PGO	X-HOT	2	0.32
16	SYM	Wind 100	15	2.41	47	SYM	x'pro 150	2	0.32
17	SYM	ATTILA 125	15	2.41	48	SYM	Wind 125	2	0.32
18	YAMAHA	GTR-125	14	2.25	49	SYM	MIO	2	0.32
19	KYMCO	G5	13	2.09	50	YAMAHA	FANCY100	2	0.32
20	YAMAHA	SV-MAX125	12	1.92	51	KYMCO	VP 125	2	0.32
21	KYMCO	SR125	10	1.60	52	KYMCO	Pentium 150	2	0.32
22	SYM	RX110	9	1.44	53	SUZUKI	DAO100	2	0.32
23	YAMAHA	FUZZY 125	9	1.44	54	SUZUKI	Address 125	2	0.32
24	KYMCO	VJR110	8	1.28	55	SUZUKI	Swing 125	2	0.32
25	KYMCO	JR100	8	1.28	56	YAMAHA	Techno 150	1	0.16
26	KYMCO	KIWI	8	1.28	57	SYM	MII	1	0.16
27	KYMCO	Movie 125	8	1.28	58	SYM	Z1 125	1	0.16
28	SYM	Fighter150	8	1.28	59	SYM	IRX115	1	0.16
29	SUZUKI	GSR125	7	1.12	60	SUZUKI	XR125	1	0.16
30	YAMAHA	VINO100	7	1.12	61	PGO	I Charge125	1	0.16
31	KYMCO	RACING150	7	1.12	62	Hartford	MIGIC 125	1	0.16
Total								622	100.00

Table 3: Motorcycle samples of SD-method cognition evaluation

Sample	1	2	3	4	5
Model	Jockey125	.Many110	Jog 100	Duke 125	BuBu 100
Picture					
Sample	6	7	8	9	10
Model	GP 125	GyugnsX 125	RS-Z 100	Attila 125	X-Hot 125
Picture					

3.4. Questionnaire design and SD word extraction

Based on common people's cognition and evaluation of motorcycles summarized from field observation and interview data as well as a reference to literatures A Study of the Images of the Relation between Women Consumer's Pleasure and Motorbike Product Design(Yu-Lin Shen, 2007), this study generalized words in regard to physical property, psychology and motorcycle appearance, performance, operation and function as shown in table 3. Then, 14 pairs of words were extracted from 56 pairs of opposite words. 10 representative models were listed in the questionnaire along with 45-degree-angle pictures of front motorcycle body and corresponding pairs of words. These words were divided into five levels from -2 to +2; testees were asked to look at pictures and then check words shown in figure 1 in accordance with their feelings.

	-2	-1	0	+1	+2	
Cheap	☐	☐	☐	☐	☐	Expensive
Poor-appearance	☐	☐	☐	☐	☐	Good-looking
Uncomfortable	☐	☐	☐	☐	☐	Comfortable
Difficult-to-operate	☐	☐	☐	☐	☐	Easy-to-operate
Dull	☐	☐	☐	☐	☐	Flexible
Compact	☐	☐	☐	☐	☐	Huge
Gas-guzzling	☐	☐	☐	☐	☐	Fuel-efficient
Low performance	☐	☐	☐	☐	☐	High performance
Common	☐	☐	☐	☐	☐	Unique
Female	☐	☐	☐	☐	☐	Male
Simple	☐	☐	☐	☐	☐	Fancy
Light	☐	☐	☐	☐	☐	Steady
Submissive	☐	☐	☐	☐	☐	Firm
Small storage space	☐	☐	☐	☐	☐	Large storage space

Figure 1: SD word extraction

4. DESIGN AND IMPLEMENTATION OF QUESTIONNAIRE SURVEY

4.1. Contents of questionnaire survey

Questionnaire survey of this study was aimed at knowing different genders and different generations' differences in motorcycle shape cognition and usage evaluation in Taiwan. Contents of the questionnaire were composed of four parts: (1)basic information (6 items): to be used for statistics of variable data; (2) motorcycle purchase and usage (6 items): to know owners' purchase motivations and priorities when buying motorcycles, as well as their current evaluations of motorcycle usage; (3) lifestyle AIOs scale(23 items): to investigate lifestyles of motorcycle groups;(4)cognition and perceptions of motorcycle (10 items): use SD method to know interviewees' perceptions and feelings of shapes of different models.

4.2. Implementation of questionnaire survey

From December 2013 to January 2014, questionnaires in the form of online edition and paper version were sent out to 18-55 years old males and females in Taiwan Online questionnaires were published on social-networking sites and related forums. Paper questionnaires were delivered to

friends, relatives and family members, who filled in on site. There were 114 questionnaires totally, including 99 online questionnaires and 15 paper ones.

4.3. Interviewees' basic information

Interviewees' basic data of this study are summarized in table 4. With respect of sex ratio, males and females account for 49% and 51% respectively. Interviewees' ages are classified into 18-25 (18.4%), 25-30 (24.5%) and 31-35 (20.1%). In terms of education background, university (36.8%) and "above graduate school" (32.4%) show high proportions. Top three occupations are professional technician (19.2%), student (13.1) and office personnel (13.1%). With regard to revenue, 21-30 thousand (21.0%) and 31-40 thousand (24.5%) are at high proportion. In addition, most interviewees reside in Taichung, Changhua, Yunlin & Nantou (46.4%) and New Taipei, Taipei & Keelung (27.1%).

Table 4: Interviewees' basic information

Item	Content	times	percentage
Gender	Males	56	49.1
	Females	58	50.9
Age	18-25 years old	21	18.4
	26-30 years old	28	24.5
	31-35 years old	23	20.1
	36-40 years old	13	11.4
	41-45 years old	16	14.0
	46-50 years old	8	7.0
	51-55 years old	5	4.3
Educational Background	Junior	3	2.6
	Highschool(grades)	9	7.8
	Specialist	23	20.1
	graduates	42	36.8
	Graduate	37	32.4
Occupation	Student	15	13.1
	Civil servants and teachers	14	12.2
	professional technicians	22	19.2
	business personnel	15	13.1
	Housewife	3	2.6
	Since business	6	5.2
	Production operator	6	5.2
	Service workers	25	21.9
	Other	8	7.0
Income	Ten thousand or less	13	11.4
	11-20 thousand	12	10.5
	21 -30 thousand	24	21.0
	31-40 thousand	28	24.5
	41-55 thousand	22	19.2
	56-70 thousand	7	6.1
	70 thousand or more	6	5.2
	Other	2	1.7
Total		114	100.0

4.4. Motorcycle purchase and use conditions

Table5 lists top three brands owned by interviewees of this study are KYMCO (35%), Yamaha (28.9%) and SYM (26.3%), and these data are similar with results of popularity rate survey. With regard to conditions of motorcycles purchased, old and new motorcycles make up 52.7% and 47.3%

respectively. Concerning price, 30-45 thousand (27.1%) and 46-55 thousand (26.3%) are the top two. Top two in terms of engine displacement are 125c.c (49.1%) and 100c.c (28.9%). In respect of service time, 4-6 years (36.8%) and 1-3 years (23.6%) account for larger proportions as shown in table 5. Main purposes are as below in order: going to work (32.5%), going to restaurant or shopping (25.9%), recreation & journey (14.8%) and picking up family members (11.5%). The most satisfactory conditions for users are as below in sequence: reasonable price (14.2%), easy-to-operate (13.4%), brand trust (11.1%) and low fuel consumption (11.6%).

Table 5: Statistical table of motorcycle purchase and use conditions

Item	Content	times	percentage
Brand	KYMCO	40	35.0
	YAMAHA	33	26.3
	SYM	30	26.3
	SUZUKI	5	4.3
	PGO	2	1.7
	Other	3	2.6
Purchase condition	New	54	47.3
	Used	60	52.7
purchase price	Ten thousand or less	3	2.6
	10-29 thousand	19	16.6
	30-45 thousand	31	27.1
	46-55 thousand	30	26.3
	56-65 thousand	11	9.6
	66-80 thousand	14	12.2
	80 thousand or more	5	4.3
exhaust volume	100 C.C	33	28.9
	110-115 C.C	13	11.4
	125 C.C	56	49.1
	150 C.C	12	10.5
Use Year	1-3 years	27	23.6
	4-6 years	42	36.8
	7-10 years	22	19.2
	11-15 years	13	11.4
	15 years or more	10	8.7
Total		114	100.0

5. STATISTICAL RESULTS OF SD EVALUATION OF MOTORCYCLE

5.1. Average values and line chart of 100C.C motorcycle

This study provided interviewees 14 pairs of words to know their shape cognition and usage evaluation of four motorcycles. Statistical results of average values are listed in table 6. With regard to appearance-related psychological factors-“cheap-expensive”, “tacky-elegant”, “common-unique” and “simple-fancy”, all models except Jog 100 obtain evaluations above average value. Jog is positioned as an economical model. In terms of compact-huge, low performance-high performance, female-male, light-steady and submissive-firm, motorcycles are divided into two groups: RS-Z 100 and BUBU 100 show a sense of high performance and being firm while Jog100 and Many110 look submissive and female-like. As illustrated in figure 2, four models are not significantly different in operation: uncomfortable-comfortable, difficult-to-operate and easy-to-operate, dull-flexible and gas-guzzling & fuel-efficient.

Table 6: Statistical results of 100C.C. evaluation

Semantic \ Model	many110		jog 100		BUBU 100		RS-Z	
	A*	S**	A	S	A	S	A	S
1. Cheap - Expensive	3.54	1.04	2.57	1.04	3.92	0.91	4.04	0.94
2. Poor-appearance - Good-looking	3.31	1.15	2.74	1.02	3.28	0.89	3.43	0.90
3. Uncomfortable - Comfortable	3.41	1.05	3.15	0.88	3.41	0.88	3.50	0.90
4. Difficult-to-operate - Easy-to-operate	3.73	0.89	3.61	0.88	3.63	0.93	3.53	0.93
5. Dull - Flexible	3.81	0.93	3.48	0.99	3.64	0.82	3.57	0.89
6. Compact - Huge	2.08	0.99	2.38	0.93	3.32	0.98	3.51	1.15
7. Gas-guzzling - Fuel-efficient	3.38	0.94	3.34	0.94	3.00	1.00	2.91	1.01
8. Low performance - High performance	2.89	0.90	2.87	0.90	3.61	0.82	3.57	0.87
9. Common - Unique	3.38	0.94	2.47	0.97	3.41	0.88	3.55	0.92
10. Female - Male	1.80	0.94	2.54	0.99	3.55	1.05	3.70	0.93
11. Simple - Fancy	3.50	1.07	2.35	0.89	3.45	0.94	3.21	1.00
12. Light - Steady	2.15	0.95	2.41	0.92	3.29	0.89	3.48	0.99
13. Submissive - Firm	2.13	0.85	2.56	0.96	3.48	0.90	3.58	0.91
14. Small storage space - Large storage space	2.50	1.16	2.43	1.07	3.23	.97	3.33	1.14

*A: Average **S: Standard deviation

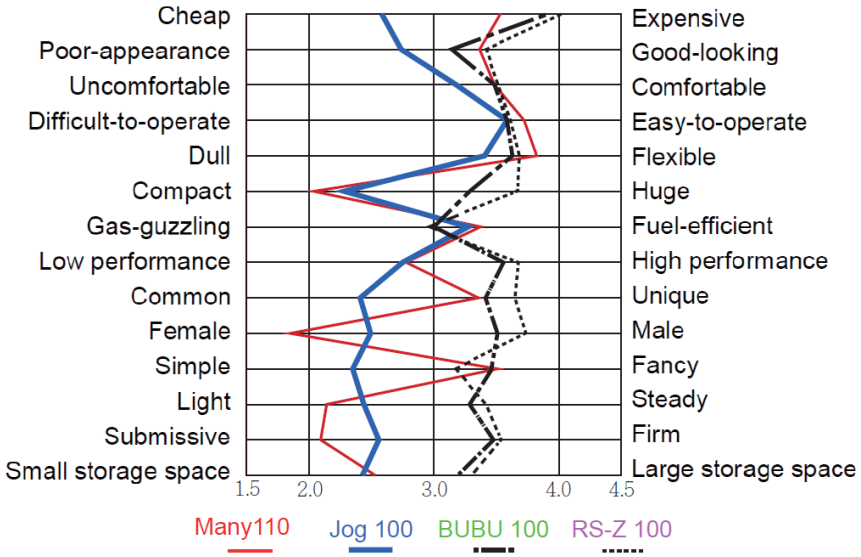

Figure 2: Line chart of 100C.C analysis

5.2. Average values and line chart of 125C.C motorcycle

Table 7 lists statistical results for average values of shape cognition and usage evaluations of six motorcycles in 125C.C group. Results of “cheap-expensive”, “common-unique” and “simple-fancy” are classified into two groups. Cheapness of motorcycle is positively related with “common” and “simple”. Expensive motorcycles look unique and fancy. All models have results obviously higher than average value in terms of “female-male”, “light-steady” and “submissive-firm”. It can be inferred that 125C.C motorcycles are perceived as “high-performance”, “steady” and “suitable for male”. All models show no significant difference in “uncomfortable-comfortable”, “difficult-to-operate & easy-to-operate”, “compact-huge”, “gas-guzzling & fuel-efficient and “low-performance & high-performance” as illustrated in figure 3.

Table 7: Statistical results of 125C.C. evaluation

Semantic \ Model	jockey 125		duke 125		GP 125	
	A*	S**	A	S	A	S
1. Cheap - Expensive	3.13	1.14	2.46	1.06	3.92	0.91
2. Poor-appearance - Good-looking	2.92	1.02	2.15	0.95	3.28	0.89
3. Uncomfortable - Comfortable	3.38	0.96	2.97	0.95	3.41	0.88
4. Difficult-to-operate - Easy-to-operate	3.57	1.02	3.17	1.03	3.63	0.93
5. Dull - Flexible	3.33	1.01	2.64	1.01	3.64	0.82
6. Compact - Huge	3.42	0.95	3.71	0.92	3.32	0.98
7. Gas-guzzling - Fuel-efficient	2.99	0.86	2.81	1.00	3.00	1.00
8. Low performance - High performance	3.38	0.94	3.03	0.93	3.61	0.82
9. Common - Unique	2.77	1.03	2.32	0.93	3.41	0.88
10. Female - Male	3.60	0.98	3.65	0.92	3.55	1.05
11. Simple - Fancy	2.48	1.02	2.11	0.96	3.45	0.94
12. Light - Steady	3.46	1.00	3.62	0.96	3.29	0.89
13. Submissive - Firm	3.53	0.89	3.54	1.03	3.48	0.90
14. Small storage space - Large storage space	3.35	1.00	3.13	1.04	3.23	0.97
Semantic \ Model	**CygnusX 125**		**Attila 125**		**X-hot 125**	
	A	S	A	S	A	S
1. Cheap - Expensive	4.36	0.86	2.66	1.10	4.18	0.95
2. Poor-appearance - Good-looking	3.37	0.95	2.68	1.08	2.78	1.05
3. Uncomfortable - Comfortable	3.79	0.91	3.07	0.96	2.99	1.08
4. Difficult-to-operate - Easy-to-operate	3.49	0.97	3.36	1.00	3.04	1.10
5. Dull - Flexible	3.37	1.07	2.96	1.02	3.13	1.08
6. Compact - Huge	4.11	0.89	3.52	1.00	4.07	0.98
7. Gas-guzzling - Fuel-efficient	2.84	1.09	2.87	0.89	2.45	1.04
8. Low performance - High performance	3.84	1.00	3.11	0.88	3.67	1.06
9. Common - Unique	3.68	1.03	2.59	0.98	3.92	1.09
10. Female - Male	4.13	0.89	3.55	0.89	4.27	0.85
11. Simple - Fancy	3.27	0.94	2.39	0.95	3.68	1.07
12. Light - Steady	3.98	0.94	3.42	1.03	3.86	0.95
13. Submissive - Firm	4.08	0.93	3.15	1.04	4.20	1.00
14. Small storage space - Large storage space	3.80	1.05	3.21	0.94	3.34	1.23

*A: Average **S: Standard deviation

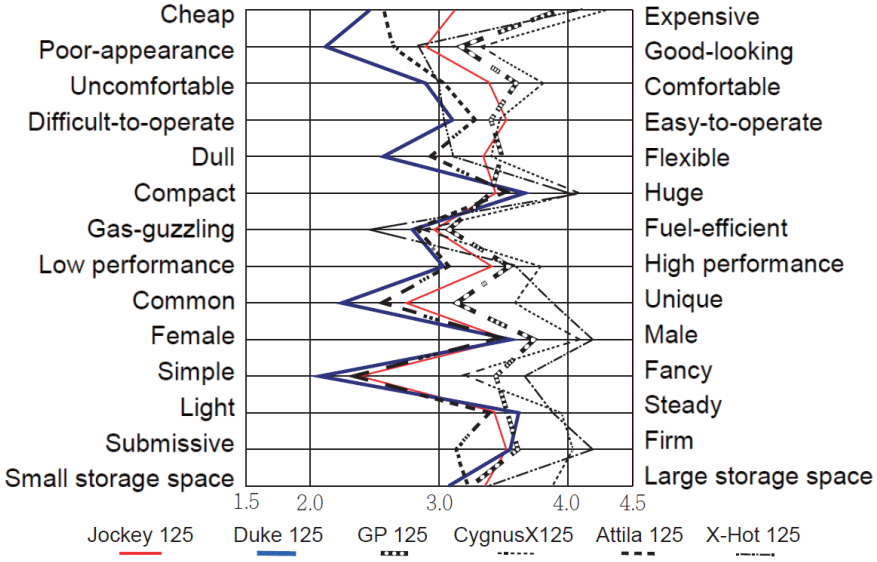

Figure 3: Line chart of 125C.C analysis

5.3. Average values and line chart for males and females' evaluations of motorcycle

Table 8 lists male and female samples' evaluations of all motorcycles are summarized. From line chart we can see males and females don't have significant difference in "tacky-elegant", "difficult-to-operate and easy-to-operate", "gas-guzzling and fuel-efficient" and "simple-fancy". Significant perceptive differences are in "compact-huge", "low-performance & high-performance", "male-female" and "light-steady". It's apparent that males and females have different demands and evaluations of operation due to physiological diversities as shown in figure 4.

Table 8: Statistics of male and females' evaluations

Semantic \ Model	Male		Female	
	A*	S**	A	S
1. Cheap - Expensive	3.27	1.31	3.59	1.09
2. Poor-appearance - Good-looking	2.93	1.07	3.03	1.09
3. Uncomfortable - Comfortable	3.16	0.92	3.41	1.02
4. Difficult-to-operate - Easy-to-operate	3.48	0.96	3.43	1.01
5. Dull - Flexible	3.32	1.03	3.33	1.03
6. Compact - Huge	3.12	1.16	3.43	1.18
7. Gas-guzzling - Fuel-efficient	3.01	0.99	2.95	0.99
8. Low performance - High performance	3.13	0.97	3.47	0.97
9. Common - Unique	3.08	1.10	3.20	1.13
10. Female - Male	3.20	1.15	3.50	1.22
11. Simple - Fancy	2.96	1.10	2.98	1.15
12. Light - Steady	3.08	1.09	3.40	1.13
13. Submissive - Firm	3.17	1.10	3.43	1.15
14. Small storage space - Large storage space	2.88	1.07	3.33	1.15

*A: Average **S: Standard deviation

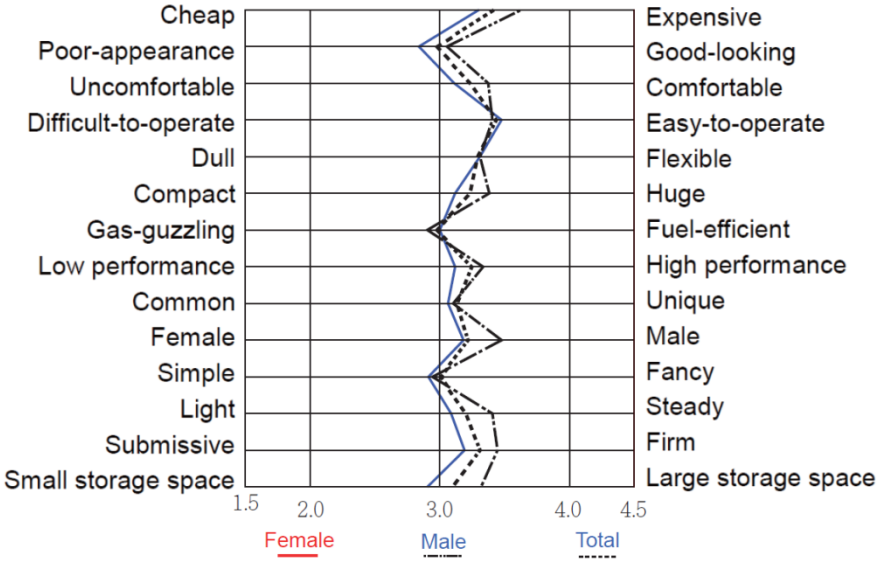

Figure 4: Line chart of male and female differential analysis

5.4. Average values and line chart for young and middle-aged generations' evaluations of motorcycle

Table 9 lists statistical analysis of young (18-35years) and middle-aged (36-55 years) groups' evaluations of all motorcycles show that middle-aged people's evaluations of each item are higher than youths. The two groups are significantly different in cheap-expensive, common-unique, compact-huge and low-performance-high-performance. Young people pursue cool appearance,

think such motorcycle has high value and thus form a perception of low price. They also make refitting because motorcycles are not unique. Middle-aged people think motorcycle has sufficient performance because their physiological responses are slow; this group focuses on convenience and believes motorcycle should have a large volume. As illustrated in figure 5, males and females have no significant difference in operation and dull-flexible.

Table 9: Statistics of young and middle-aged generations' evaluations

Semantic \ Model	Young Generation		Middle-aged generation	
	A*	S**	A	S
1. Cheap - Expensive	3.33	1.25	3.61	1.12
2. Poor-appearance - Good-looking	2.94	1.13	3.05	1.01
3. Uncomfortable - Comfortable	3.25	1.01	3.35	0.92
4. Difficult-to-operate - Easy-to-operate	3.45	1.00	3.47	0.95
5. Dull - Flexible	3.31	1.07	3.35	0.95
6. Compact - Huge	3.23	1.24	3.36	1.07
7. Gas-guzzling - Fuel-efficient	2.98	1.03	2.99	0.93
8. Low performance - High performance	3.22	1.00	3.45	0.92
9. Common - Unique	3.05	1.18	3.29	0.98
10. Female - Male	3.35	1.19	3.36	1.22
11. Simple - Fancy	2.92	1.18	3.07	1.03
12. Light - Steady	3.20	1.18	3.31	1.01
13. Submissive - Firm	3.25	1.17	3.39	1.07
14. Small storage space - Large storage space	3.06	1.17	3.19	1.06

*A: Average **S: Standard deviation

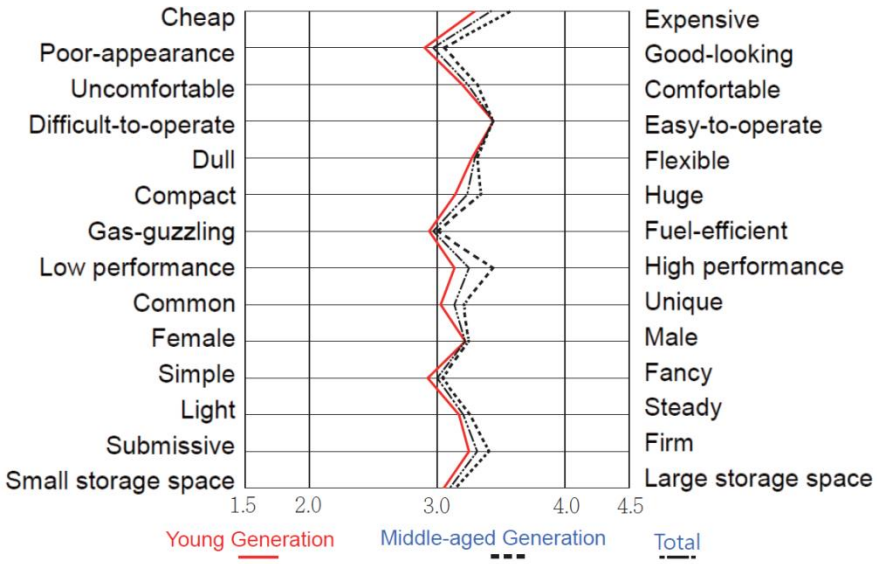

Figure 5: Line chart of generation difference analysis

6. FACTOR ANALYSIS AND SPACE COORDINATES DISTRIBUTION

6.1. Statistical results of factor analysis

This study utilizes factor analysis to reduce semantic spatial dimension and obtain proper number of factor dimensions and number of factors. SPSS software is used for statistical analysis and extracting factors with eigenvalue above 1. Through scree plot , three factors are determined and respectively named as Appearance factor, Design factor and Operability factor as listed in table 10.

Table 10: Factor analysis of evaluation words

Content	Factor 1	Factor 2	Factor 3
12. Light - Steady	.853	.043	-.057
06. Compact - Huge	.838	.080	-.124
13. Submissive - Firm	.825	.162	-.031
10. Female - Male	.824	.105	-.076
14. Small storage space -Large storage space	.735	.101	.115
08. Low performance - High performance	.557	.410	.359
09. Common - Unique	.188	.825	.147
11. Simple - Fancy	.012	.823	-.027
01. Cheap-Expensive	.327	.731	.087
02. Poor-appearance - Good-looking	.016	.615	.339
04. Difficult-to-operate - Easy-to-operate	.018	.039	.820
05. Dull - Flexible	- .099	.342	.726
03. Uncomfortable -Comfortable	.282	.199	.679
07. Gas-guzzling -Fuel-efficient	-.254	-.028	.643
Feature value	4.669	2.892	1.418
Explained variance %	28.12	18.96	17.05
Cumulative variance %	28.12	47.08	64.14
Factor denomination	appearance	design	Operability

6.2. Explanation of factor analysis naming

1. Factor 1-appearance: explained variance of this factor is 28.12%. There're six pairs of words, most of which evaluate overall appearance and volume of product, such as light-steady and compact-huge. Therefore, this type is named appearance factor with "compact & light-huge & steady" as spatial scale sample.

2. Factor 2-design: explained variance of this factor is 18.96%. Four pairs of words mainly describe people's feeling of the product like quality and distinctiveness , e.g common-unique and simple-fancy. These evaluations result from design of motorcycle model, so this factor is named as design factor. "Common & simple-unique & fancy" is the spatial scale sample.

3. Factor 3-operability: explained variance of this factor is 17.05%. Four pairs of words are all related to motorcycle operability such as "difficult-to-operate and easy-to-operate", "dull-flexible". Therefore, it is named "operability factor" with "dull-flexible operation" as spatial scale sample.

6.3. Coordinate space analysis for cognition and evaluation of motorcycle

This study extracts three typical factors from cognition and evaluations of 10 motorcycle models, and scores of these three factors are listed in table 11. Then, two-dimensional coordinate is used to present the ten models' distribution conditions of two image space coordinates-"appearance and design" and "appearance and operability".

6.3.1. Appearance and design factors

Figure 6 illustrates cognition-evaluation coordinate distribution of appearance and design factors. In the first quadrant there are CygnusX 125, X-Hot125, GP 125, RS-Z 100 and BUBU100, all

belonging to high-price and sport-style models. “Many” in the second quadrant is a preppy-look model more suitable for females. Jog in the third quadrant features reasonable price, submissive property and being economical. In the fourth quadrant, Jockey is a major economical model of KYMCO while Attila125 and Duke 125 are early-stage models in conformity with a fact that motorcycles of that time are generally cheap. From coordinate space we can see 125cc models are usually huge and steady while 100cc models are compact and light.

Table 11: Motorcycle evaluation factor score

Product\factor score	Factor 1	Factor 2	Factor 3
	appearance	design	operability
1. Jockey 125	0.46	-0.20	0.33
2. Many110	-0.79	0.43	0.59
3. Jog 100	-0.49	-0.49	0.40
4. Duke 125	0.47	-0.74	-0.10
5. BUBU 100	0.40	0.51	0.43
6. GP 125	0.53	0.49	0.45
7. CygnusX 125	1.00	0.66	0.38
8. RS-Z 100	0.52	0.55	0.39
9. Attila 125	0.34	-0.43	0.07
10. X-hot 125	0.92	0.68	-0.09

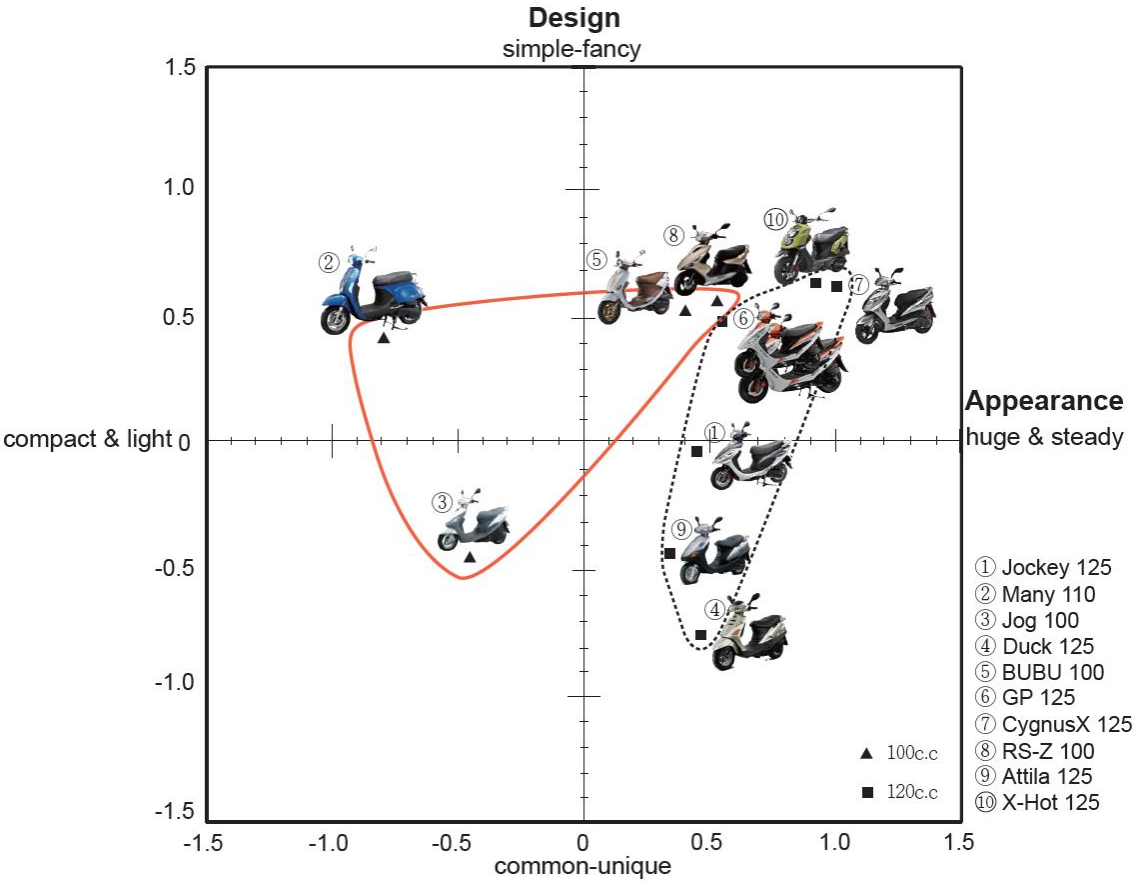

Figure 6: Coordinate spaces of appearance and design factors

6.3.2. Appearance and operability factors

With respect to distribution of cognition-evaluation coordinate constituted by appearance and operability factors, the first quadrant includes six models: CygnusX 125, GP 125, Attila125, RS-Z 100 and BUBU100. There are only two models in the second quadrant: Many110 and Jog 100. In the fourth quadrant we can find Duke 125 and X-Hot 125. It's clear that 100cc models are generally considered as "easy-to-use". The reason is probably that the compact and flexible characteristics meet users' needs. Particularly, X-Hot is evaluated as "unique" and "fancy" in terms of design, but "dull" and "difficult-to-operate" in terms of usage. It is might because this model is positioned as "personalized".

7. CONCLUSIONS AND SUGGESTIONS

This study conducts three-stage survey-field observation & interview, questionnaire and SD cognition evaluation-among young and middle-aged males and females in Taiwan. Then, evaluation factors are extracted after SPSS statistical analysis of survey results and space coordinate analysis is performed. Finally, following conclusions are drawn:

1. When purchasing motorcycle, young-generation males mainly consider acceleration performance and appearance style while females focus on light weight, small size, easy operation and large storage space. Middle-aged males' primary considerations include reasonable price and brand trust while females pay attention to conditions such as picking up children and shopping.
2. Young people are common in going to work or class. With respect of other purposes, proportion of leisure and recreation is higher in males. Common use for middle-aged people is "vehicle for short distance"; males mostly ride motorcycle for going to restaurant and shopping and females use motorcycle for picking up family members more frequently.
3. Statistical results of average values of SD-method cognition evaluation show 125c.c models make people feel expensive, steady, "large in storage space", firm, simple and suitable for male; 100c.c models provide senses of easy operation, comfort, soft shape and femininity. With regard to factor analysis results, three factors are extracted: appearance,
4. Results of spatial distribution of shape evaluation coordinate show that eight of ten samples are distributed in the first and fourth quadrants, indicating appearance of the motorcycle is large and steady. Such result is in agreement with the feature that motorcycle is a mechanical structural product full of weight sense. Next, six models distributed in the first and second quadrants receive a comment of distinctive and fancy shape; these motorcycles, expensive new patterns launched in recent three years, are favored by young generations. Four models distributed in the third and fourth quadrants are old motorcycles with an age of more than three years; with simple and ordinary appearance as well as firm and durable image, they are popular among middle-aged generations.Acknowledgments

The author would like to extend her appreciation to the National Science Council Gender and Science and Technology of Research Projects' "Oriented basic research" (program number NSC 102-2629-E-224-001) for its subsidies. Special thanks to the 114 respondents were involved in the questionnaires.

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Consideration of the frequency characteristics of a sound system in a traveling vehicle

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Abstract: We conducted a subjective evaluation experiment to determine the optimal frequency characteristics for a car audio system during vehicle travel . In this experiment, the car interior noise typically generated when a vehicle travels at a speed of 60 km/h was added to the experimental sound sources, and subjective evaluation was made of the sound passed through filters modifying the frequency characteristics. A total of 10 types of sound sources were used in the evaluation (narration, fusion, classic, J-pop, vocal, healing, nature, jazz, rock, and pop). Five levels of frequency characteristic filter (-5 to -9 dB/oct.), which augmented the bass in response to car interior noise, were used. The evaluation terms were 12 pairs of words related to sound quality, comfort, added value, and safety. Higher evaluation scores were given to items of palatability and safety in the vicinity of the -6 dB/oct. filter level, which augmented the bass to a level slightly below the frequency characteristic curve of the car interior noise (≃-7dB/oct.), and to items of sound quality and added value at the -9 dB/oct. filter level. Factor analysis was also conducted, to identify comfort, sound field, and clarity factors. Based on these factors, the filter results were compared. Higher comfort and clarity factor scores were obtained in the vicinity of the -6 dB/oct. characteristics versus those of other filters. These results confirmed that taking frequency characteristics into account in the performance of a car audio system during travel is effective in improving car interior comfort.

Keywords: car audio system, comfort, car interior noise, subjective evaluation

1. INTRODUCTION

In addition to safety and reliability, basic transport performance features are important requirements for recent vehicles. Among these, the car audio system in particular plays a pivotal role in determining the level of passenger comfort. Car interior comfort, however, is degraded by car interior noise, which typically increases with increasing car speed, due to various noise sources, including engine noise, muffled sound, noise from road surfaces, and wind roar (Figure 1), which detract from the sound reproduction of the car audio system. In response, systems capable of automatically adjusting the reproduced sound, to exceed the interior noise related to car speed, have been commercialized. Many of these systems, however, do not take into account the frequency characteristics of such interior noise, which is critical to improving the overall sound experience.

With the ultimate aim of achieving an optimal car audio system, a subjective evaluation experiment was conducted concerning frequency characteristic correction of reproduced sound, with respect to the frequency characteristics of traveling noise, and the effects of the proposed system were verified.

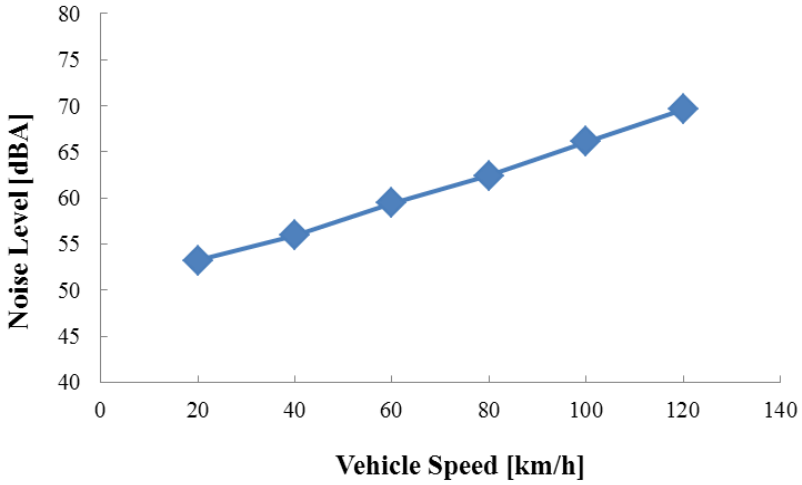

Figure 1: Relationship between car speed and car interior noise (compact car)

2. SUBJECTIVE EVALUATION EXPERIMENT

In this experiment, we created sound sources with the bass augmented by an equalizer in response to the noise characteristics of the car interior, and conducted a subjective evaluation of the respective sound sources with the addition of car interior noise.

2.1. Selection of Adjectives

Adjectives used as evaluation words in the experiment were determined through brainstorming, from the viewpoint of sound quality, palatability, added value, and safety, based on the assumption of car interior noise during car travel. A total of 12 specified adjective pairs are shown in Table 1. Each adjective pair was evaluated by the subjects on an evaluation scale of 1 to 7.

Table 1: Evaluation adjective pairs

Classification	Term	Evaluation adjective pair
Sound quality	Clarity	Clear — Fuzzy
	Spaciousness	Spacious — Confined
	Depth	Deep — Shallow
Palatability	Comfort	Comfortable — Uncomfortable
	Refreshment	Refreshing — Unrefreshing
	Palatability	Palatable — Unpalatable
Added value	Realism	Realistic — Unrealistic
	Classiness	Classy — Cheap
	Sharpness	Innovative — Conservative
Safety	Wakefulness	Wakeful — Soporific
	Concentration	Concentrating — Distracting
	Fatigue	Not fatiguing — Fatiguing

2.2. Experimental Stimuli

The sound sources (contents) used in the experiment included 10 types of sound: J-pop, fusion, narration, nature, healing, classic, vocal, jazz, pop, and rock (Table 2). To ensure that all the sound sources were heard at the same volume, the ITU loudness level of the respective sources was properly adjusted. The value of binaural loudness was also adjusted, to 14.1 sone, which is equivalent to the road noise at a speed of 60 km/h (recorded with a dummy head). Each sound source was passed through each of five filters, which augmented the bass between 100 Hz and 800 Hz by -5 dB/oct., -6 dB/oct., -7 dB/oct., -8 dB/oct., or -9 dB/oct., in response to the traveling noise of the car. To each sound source was added car interior noise at a speed of 60 km/h. Headphone characteristics were ignored. All sound sources were recorded with a dummy head.

Table 2: Sound sources

Genre	Name of piece	Artist
Narration	Woman's narration + man's narration + BGM	JAS - Impact2
Fusion	Forget Me Nots	Patrice Rushen
Classic	Piano Concerto In A Minor, Op. 54, 2. Intermezzo	Schumann
J-pop	Beginner	AKB48
Vocal	Toire no kamisama	Kana Uemura
Healing	Only Time	Enya
Nature	Sound of nature	Sound Design Japan
Jazz	Mori's Waltz	Yasuhiro Mori
Rock	I Was Born to Love	Queen
Pop	Born This Way	Lady GaGa

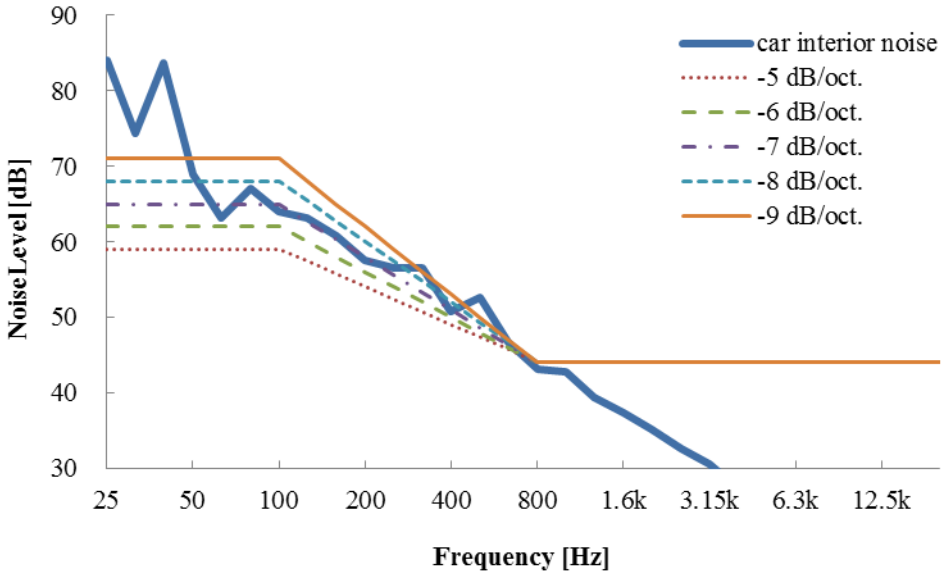

Figure 2: Frequency characteristics of the car interior noise of a compact car traveling at 60 km/h, with five filter types

2.3. Experimental Method

The experiment was conducted in a room less disturbed by noise. Figure 3 shows a schematic diagram of the experiment. Subjects sat on chairs, and the sound sources were presented through headphones (HD 595, SENNHEISER) from a music player (iPod nano, Apple). The subjects were requested to evaluate their impressions of the heard stimuli, using 12 adjective pairs on an evaluation scale of 1 to 7, as shown in Fig. 4. This procedure, counted as one test, was conducted for a total of 50 stimuli, or 5 frequency characteristic filters by 10 sound sources. Subjects were instructed to operate the music player by themselves, and allowed to replay the sound source as many times as desired. The adjectives and stimuli were randomly presented, to eliminate the order effect. The test was repeated 10 times per session, and a total of 5 sessions were conducted; 20 subjects, including men and women with normal hearing capability, were used. To avoid subject fatigue, tests were conducted with at least a one-hour interval between sessions and with a maximum of two sessions per day.

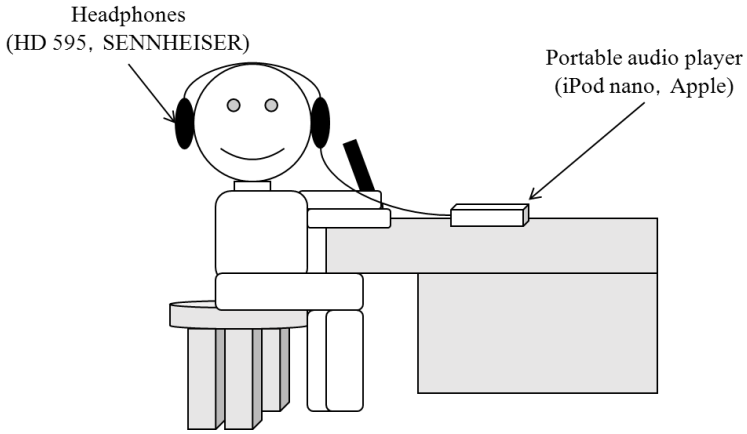

Figure 3: Schematic illustration of the experiment

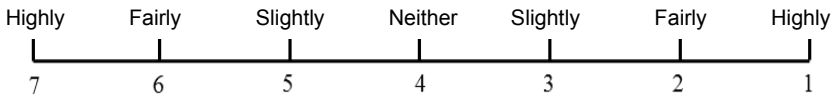

Figure 4: Evaluation scale (1 to 7)

2.4. Experimental Results

The results of the evaluation for the respective filters are summarized in Fig. 5, while the adjectives that showed specific results after a t-test are shown in Table 3. Among these, values with a significance level of 0.05 or less are shown in boldface. In the case of the evaluation items "comfortable" and "not fatiguing," the scores tended to decrease, after peaking at the -6 dB/oct. filter level, as the bass was augmented. In the case of the items "spacious," "deep," and "realistic," roughly increasing scores were obtained, from the -5 dB/oct. filter to a peak at the -9 dB/oct. filter, with increasing bass augmentation. In the t-test, a difference of significance was observed between the -6 dB/oct. filter and the -9 dB/oct. filter for the items "deep," "realistic," and "not fatiguing." In the case of the item "comfortable," a difference of significance was observed between the -6 dB/oct. filter and the -5, -8, and -9 dB/oct. filters, respectively.

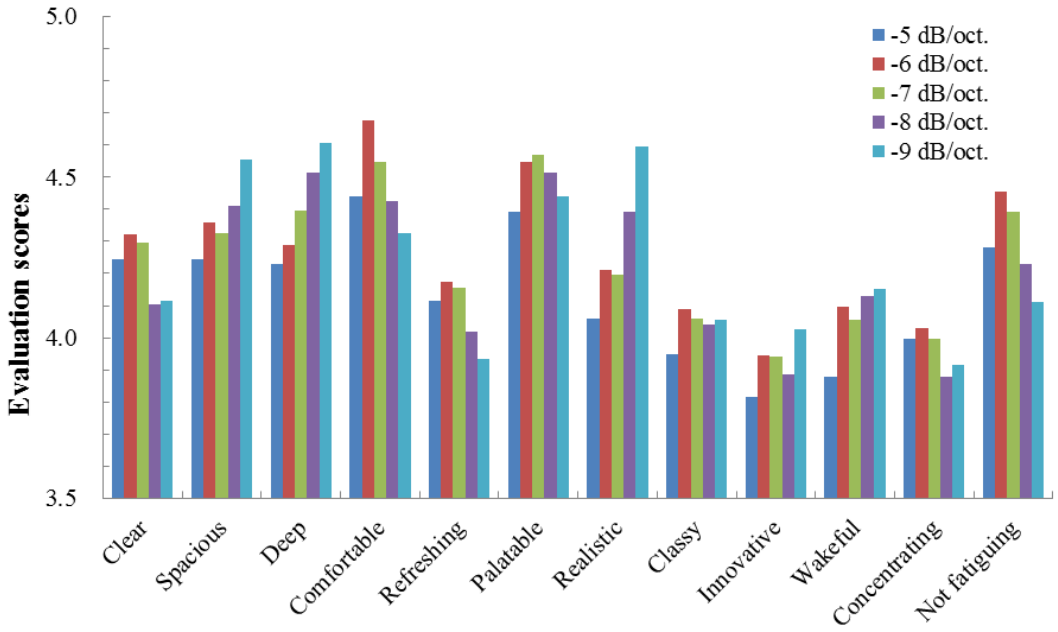

Figure 5: Evaluation scores for the respective filters

Table 3: T-test

Characteristic filter [dB/oct.]	Deep	Comfortable	Realistic	Wakeful	Not fatiguing
-5 vs. -6	0.591	**0.015**	0.211	0.054	0.112
-5 vs. -7	0.149	0.306	0.230	0.119	0.327
-5 vs. -8	**0.015**	0.897	**0.011**	**0.033**	0.676
-5 vs. -9	**0.004**	0.353	**0.000**	**0.015**	0.213
-6 vs. -7	0.377	0.212	0.890	0.723	0.533
-6 vs. -8	0.056	**0.020**	0.131	0.774	0.055
-6 vs. -9	**0.011**	**0.002**	**0.001**	0.626	**0.008**
-7 vs. -8	0.293	0.246	0.091	0.539	0.151
-7 vs. -9	0.066	**0.046**	**0.000**	0.448	**0.017**
-8 vs. -9	0.452	0.329	0.072	0.867	0.326

The results of factor analysis are shown in Table 4. The maximum likelihood method was used to determine the factors. As shown in the table, the first to third components have an eigenvalue of 1.0 or more, and their cumulative contribution ratio is 67%. Analysis of these first to third components, as the principal components, was conducted using the varimax method, and the results are shown in Table 5. As shown there, the first group of principal components showed high loads for evaluation words related to comfort, such as "comfortable," "not fatiguing," "palatable," "concentrating," and "classy." These components are therefore denoted as "comfort factors." The second group of principal components showed high loads for evaluation words related to the added value of the sound field, such as "deep," "spacious," "realistic," and "innovative," and are therefore denoted as “sound field factors.” The third group of principal components showed high loads for evaluation words related to clarity, such as "clear," "refreshing," and "wakeful," and are therefore denoted as “clarity factors.” Factor scores for each reproduction are shown in Fig. 6. The comfort factor had the highest score when the -6 dB/oct. filter was used, while the sound field factor showed increasing scores as the bass was increasingly augmented.

Table 4: Cumulative contribution ratios

Factor	Primary eigenvalue		
	Total	Variance ratio [%]	Cumulative contribution ratio [%]
1	**5.43**	45.24	**45.24**
2	**1.55**	12.87	**58.11**
3	**1.07**	8.87	**66.98**
4	0.78	6.53	73.51
5	0.66	5.53	79.04
6	0.48	3.97	83.01
7	0.44	3.67	86.68
8	0.41	3.39	90.07
9	0.38	3.19	93.26
10	0.32	2.68	95.94
11	0.27	2.29	98.22
12	0.21	1.78	100.00

Table 5: Factor matrix of post-varimax rotation

Adjective	Factor		
	1	2	3
Comfortable	**0.831**	0.289	0.137
Not fatiguing	**0.775**	0.067	0.016
Palatable	**0.739**	0.374	0.162
Concentrating	**0.713**	0.156	0.114
Classy	**0.516**	0.482	0.240
Deep	0.164	**0.701**	0.204
Spacious	0.261	**0.679**	0.210
Realistic	0.202	**0.633**	0.285
Innovative	0.097	**0.250**	0.227
Clear	0.428	0.285	**0.666**
Refreshing	0.527	0.243	**0.612**
Wakeful	-0.067	0.138	**0.268**

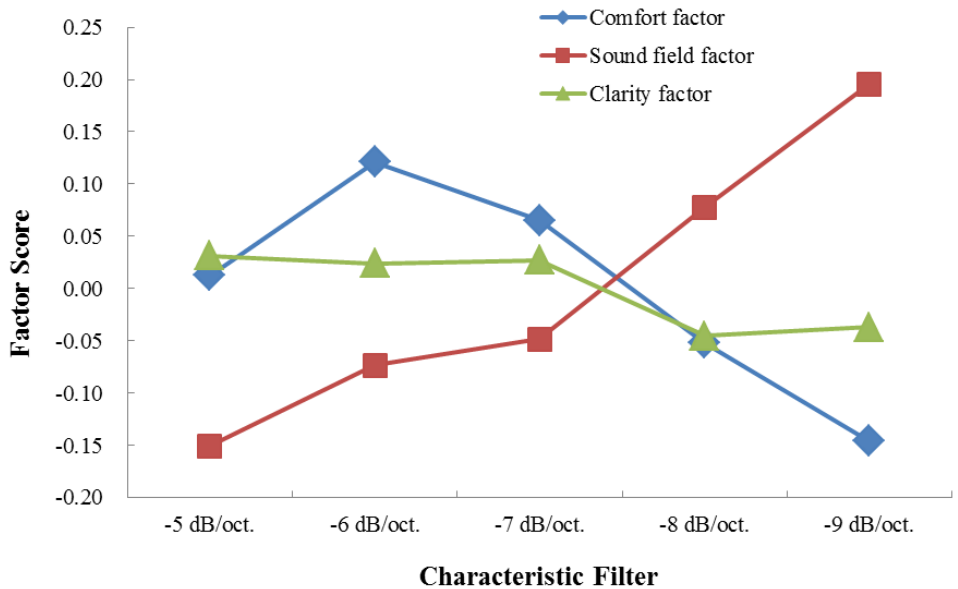

Figure 6: Factor scores

3. DISCUSSION

The experimental results show that in the case of the evaluation items "comfortable" and "not fatiguing," the scores tended to decrease, after peaking with the -6 dB/oct. filter, as the bass was augmented. It is thus apparent that, though augmenting the bass to compensate for car interior noise improves the overall sound, it is important not to overemphasize this augmentation. In the case of the items "spacious," "deep," and "realistic," higher scores were obtained as the bass was increasingly augmented. However, although these items depend on the loudness of the bass, since such items as "comfortable" and "not fatiguing" are important factors for vehicle operation, it is clearly necessary to be careful not to overly augment the lower range.

Among the three factors emerging in the factor analysis, comfort and clarity showed the highest scores with the -6 dB/oct. filter, while the sound factor showed increasing scores with increasing bass augmentation. This analysis suggests that comfort may be improved by augmenting the bass to a level roughly equal to that of the car interior noise.

The above results suggest that taking into account the frequency characteristics of car audio system sound during is effective in improving comfort.

4. SUMMARY

In the present study, a subjective evaluation experiment was conducted concerning reproduced sound, which took into account the frequency characteristics of car interior noise during car travel, and the results were verified.

The evaluation experiment was conducted using experimental stimuli consisting of 10 types of sound source, screened through 5 frequency characteristic filters designed to augment the bass, with typical car interior noise (at 60 km/h) being added to each sound source. The evaluation terms were 12 adjective pairs related to sound quality, palatability, added value and safety. The results of the experiment showed that the -6 dB/oct. filter, which augmented the bass to a level slightly below the frequency characteristic curve of the car interior noise (-7 dB/oct.), had higher evaluation scores for items of preference and safety; and that the -9 dB/oct. filter had higher scores for sound quality and added value items. Factor analysis was also conducted, to identify comfort, sound field, and clarity factors. Comparison based on the factor scores showed that higher scores were obtained in the vicinity of the -6.0 dB/oct. characteristics than those of other filters, in terms of the comfort and clarity factors. Thus, it is suggested that car interior comfort can be improved by augmenting the bass to a level roughly equal to that of road noise.

The above results confirmed that taking into account the frequency characteristics of car audio system sound during travel is effective in improving car interior comfort.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Research on the Latest Decision-Making Style in Automobile Design Development

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Abstract: Prior research has looked at the relationship between decision-making style and design strategy in the automotive industry. Table 1 shows the features derived from the prior research of automobile manufacturer's decision-making styles in Japan, Europe, and the U.S. The decision-making style of Japanese companies differs from that of European and American companies, in that (1) the frequency of decision-making is higher, (2) there is a greater diversity of members in the decision-making process, (3) the number of members involved in decision-making is larger, and (4) group consensus and guidelines are used as decision-making criteria. However, there have been changes in recent years in so called 'panel evaluation' methodology, with moves to include the best features of the Japanese and European/US models. This paper also contains the results of analysis comparing these to Korean manufacturers, which have been creating an increased presence in global markets in recent years.

Keywords: Design management, design decision-making, panel evaluation, design screening

1. RESEARCH BACKGROUND (OVERVIEW OF PRIOR AND LATEST RESEARCHES)

Prior research (Reference 1) focused on the decision-making styles of the automotive industry, and examined the differences between Japan, Europe and the U.S. In particular, it used "1. Frequency of decision-making", "2. Diversity of members", "3. Number of members" and "4. Criteria for decision-making" as common indicators in identifying regional differences (see Table 1). An overview of this research is provided as below.

With regards to the first indicator, "frequency of decision-making", Japan is the highest, with the

U.S., the second, and Europe, the least. One characteristic of Japanese automotive companies is that the frequency of decision-making in formal situations is low, but that of decision-making in informal, deliberation situations is high. European automobile companies have the highest frequency of formal decision-making, because their development periods are longer than those of the other two regions.

With regards to the second indicator, “diversity of members”, too, Japan is the most diversified, followed by the U.S., and then, Europe. In Japanese automobile companies, many departments participate in decision-making, such as Engineering, Planning, Sales, and Accounting. Furthermore, the members participating in decision-making are not limited to the leaders responsible for those departments. In contrast, in U.S. automobile companies, several design executives and top management, as well as representatives from sales and several other departments, participate in the decision-making. The decision-making members represent a relatively wide variety of organizations, but they hail from a notably narrow section of company hierarchy. Only managers responsible for each department participate in meetings. In contrast to Japan and the U.S., in European automobile companies, decisions are made mainly by directors in charge of design and development-related top executives, while sales personnel seldom participate in meetings.

Table 1: Features of Decision-Making Styles of Automobile Companies in Individual Regions

Title 1	Japan	Europe	US
1. Frequency of decision-making (meetings / clinics)	Formally 2-3 times (however, there are approximately 10 informal deliberation meetings and preliminary study meetings). Clinics are divided into in-house and external, and are performed for each screening (with sample sizes of approximately 100 members).	There are 3 or 4 decision-making sessions (due to long development periods). Clinics are performed routinely, roughly twice.	There are 3 or 4 decision-making sessions by top executives. 4 or 5 clinics are also always held, with large sample sizes (1,000 or more members).
2. Diversity of decision-makers	Related personnel from many departments, such as Engineering, Planning, Sales, and Accounting participate (not all participants are top department personnel).	Limited to design executives and top management and development executives, with almost no participation by sales personnel.	Design executives, several top management executives, and sales and other certain personnel.
3. Number of decision-makers	Many (several dozens)	Few (only a few people)	Moderate number (approx. 10 people)
4. Decision-making criteria	Consensus by many top management executives and related executives (guidelines are also used).	Reviewed by top executives at last stage (Planning / Design / Brand executives are influential).	Chosen based on clinic results. Design executives have broad decision-making authority, while top executives only confirm decisions.

With regard to the third indicator, “the number of members”, again, Japan is the largest, followed by the U.S. and Europe. In Japanese automobile companies, a large number of members

participate in meetings (for example, more than 40 personnel participate in the meeting in case of Toyota). In contrast, the number is moderate (approx. 10 members) in U.S. automobile companies, and small (only a few members) in European companies.

With regards to the fourth indicator, “decision-making criteria”, Japanese automotive manufacturers use a collegial system (including use of guidelines), while U.S. automotive manufacturers place more importance on the results of *clinic* surveys (targeted potential user-focus groups testing of designs currently under development, gathering their impressions and opinions) conducted in advance. The U.S. is home to many immigrants, with a diversity of races, values, and cultures, so American companies create manuals and promote transparency in their design decision-making systems, ensuring that they are not dependent on individual skills. More specifically, they conduct preliminary marketing research before making design decisions, and make their choices based on the results of this research, enhancing transparency in decision-making transparency. Unlike Japanese and U.S. companies, European automotive manufacturers strongly tend to first focus on brand consistency and continuity, so design managers and design directors lead discussions and make decisions on the quality of designs, based on guidelines established to ensure this consistency and continuity.

After summarizing the above research results, we also carried out interviews and investigated the design decision-making processes of Korean automobile manufacturers, whose presence has rapidly grown. An overview of this research is provided as below. (See Table 2)

Table 2: Features of Decision-Making Styles of Korean Automotive Companies

Frequency of decision-making (meetings / clinics)	As with European and U.S. manufacturers, roughly 3 to 4 times, with approximately 10 design screenings.
Diversity of decision-makers	After sufficiently narrowing down at design centers, decisions are made primarily by design executives invited from Europe and the U.S.
Number of decision-makers	Small number to moderate number
Decision-making criteria	Ultimately decided by the authority of the president, based on design executive criteria
Other (strategy, features, etc.)	* Korean manufacturers are refining development strategies with Toyota as their largest target * The decision-making process is not as simple as that of European and U.S. companies, but compared to Japanese companies it seems to be less swayed by informal discussions and interpersonal relationships * The Korean people’s mentality of respecting swift action and individuality forms, for better or for worse, the foundation for speedy decision-making

Based on these study results, it would be fair to characterize Korea automobile manufacturers’ design decision-making style as lying somewhere between Western and Japanese styles, a new approach to decision-making which takes the good points of both styles. This approach can be said to come from the fact that as the industry developed, it actively adopted technology and know-how from both Japanese and Western manufacturers, resulting in the establishment of a style which kept the strengths of both.

2. RECENT TRENDS IN DESIGN DECISION-MAKING

2.1. Trends in the Design World

Ever since the collapse of Lehman Brothers, which had a tremendous economic impact, many companies in Japan and around the world have been forced to streamline and reorganize their companies. The development of distinctive and original products has become an urgent challenge for manufacturers. In particular, competitive superiority in design is an important key to increasing product value, together with the increased competitiveness created by reducing costs.

As companies around the world struggle in their efforts to survive, Toyota, leader of Japanese automotive industry, launched a new regime in 2012. This was realized based on the company's desire to make even more sweeping design changes and create original designs that would stand at the forefront of the global automotive world. The company has overhauled its organizations and the holders of design executive positions, actively appointing young designers, and started to adopt a new decision-making style, shifting to a model in which design decisions are made by a small number of decision-makers. As shown in the survey results table above, these efforts of Toyota can be called reforms aimed at achieving the strengths of European, U.S., and Korea companies, such as their rapid decision-making.

2.2. New Approaches to Conventional *Panel Evaluations*

The *panel evaluation* system has become an essential part of Toyota's decision-making process, with the system being repeatedly improved, but this has also had negative effects. One, for example, is that the company has shown a tendency to aim for the *neutral*. One aspect that has been pointed out is that there is a tacit panel evaluation 'pass' score for approval, and committee members (executives) participating in the design decision-making discussions are influenced by such scores. Driven by the desire to change this approach, it was decided as the inaugural project of the new system to change the panel evaluation approach used in the development of the new Model 86, which held a special place in the heart of the new president.

2.3. The Project 86

We verified the new decision-making method used in the development of the new Model 86, Toyota's first sports car in a long while.

The background behind the development, and thoughts of the chief engineer (the person responsible for overall management of development) are described as below.

As Japan's automobile industry has matured and diversified, sports car model has been discontinued one after another. The same has been true for Toyota. Lagging sales of the MR-S and Supra resulted in the models no longer being profitable, and, spurred by the recession, production was discontinued. For a time, Toyota had no sports car models. However, sports cars have ardent fans, and popularity remained high for rare used sports cars and foreign cars. Young people are losing their interest in cars, and Toyota, in order to restore the allure and dream of cars, believed that it was important to propose new styles, which would pursue the "fun to drive" attraction of cars to its ultimate extreme, while at the same time responding to environmental and other demands of the day. They also believed that the key to the success of the sports car would be in creating new added value, such as by creating environments and opportunities that would provide greater joy to users. Toyota also had a history of famous FR sports cars that even today maintain an overwhelming level of popularity, such as the S800, the 2000GT, and the 86 (original model), and it heard the voices of those calling for these cars to be rolled out again.



Figure 1 Previous Model 86



Figure 2 New Model 86

In particular, since the launch of the original 86, users and various tuning venders have been developing tuning parts. Their efforts helped make the model a classic, and one of the few sports cars that is truly user-centric. The chief engineer decided to bestow the name of "86" on the newly developed sports car model, carrying on the spirit and history of the sports car.

The chief engineer, wanting to develop a sports car with the spirit of the good old days, but meeting modern needs through cutting-edge technologies, decided to go back to basics and change the car design process from the ground up. His goals were twofold. "Creation of a car based not on numbers, but on pursuing the ultimate in fun," and "a level of individuality that creates strong opinions, both pro and con, instead of an automobile project based on internal consensus."

2.4. New Movement in the Design Division

The design division followed the chief engineer's lead, deciding to greatly overhaul their own design decision-making process. They were led by a conviction that when developing a sports car, the standard consensus-driven decision-making process, in which the tastes and opinions of many people are reflected, would prevent the creation of individualistic designs, the achievement of the designers' ideals, and the production of a design that would surprise people at a visceral level. They decided to select "sports car *panelists*" for their internal *panel evaluation* (a system that engages employees who were not involved in development but matched to customer characteristics to evaluate designs of vehicles still in the development phase), get feedback that closely reflected the opinions and tastes of potential customers, and make design decisions with a very limited members. They created a list of sports car drivers inside the company, had them give their evaluations of and comments regarding sketches and design prototypes added them to the *general panel evaluation* results, and reported the results to the design deliberation committee. The model positively evaluated by this special panel differed completely from that selected by the general panelist evaluation, and the scores of the two groups clearly diverged. In the end, the model (design) which was positively evaluated by the sports car panelists was selected as the production model, and, as hoped for, the car received a lot of buzz for its unique design.

3. BIRTH OF A NEW PANEL EVALUATION SYSTEM

Amidst the challenges for recovery from the collapse of Lehman Brothers and the struggles of the automotive industry for survival, Toyota also faced design-related difficulties. When the company introduced the Lexus brand, the brand's designs had a tremendous impact worldwide, but in recent years, it had been chased closely by the designs of European and Korean manufacturers, and its superior position had become precarious. The engineering division found

itself in the same predicament as the design division. In particular, the novelty and originality that had been so pronounced when the Lexus brand was launched had weakened. The top executives turned the Lexus brand into an internal split-up company, and decided to clearly separate it from the Toyota brand, in order to ensure its position of superiority, and exclusively work on developing designs and technologies that would be at the forefront of the global automotive industry.

The design decision-making processes used by Japanese automotive manufacturers such as Toyota was to present the results of panel evaluations using a seven point scale to executives at deliberation committee meetings, using the results as reference data for decision making. Interviews with Toyota showed that although these evaluations were called 'references', in reality, depending on the model and type, there were required threshold scores which had to be met for the vehicles to be approved. In other words, the panel evaluation results, which were supposed to be nothing more than reference data, were functioning as an implicit consensus criterion.

Our latest interviews found that scores have not been reported in design deliberation committee meetings in the past few years (especially since the head of the design division changed). However, the panel evaluations themselves are still carried out, and related divisions analyze the panel evaluation results, using them for reference, and the results are used in opinion summaries by each division. Nonetheless, panel evaluation results are no longer reported as scores in official design deliberation committee meetings, instead, only opinions and comments from the evaluations are presented. Also, with the conversion of Lexus into an internal split-up company (as Lexus International), deliberations are held independently, and decisions are made by small groups, with 10 or fewer executives in attendance. Compared to the past, when almost 50 related executives would attend, as well as the respective managers, and consensus would be sought within this large group, the current Japanese decision-making style has clearly shifted to a more Western one. Because the vehicles designed using this new approach have yet to be launched, time has yet to tell whether this approach is appropriate, but looking at the distinctive Toyota designs shown at recent motor shows, it is clear that tremendous changes are taking place.

4. CONCLUSIONS

Research performed since 2009 into design decision-making has found that (1) Japanese decision-making in design development is changing from a model in which consensus is reached by members from a large number of related divisions to a more European and American model in which decisions are made by a small number of top management, and (2) because of its effectiveness, the panel evaluation system is still being used, but the reporting of scores is seen as having a negative impact on decision-making, and is being phased out. The method of reporting scores can appear to be a method of providing what seems to be objective data, but it lacks rigor with regards to the meanings of scores and the potential for score manipulation, and indicates that concerns about the reliability of score results have not been dispelled.

The car models developed with Toyota's new method have not yet been launched, so the efficacy of the method cannot be verified, but once models featuring designs decided on with this new decision-making style are released into the market and when it becomes possible to confirm how they have been evaluated, we would like to compare and verify Japanese, European, American, and Korean decision-making styles again, including the verification of this new evaluation system.

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BIOGRAPHY

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Noboru Koyama is a professor, Master Program of Innovation for Design and Engineering, Advanced Institute of Industrial Technology, Tokyo Japan. He was a Specially Appointed Professor, International Design Management Research Center (IDMRC), Kyoto Institute of Technology(KIT) in 2009-2010. He received M.I.D. from Pratt Institute, New York. He was an Assistant Director of Toyota Commemorative Museum of Industry and Technology, and was an Executive Manager of Calty Design Research, USA. He was engaged in designing automobile design at Toyota Motor Corporation after he graduated from Chiba University. He is a member of Japan Society of KANSEI Engineering (JSKE), Japanese Society for the Science of Design(JSSD) and Japan Industrial Designers' Association(JIDA). His current interests are Design Management and Communication Design.

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2D - Virtual Matter

Utilizing Real-time Human-Assisted Virtual Humans to Increase Real-world Interaction Empathy

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Abstract: Empathy is an important aspect of interpersonal communication skills. These skills are emphasized in medical education. The standard source of training is interviews with standardized patients. Standardized patients are trained actors who evaluate students on the effectiveness of their interviews and diagnosis. One source of additional training is interviews with virtual humans. Virtual humans can be used in conjunction with standardized patients to help train medical students with empathy. In this case, empathy training took place as part of a virtual human interaction that represented a patient suffering from depression. However, computers cannot accurately rate empathy, and we thus propose a hybrid experience. We propose a hybrid virtual human approach where hidden workers assist the virtual human. Hidden workers provide real-time empathetic feedback that is shown to the students after their interaction with the virtual human. The students then interview a standardized patient. All empathetic feedback and ratings are based on the Empathic Communication and Coding System (ECCS) as developed for medical student interviews. Fifty-two students took part in the study. The results suggest that students who received feedback after their virtual patient interview did provide more empathetic statements, were more likely to develop good rapport, and did act more warm and caring as compared to the control group that did not receive feedback.

Keywords: Virtual, human, empathy.

1. INTRODUCTION

Empathy is an integral part of a medical student's interviewing skillset. The display of empathy on the part of the interviewer can lead to more satisfying and honest interactions. These improved interactions in turn lead to better medical resolutions (Hojat et al., 2010).

Empathy is the ability to view the world from another person's perspective while identifying their

feelings and experiences. We investigated the impact of hidden workers on the empathy of medical students as they interviewed standardized patients after having interviewed a virtual patient. Empathetic feedback from hidden workers was found to increase several aspects of the standardized patient interaction including empathy, rapport, and caring.

Empathy can be divided into four different forms that are of concern to the medical student or doctor when interviewing a patient: emotive, moral, cognitive, and behavioral. Emotive empathy is the imagining of the patient's emotions. Moral empathy is empathizing with those patient emotions. Cognitive empathy is identification of those emotions, and behavior empathy is conveying understanding of those emotions back to the patient (Teherani, Hauer, & O'Sullivan, 2008).

Empathy is an integral part of a medical student's interview with a standardized patient. A standardized patient is a trained actor who plays the role of a patient with a medical problem and provides constructive feedback.

While useful, standardized patients suffer from drawbacks concerning cost, scheduling, and variability (Stevens et al., 2006) which are not an issue with virtual humans. Virtual humans are playing an increasingly important role in the training of medical students in interpersonal communication skills including empathy. Virtual humans provide a secure sandbox for students to assess patients and receive feedback.

While strides forward have been made in automatic detection of empathy (Mcquiggan, Robison, Phillips, & Lester, 2008), these facets of empathy recognition and feedback are currently best accomplished by humans. Humans can fill in this gap in the underlying algorithms that govern virtual human behavior and can do so without the drawback of traditional standardized patients.

In this paper, we focus on empathetic feedback and the use of a real-time hybrid framework that utilizes hidden workers to assist a virtual human. In our proposed framework, these workers provided ratings for different moments of empathy encountered by the user.

In order to keep the hidden workers busy, they also assisted the virtual human matching algorithm which will be mentioned later for completeness. However, in this paper, we focus primarily on the role of hidden workers' evaluation of empathy, and its resulting impact on learners' empathy with humans.

Using this framework, we conducted a study using hidden workers with a virtual human designed to represent a patient suffering from depression. The workers were trained on both the Empathic Communication and Coding System (ECCS) rating scale (Bylund & Makoul, 2006) and the hidden worker system and were familiar with the scenario.

2. RELATED WORK

Empathy is an important aspect of the doctor-patient relationship. Increased empathy has been shown to improve interpersonal communication and promote therapeutic alliance (Charon, 2001). Increased empathy also results in higher patient satisfaction with their physician and promotes an honest interaction that leads to better medical outcomes (Hojat et al., 2010).

Empathy is regarded as a necessary component to medical student training. However, Hojat et al. (2009) conducted a longitudinal study which showed that as medical student training progresses, the empathy displayed by students decreases.

As part of their education, medical students are exposed to various new technologies. Mohr, Moreno-Walton, Mills, Brunett, and Promes (2011) finds that new medical students are comfortable with the use of new technologies for training. One such technology is virtual humans.

Virtual humans are an additional component to medical student training that can be used for interpersonal communications training. Deladisima et al. (2007) found that virtual humans can elicit the same empathetic response that standardized patients can. Overall, the empathetic response is less with a virtual human than for a real human. However, measured empathy increases the same way it would for a real human interaction. In this case though, the virtual humans did not provide explicit feedback to the students on their empathy performance.

Empathy recognition and its associated feedback are still the domain of humans despite recent improvements (Mcquiggan et al., 2008). So, crowdsourcing techniques can be consulted to allow real humans to be incorporated into the virtual human system.

Humans have previously been utilized to assist computer algorithms in a number of domains. Bigham et al. (2009) used hidden workers to assist in identifying images for the blind using a mobile phone app called VizWiz. Snow, O'Conner, Jurafsky, and Ng (2008) evaluated workers on performing linguistic annotations and found small groups to be on par with expert evaluation. Su, Deng, and Fei-fei (2012) also utilized workers in order to assist in image annotation. All of these various applications illustrate the benefit of human assistance to algorithms. This benefit also applies to the empathy domain in which algorithms struggle to identify what humans can readily rate.

Another similar example is the use of a real-time crowd by Lasecki et al. (2012) in Chorus. Here, humans were used in small groups to assist a Siri-like interface with answering questions. The workers for Chorus were recruited from Amazon's Mechanical Turk marketplace. This is a marketplace for microtasks where workers are paid a few cents to a few dollars to complete some small task.

While recruitment for microtasks from Mechanical Turk was considered, Mason, Street, and Watts (2009) found that payment and duration of task do not indicate a worker's level of skill. Further, the workers for rating empathy must be trained and familiar with a specific coding system. So, local, expert workers were recruited to assist our virtual humans.

3. CONVERSATION SYSTEM

Virtual People Factory (VPF) is a web-based tool for the creation and improvement of virtual humans (Rossen, 2012). VPF facilitates online, text-based virtual human interactions. The VPF interface is shown in Figure 1.

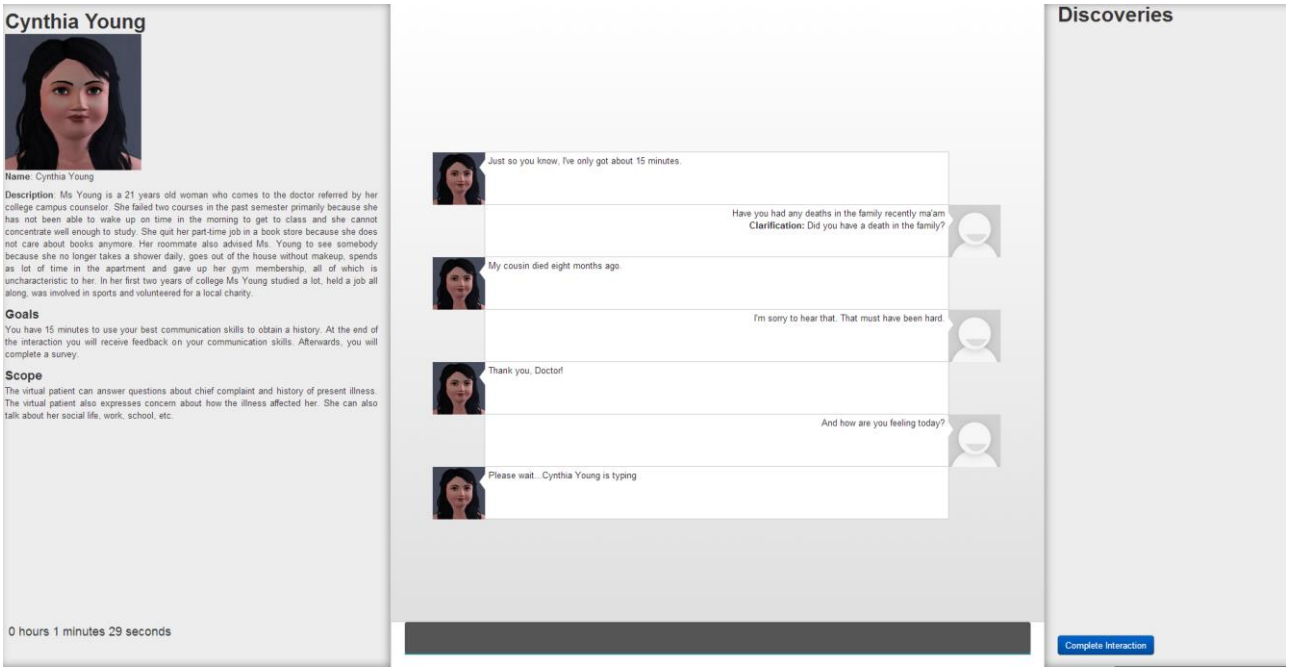

Figure 1: Screenshot of the Virtual People Factory Interface. Using VPF, students conducted a doctor-patient interview using a typed, chat-based interaction.

Here, a user is presented with basic information about the virtual human on the left. On the top-left is a picture of the character, and below that is basic information including the character name and a short description of the case. There is also basic information as to the goals and scope of the interaction. In the center is the main interaction area that contains the transcript and the input to allow a user to type in a question.

Once a user types a question and presses enter, the matching algorithm consults a corpus. A corpus is a structured set of questions and answers that the virtual human can compare its input to and select a response. If the confidence of the response is above a minimum threshold, the related response is returned. Otherwise, the system indicates that it does not have a response for the given input.

There are numerous matching algorithms. Two general classifications of matchers are keyword and Natural Language Processing (NLP) matchers. We have implemented both types of matchers for VPF. We found the accuracy for a keyword matcher is comparable to NLP matchers for virtual humans with a robust corpus and a limited interaction scope such as a medical interview. For this paper, the keyword matching algorithm was used.

A keyword based matcher divides all words into either keywords or stopwords. Keywords are the important words of a sentence that provide meaning such as a name or place and have a relatively lower frequency of occurrence than stopwords. Stopwords are common words that occur often, but don't impart any meaning to sentence such as articles and prepositions.

To find an appropriate response, VPF scans for common words between two phrases and applies appropriate weights to those words. Keywords are weighted more heavily than stopwords. The highest weighted phrase above a minimum threshold is considered a match.

3.1. Hybrid Framework Empathy Alterations

The hidden workers were tasked with providing assistance to two different aspects of the virtual human algorithm. These two aspects were empathetic ratings and matching algorithm assistance. Matching algorithm assistance is outside the scope of this paper as we will primarily focus on the empathetic rating provided by the hidden workers.

The hidden workers first and primary responsibility was to provide ratings for empathetic opportunities during the interaction. An empathetic opportunity is an instance during the interaction when a user has a chance to display empathy towards the virtual human. This opportunity represents the best chance opportunity. This best chance opportunity is the point in time at which a student should absolutely display empathy such as when the virtual human discusses the loss of a family member.

Empathetic opportunities are identified in the system using meta-data tags. The tags are associated with certain responses from the virtual human where users would be expected to offer empathetic words. The empathetic opportunity is thus an opportunistic response from the virtual human and the user input immediately following this response. For example, in the depression scenario we utilized, a student might ask the virtual human about her sister. The virtual human would respond that her sister was recently killed in a car crash. The student would then say how sorry she is to hear that. The empathetic opportunity is the response from the virtual human (the passing of the sister) and the student's input (the extension of empathy by saying she is sorry to hear of the event).

As opportunities are encountered, the relevant response and subsequent input are sent to a hidden worker to be rated. Empathetic opportunities are rated on a scale from 0-6 according to the Empathic Communication and Coding System (ECCS) as developed for medical student interviews (Bylund & Makoul, 2006). The relevant scale and examples are shown in Table 1:

Table 1: ECCS Scale

Level	Description	Example
0 – Denial of Patient Perspective	This response is characterized by the physician ignoring the patient's empathic opportunity or making a disconfirming statement.	Patient: "I'm really concerned about going off this medication." Doctor: "You can go ahead and change into the gown now."
1 – Perfunctory Recognition	This level is characterized by a physician's automatic, scripted-type response to a patient's statement.	Patient: "I was so frustrated." Doctor: "hmmm."
2 – Implicit Recognition	This level contains responses that focus on a peripheral aspect of the empathic opportunity, such as the biomedical issue, but not dealing directly with the progress, challenge or emotion.	Patient: "I'm really happy that I finally quit smoking!" Doctor: "When did you start smoking?"
3 - Acknowledgement	Physician's acknowledgment of the central issue in the empathic opportunity (i.e., conveys that the physician "heard" the patient). Often the	Patient: "I'm so worried about this upcoming biopsy."

	response is a restatement of what the patient has said with or without questions, statements, advice, or offers of help.	Doctor: "I can see that you are scared by the idea of having cancer."
4 – Acknowledgement with pursuit	Identical to Level 3. The distinction between levels 3 and 4 is whether or not the physician pursues the central issue in the empathic opportunity by asking the patient a question.	Patient: "I'm so worried about this upcoming biopsy." Doctor: "I can see that you are scared by the idea of having cancer. Tell me more about that."
5 – Confirmation	The doctors conveys to the patient that the expressed emotional feeling, progress or challenge is legitimate and provides confirmation by using a congratulatory remark, an acknowledgment that the challenge the person is experiencing is difficult, or identifying the importance of the feeling for the patient.	Patient: "I'm so worried about this upcoming biopsy." Doctor: "Of course you're scared. Others are scared also, when there's a possibility of cancer."
6 – Shared feeling or experience	Explicit statement that he or she either shares the patient's emotion or has had a similar experience, challenge, or progress.	Doctor: "In my experience, it is hard to study if you have a headache."

In terms of empathetic ratings, medical students traditionally perform poorly. A previous pilot study found that approximately 48% of students' empathetic opportunities can be classified as a zero with another 28% classified as two. Generally, the higher the rating the better, as higher ratings demonstrate increasing amounts of empathy.

Once users had finished the interaction, all ratings would be displayed to the user for review. An example is shown in Figure 2.

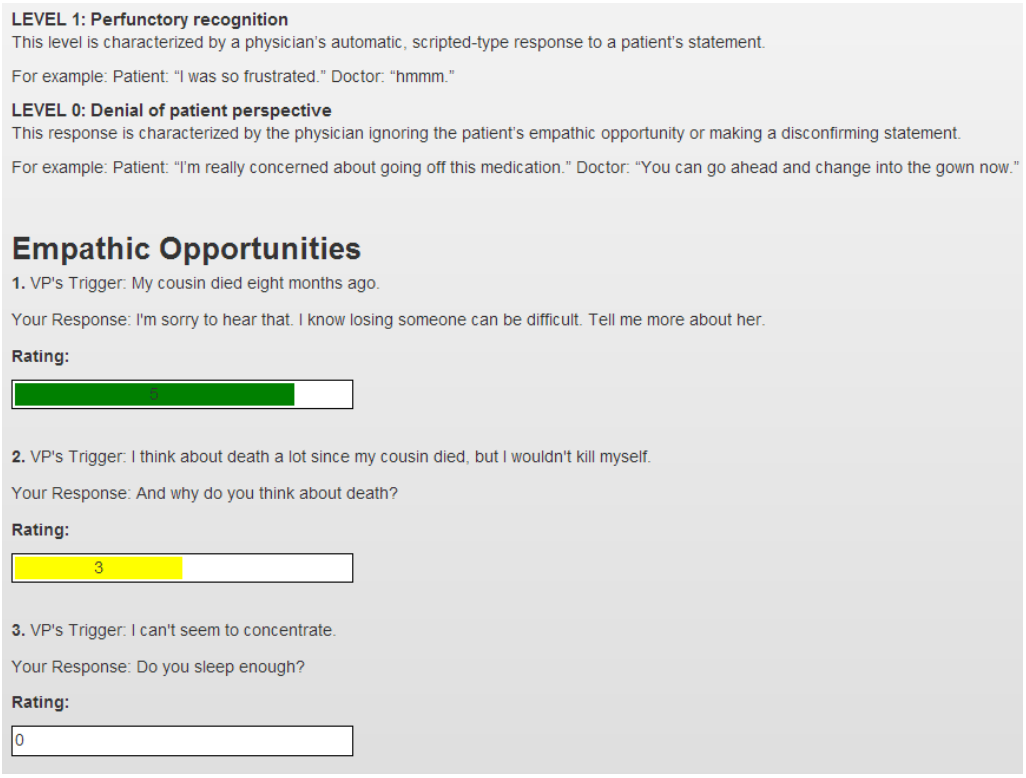

Figure 2: Empathy Feedback Page

Not all rating levels are shown in Figure 2, but the Empathy Feedback page displays a short explanation and description for each rating level at the top of the page. These explanations and descriptions are the same as those listed in Table 1. The webpage also lists every empathetic opportunity and its rating beneath. This way a user could review how empathetic they were during their interaction with the virtual human.

As part of this framework, it is critical to keep background workers occupied. Background workers need incentives to stay engaged so as to be available during empathetic moments. To keep background workers engaged, we leveraged workers to assist the keyword matcher in selecting paraphrases when the matching algorithm was not able to clearly match a student's input to the corpus. The closest paraphrases to a question are called speech clarifications. Speech clarifications occur when no paraphrase scores above a certain threshold calculated by the matcher. The speech clarifications are the best choices for an alternative question because they are the highest scored alternatives in the conversational corpus. In essence, background workers assist the virtual human by helping the matching algorithm throughout the interaction. Workers assist the matching algorithm approximately 40% of the time. Besides utilizing this unused time, the clarifications form the basis for future improvements to the virtual human (Rossen, 2010).

3.2. Hybrid Approach Considerations

In order to give the hidden workers the time necessary to complete their work, a small delay was introduced into VPF. This delay hid the latency of the workers as they provided real-time assistance for empathy ratings and clarifications. The delay was present for all responses the user received from the virtual human.

For instances in which no hidden worker help was required, the delay is based on the length of the response and the average typing speed of the typical user. Otherwise, the delay is the amount of time taken by hidden workers to provide a response or a time limit of seven seconds is reached. This time limit is based on a preliminary study that found five seconds of delay does not impact overall virtual human perception. Given the findings from this study, the time limit of the delay was increased slightly to seven seconds.

By always having a response delay, the system maintains the illusion of a chat with another person. Framing the interaction as an online chat, as well as hiding the delay, is accomplished with displaying a "Character name is typing…" message while the user is waiting for a response. A typical example is shown in the bottom virtual human text box in Figure 1.

3.3. Worker Interface

Input from the user on the interaction page streams to the workers in real-time to a separate webpage. The sections of the webpage that workers use to provide hidden assistance to the virtual human is shown below.

The upper section of the worker page allows a worker to select a clarification as shown in Figure 3.

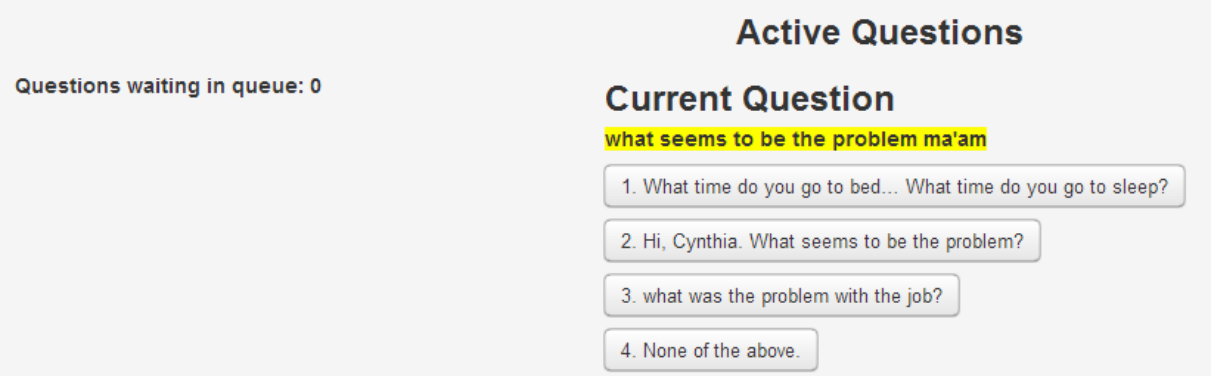

Figure 3: Clarification Selection Area

The lower section of the worker page is shown in Figure 4.

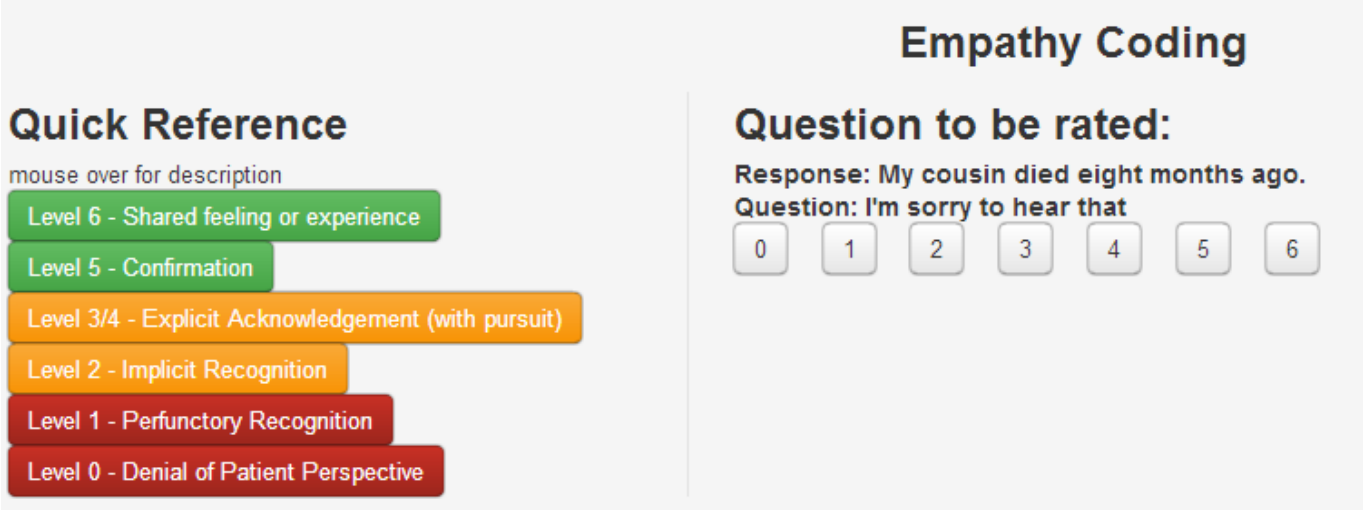

Figure 4: Empathy Selection Area

This section allows the worker to provide the empathetic ratings that are shown to the user on the empathetic feedback page as previously described in the implementation section. Once a user receives a response that is tagged as an empathetic opportunity, the system sends across this response as well as the next user input.

This empathetic opportunity is then rated according to the ECCS scale. Each level is listed on the left and provides a short description for the worker to reference if necessary. This description is based on the scale's full description listed in Table 1.

A typical example of student response for an empathetic opportunity is shown in Figure 4. Here, the virtual human has just responded that her cousin died eight months ago. The student's next input is that they are sorry to hear that. Based on the ECCS scale, this pair of sentences qualifies as Level 3. The student explicitly acknowledged the virtual human's emotional response, but did not continue with a follow up question to probe for more information.

4. STUDY DESIGN

We conducted a study to investigate the impact of the proposed framework and the use of hidden workers to provide empathetic feedback. All students were 1st year medical students that had not previously been exposed to our system nor had they taken part in a previous study. The medical students (N=52) were randomly divided into two groups. The study flow is shown below:

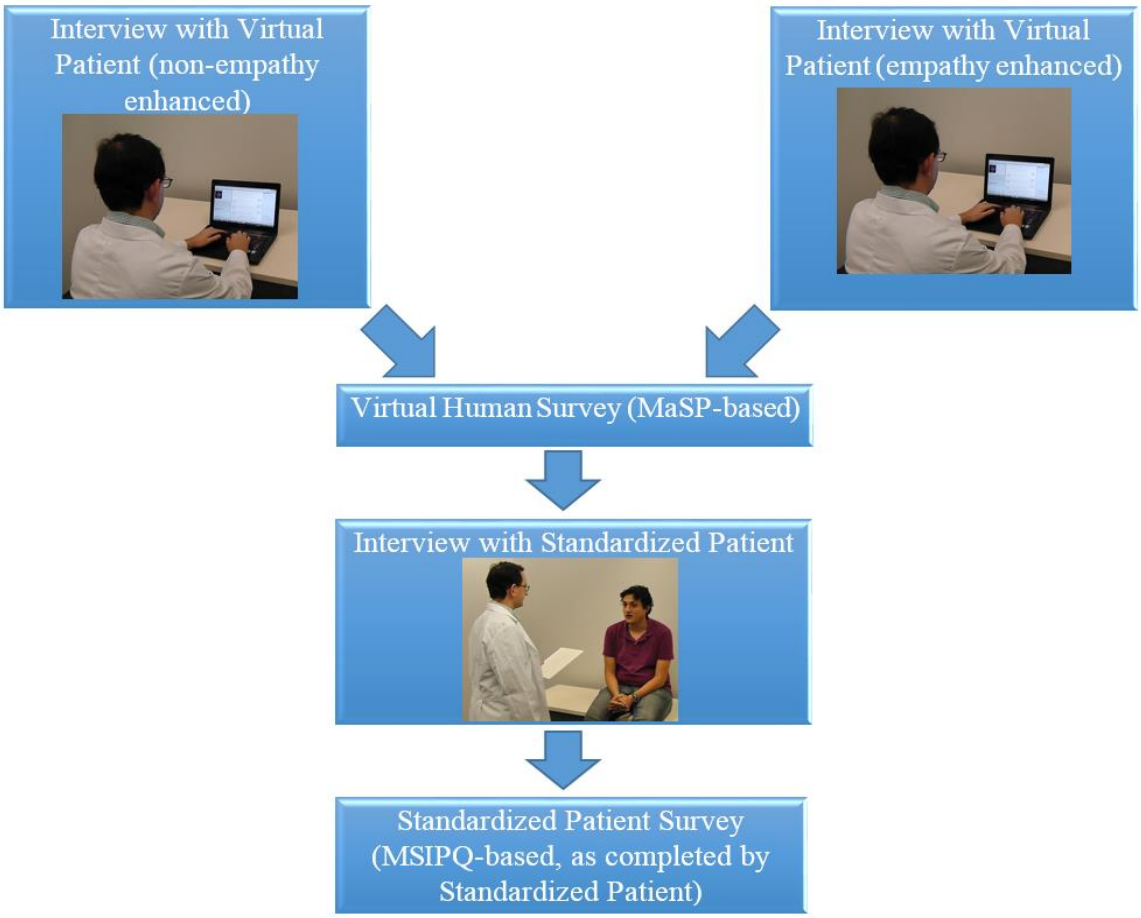

Figure 5: Study Flow

The first group is the control group (N=17). The control group engaged our depression virtual human in an interaction without the aid of a hidden worker or empathetic feedback. Once their interaction was complete, they filled out a survey concerning the virtual patient. Afterwards, the students engaged a standardized patient who also represented a depression scenario.

The second group is the intervention group (N=35). The intervention group engaged our depression virtual human with the benefit of a hidden worker. They then completed the same survey as the control group and following this, received empathetic feedback as described in the implementation section. Afterwards, the students also engaged a standardized patient representing a depression scenario in the same way as the control group.

Both groups filled out a survey after their interaction with the virtual human. This survey is based on the Maastricht Assessment of Simulated Patients (MaSP) (Wind et al., 2004) survey for virtual human evaluation. All responses were on a 5-point scale of Poor, Fair, Average, Good, and Excellent and consisted of the following questions:

- The virtual patient responded in an appropriate amount of time.
- Did the virtual patient interaction help you learn how to formulate questions about a patient's history?
- Were the virtual patient's answers appropriate?
- Did the interaction with the virtual patient simulate real life?
- The virtual patient responded to questions in a natural manner.
- The virtual patient appeared to withhold information.
- The virtual patient communicated how he/she felt during the session.
- The virtual patient stimulated me to ask questions.
- The virtual patient understood my questions.
- Did you enjoy this interaction?
- How valuable is this interview training tool?
- Was Virtual Patient Factory easy to use?
- Were the discoveries useful?
- Was the transcript useful?
- How do you rate the overall interaction?

Both groups also had their overall empathetic rating calculated for the virtual human interaction. The empathetic rating for the interaction was calculated based on the cumulative rating for all empathetic opportunities that occurred during the interaction.

The workers that assisted the virtual humans in the intervention group were all experts. They were trained on the appropriate classification of students' empathetic opportunities and achieved an intra-class correlation coefficient (ICC) of .81. ICC is a measure of inter-rater reliability (IRR) which is how well different raters agree on what the classification of a particular empathetic opportunity should be. A minimum of .7 is considered acceptable in various medical disciplines.

The standardized patients that were interviewed for both groups were blind to the study condition. After their interaction with the students, the standardized patients completed a survey, the Medical Student Interviewing Performance Questionnaire (MSIPQ) (Black & Church, 1998). The MSIPQ is a well-established checklist that rates the medical students' professional appearance, behavior, empathy, and rapport. The relevant section of the questionnaire included the following questions:

- The examinee offered encouraging, supportive, and/or empathetic statements.
- The examinee developed a good rapport with me.
- The student appeared warm and caring.
- The examinee knocked first before entering the exam room.
- The examinee addressed me by my name
- The examinee introduced him/herself
- The examinee washed his/her hands
- The examinee began the interview with open-ended questions
- The examinee repeated, and/or summarized the information I gave him/her during the interview.
- The examinee used language appropriate for me as a person (did not used "medical jargon").
- The examinee's overall professional appearance was appropriate.
- The examinee did not display judgmental behavior.
- The examinee conducted the interview in an organized manner.
- The examinee did not invade my personal space.
- The examinee demonstrated attentive listening.
- The student seemed stiff and unnatural.
- The student seemed confused and nervous.
- The student seemed comfortable talking to me.
- The student talked down to me.

The video for the standardized patient interaction was also reviewed by experts. Empathetic ratings were applied for each empathetic opportunity in the same way they were applied by hidden workers during the virtual patient interaction. The overall empathetic rating was calculated from these opportunities.

5. RESULTS AND DISCUSSION

5.1. Standardized Patient

Students demonstrated more empathy in their interview with a standardized patient after having interacted with a virtual human that provided empathy feedback than students who interacted with a virtual human that did not provide feedback.

For the questions presented as part of the MSIPQ to the standardized patients, a Chi-Squared test was performed. Statistical significance was found for the following statements: “The examinee offered encouraging, supportive, and/or empathetic statements”, “The examinee developed a good rapport with me”, and “The student appeared warm and caring.”

In the depression standardized patient communications survey, those in the intervention group were more likely to have offered encouraging, supportive, and/or empathetic statements ($df=1$, $p<0.0001$), were more likely to have developed a good rapport ($df=1$, $p=0.003$), and were more likely to appear warm and caring ($df=4$, $p=0.0157$) than those in the control group. The frequencies for those ratings are shown respectively in Figure 6.

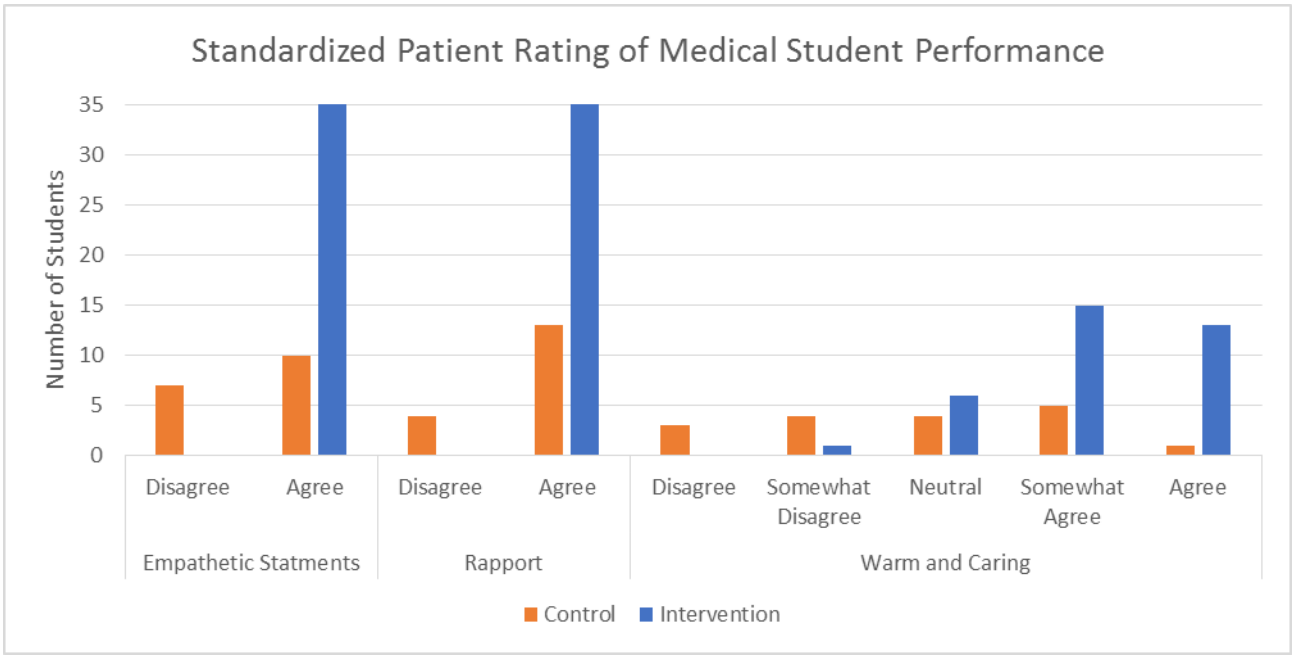

Figure 6: Standardized Patient Ratings for Medical Students

This relationship held true when accounting for the number of empathetic opportunities that students encountered when interviewing the depression virtual patient.

These three specific statements are directly related to how empathetic and caring the medical students appeared to the standardized patients. All three indicate a better interaction as scored by the standardized patient demonstrating that the empathy feedback page after the virtual human interaction influenced the student’s behavior in the mock scenario. The magnitude of this

difference is easily visible in the frequency counts from the standardized patient. For example, for the section on empathetic statements in Figure 6, the standardized patient agreed with the statement that “The examinee offered encouraging, supportive, and/or empathetic statements ”for all 35 of the students in the intervention group. However, only 10 students out of 17 from the control group were listed as such.

The standardized patient interaction video was reviewed by experts and the empathetic opportunities scored on the ECCS scale. Statistical significance ($t=2.39$, $p < .0206$) was found between the control (mean = 2.29, SD = .67) and intervention group (mean = 2.87, SD = .73). This indicated that the medical students were more empathetic after having interviewed a virtual human first.

The data show that the medical students have had their behavior altered by interacting with the virtual human before the interview with the standardized patient. Allowing a student to review how empathetic they were to the virtual patient through the feedback page is enough to not only increase several specific measures of standardized patient interaction efficacy, but the overall amount of empathy as well.

An ANCOVA analysis was conducted to determine the influence of a variety of covariate factors on the empathetic score analysis. The base ANCOVA model controlled for the number of empathetic opportunities encountered during the interaction while covariates for gender, race, medical specialty, and mental health experience score where investigated. No statistical significance was found for any covariate.

This reinforces our conclusion that the increase in empathy was due to the feedback received as part of the virtual human interaction

5.2. Virtual Human

Students demonstrated more empathy when interviewing a virtual human that provided empathy feedback than with a virtual human that provided no empathy feedback.

An ANOVA was performed to determine the statistical significance of overall virtual patient empathy. Statistical significance was also found for the overall virtual patient empathetic ratings ($F=4.98$, $p=.029$). Students in the intervention group (mean = 2.2, SD = .32) had higher empathetic ratings than those in the control group (mean = 1.9, SD = .32).

A difference in the empathy among students was not expected during the virtual patient interaction. At this point, no student had received any empathetic feedback. Due to IRB restrictions and educational goals, as discussed later in the limitations section, the students did have an idea as to the overall nature of this exercise. However, all were informed to the same degree and blind to the condition they were grouped in. As a result, we expected that the students in both groups might be more empathetic in general. Regardless, the intervention group performed better than the control group, and we can only hypothesize as to the reason for a difference between groups.

We hypothesize that this difference could be due to two factors. First, the issue of priming. Students could have been primed to be more empathetic due to IRB limitations and the stated educational goal of improving their empathy. Second, the intervention group had more self-reflection time due to the latency of the hidden worker assistance.

Despite these factors, it should be noted that there is a difference between statistical and meaningful significance. While statistical significance was found, both averages are still around

two. This is a low score on the ECCS scale and both groups could improve their empathy significantly. This significant increase in empathy is what was found in the intervention group as previously described in the standardized patient results. Still, this unexpected difference presents an opportunity for additional further study.

A t-test was conducted on the virtual human response survey. Statistical significance ($t = 3.209$, $p = .002$) was found for the statement "The virtual patient responded in an appropriate amount of time." Students in the control group rated the response time of the virtual human higher (mean = 4.74, SD = 0.62) versus the intervention group (mean = 4.09, SD = 0.98).

This difference in perception is likely due to the increased latency involved in receiving a response. As mentioned previously, when a clarification is sent to the hidden workers, there was a timeout of seven seconds. During this time, the user receives a status message that the character is typing. A previous study used a similar worker page to allow hidden workers to answer clarifications as part of a small group where majority vote was required. This scheme allowed only a five second timeout. That study identified no difference in perception. So, using this technique of displaying a status message to hide the latency has an upper bound between five and seven seconds before negative perception of the virtual human occurs. Despite thinking that the virtual human should respond quicker, no other change in perception was found.

6. LIMITATIONS

While we took as much care as possible in designing the study and controlling for factors that may have influenced results, there were some limitations. Due to student availability, we are unable to use the same students for repeat experiments. Repeat experiments with the same students would be necessary to determine what type of lasting effect, if any, the virtual human interaction has on the students.

Due to IRB restrictions, the students were aware that the study involved empathy. Empathy was mentioned on the recruitment flyer. This likely biased the students and led them to be more empathetic than they otherwise would normally be. However, this same flyer was shown to all participants.

Additionally, participants in the intervention group were reminded to review any feedback the virtual human provided. This too likely biased them to be more empathetic with the standardized patient. However, all students are always aware of the standardized patient checklist and know that empathy is a major component.

7. CONCLUSION AND FUTURE WORK

We found the overall empathetic response from students when interacting with a standardized patient was improved after interacting with a virtual patient that utilized our hybrid framework. This hybrid framework makes use of hidden human workers to assist the virtual human. The hidden workers provide ratings for empathetic opportunities to provide feedback to the students.

This feedback altered students' empathetic response. Empathy is a vital component to medical student training. Improved empathy improves doctor-patient interactions and can make a significant difference in the treatment and outcome for a patient. Despite improvements shown here, the overall empathetic rating continues to be fairly low on the ECCS scale with plenty of room for improvement.

Regardless of the low initial scores, as a result of these interactions, 52 medical students have now received additional training when dealing with a patient suffering from depression. Depression is a serious condition that medical literature indicates is hard to treat due to training constraints and stigmatization. Medical educators are thrilled to have a new tool that results in demonstrable improvements in empathy to help train students on a previously difficult subject area (Stevens et al., 2006).

We intend to pursue this research with additional studies. We intend to see if some of the worker's responsibility can be shifted to an automated algorithm now that there is a basis for classification. Also, the virtual humans have a difficult time in responding to the empathetic opportunities as opposed to general question matching. We intend to investigate whether direct worker involvement at those specific moments would lead to an improved interaction. We also intend to investigate the underlying causes for the difference in initial empathy displayed by the different groups.

ACKNOWLEDGMENTS

The authors would like to thank everyone involved for their work in helping to make this study a success. This work was funded by the Arnold P Gold Foundation research grant FI-12-010.

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A perceptual study on face design for “Moe” characters in “Cool Japan” contents

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Abstract: The term “Moe” is one of the most important keywords in Cool Japan contents, i.e., Japanese animated movies, video games and cartoons. Moe has been discussed from viewpoints of philosophy, aesthetics or literature: Moe is a concept in which chiefly a male feels for a pretty female character, but it does not include direct sexual emotion. In the present study, a perceptual experiment was conducted using semantic differential method to reveal how we can design a Moe character. The results showed that a cute, showy and childlike character evokes Moe emotion. On the other hand, a cute, gentle and mature character is recognized as a beautiful woman but does not evoke Moe emotion. Moreover, the results suggested that there are tactics to design a Moe character.

Keywords: Moe, Anime, Video game, Face design, Semantic differential method.

1. INTRODUCTION

Animated movies (anime), video games and cartoons have been developed in Japan as a kind of subculture. However, in recent years, these contents have been called “Cool Japan,” and Cool Japan contents are recognized as an export-oriented manufacture of Japan. In fact, the Japanese Ministry of Economy, Trade and Industry supported overseas operations of Cool Japan contents under a supplemental budget of 34.4 billion yen in 2012 (Japanese Ministry of Economy, Trade and Industry, 2012).

“Moe” is one of the most important keywords in the Cool Japan contents. Moe characters play important roles in most of the contents of Japanese anime, video games and cartoons. Most of the Moe characters are pretty girls and they evoke Moe emotion in viewers of the contents. Sometimes Moe is misunderstood as a kind of immoral sexual emotion like paedophilia. However, Moe does not include direct sexual emotion. One of the most authoritative journals, “Kokubungaku (Japanese Literature)” published a special issue of Moe in 2008 (Kokubungaku, 2008). This issue contained fourteen papers which discussed Moe from viewpoints of philosophy, aesthetics and literature. To conclude their discussion, Moe contains an ambivalent emotion: One wants to be intimate with her (it) but recognizes that it is quite difficult to realize. Moreover, females can feel Moe for young female characters, and sometimes females and males may feel Moe for male characters, also. Similar philosophical and aesthetic discussion on Moe has frequently taken place in articles in books and magazines. However, no experimental study has been carried out on Moe.

We empirically know that we do not feel Moe for ugly characters, but sometimes we feel no Moe even for beautiful characters. Therefore, we requested a professional designer to provide face designs of a typical “beautiful” character and “Moe” character in the present study. Then we arranged various faces manipulating parameters of several components of the face. Using these faces as stimuli, a perceptual experiment was conducted.

2. EXPERIMENT

2.1. Stimuli

To construct faces, the character creation system in the PC game “PHANTASY STAR ONLINE 2” was used. Using this system, various components of the face (e.g. hair style, face shape, distance between eyes, eye opening and nose length) can be manipulated. In this system, hair style, type of pupils and type of makeup can be chosen from several alternatives. Except for these three components, each parameter can be varied from -100 to 100 degrees. Using this system, a professional character designer, who creates various anime and promotion videos for Hatsune Miku, provided two faces of characters: One is a typical Moe character. We call it Basic Moe Character (BMC). And the other is a typical character who is beautiful but we do not feel Moe for it. We call it Basic Beautiful Character (BBC). These two faces are shown in Figure 1.



Figure 1: Two basic characters designed by a professional designer.

Twelve characters were synthesized by morphing processes between the BMC and BBC. In one series, the hair style was fixed in “angel wings” (hair color was fixed in pink), which was used in the BMC. The type of pupils was also fixed for the BMC. The type of makeup was fixed as “no

makeup," which was used both in the BMC and BBC. Using the parameters of the other components, the values of the parameters in the BMC were set at Step 1 and the values in the BBC were set at Step 5. Then, Steps 2-4 were synthesized by morphing with linear interpolation. Steps 6 and 7 were similarly synthesized by extrapolation. The face of the Step 5 was different from the BBC in the hair style and the type of pupils, but Step 1 was exactly the same as the BMC. Therefore six new faces were synthesized in this series. Similarly, the BBC was set at Step 1, and the BMC was set at Step 5. Then, the other six faces were synthesized using the same hair style and type of pupils as the BBC. In this series, hair style was fixed in dark-brown mid-length "suave."

Moreover, 38 faces were synthesized selecting one of the parameters of hair style, type of makeup, or type of pupils, based on the BMC and BBC. Thirty-one characters were also synthesized by varying value of one parameter of eye opening, distance between eyes, nose length or face shape from the BMC and BBC. In total 83 faces were prepared for the perceptual experiment as stimuli (Table 1).

Table 1: Stimuli used in the perceptual experiment.

Varied component(s)	# of stimuli
Base	2
Morphed	12
Hair Style	14
Makeup	8
Pupils	16
Eye Opening	8
Distance between Eyes	6
Nose Length	9
Face Shape	8
Total	83

2.2. Procedure

Eight students from the Kanazawa Institute of Technology, ranging from 20 to 25 years old, participated in the experiment. The participants looked at each of the 83 characters and then they were requested to rate the emotional features of them, using 19 seven-step bipolar scales listed in Table 2, e.g., "very showy", "fairly showy", "slightly showy", …, "very gentle" (C. E. Osgood, G. J. Suci, & P. H. Tannenbaum, 1957). The order of the scales was determined in a random way for each combination of character and participant. The participants were also requested to rate the degree of Moe, the degree of beauty of the character and rate the degree of preference to the character, using seven-step scales. The characters were presented through the 24.1-inch display (EIZO, FlexScan SX2462W). The distance between the eyes of the participants and the display was fixed at 70 cm.

3. RESULTS AND DISCUSSION

Numbers -3 to 3 were given for each of the seven categories on the SD scales. The mean value was calculated from the participants' responses for each combination of scale and stimulus. Then factor analysis was performed for these mean scores with the principal factor method and varimax rotation. The results showed that a four-dimensional space accounted for 85% of data

variance. Table 2 shows the resulting factor loadings for the 19 SD scales. The four factors are labeled “evaluation”, “showiness”, “potency” and “maturity” respectively, after the scales, which show large absolute values in the loadings for these factors. The characters were plotted on the “evaluation - showiness” and the “potency – maturity” planes. In Fig. 2 and 3, the white and black diamond marks show the BMC and BBC, respectively. In Fig. 3, the white circles show the stimuli based on the BMC, and the black circles show the stimuli based on the BBC. The arrows connected stimuli from low to high values in the components.

Table 2: Semantic differential (SD) scales and there factor loadings.

	Factor			
SD scale	Evaluation	Showiness	Potency	Maturity
Healing - Irritating	-.965	.143	-.002	.008
Agitated - Calm	-.958	-.095	-.076	.119
Cute - Uncute	-.946	-.001	-.004	.156
Fascinating - Boring	-.940	-.174	-.068	.050
Eye pleasing - Ugly	-.910	.121	.105	-.205
Stylish - Loutish	-.747	-.010	.085	-.500
Unique - Banal	.276	-.876	-.172	.049
Showy - Gentle	-.119	-.854	-.194	.298
Unreal - Real	-.066	-.789	-.012	.377
Impressive - Unimpressive	.256	-.784	-.311	-.008
Elegant - Rustic	-.324	-.769	-.142	.310
Frail - Burly	-.237	.010	.913	.048
Imposing - Cowardly	-.033	-.141	-.898	-.092
Powerful - Powerless	.029	-.276	-.878	.113
Active - Quiet	.059	-.365	-.821	.248
Sharp - Round	-.066	.258	.166	-.851
Mature - Childlike	.046	.427	-.050	-.813
Mixed - Neat	.690	-.339	.000	.502
Bright - Dark	-.403	-.003	-.692	.145
Contribution Rate	.315	.210	.202	.127

In the next step, multiple-regression analyses were applied to investigate the differences between Moe and beauty. Factor scores of the “evaluation”, “showiness”, “potency”, and “maturity” were used as explanation variables, and each degree of Moe, beauty and preference was used as a criterion variable in each analysis. The results showed that the coefficient of determination, R2 was larger than 0.9, for the degree of Moe, beauty and preference, respectively.

Figure 2 shows the multiple-regression lines for the degrees of Moe, beauty and preference as vectors. Figure 2 shows that degrees of Moe, beauty and preference increase along with the value of the evaluation. In fact, the BMC and BBC both show high values on the evaluation axis. This implies that a “cute” face is preferred and evokes Moe emotion or is recognized as a beautiful woman. However, Fig. 2 also indicates the factors which differentiate Moe and beautiful faces: If a “cute” character is also perceived as “showy” and “childlike,” it is recognized as a Moe character. On the other hand, if a “cute” character is perceived as “gentle” and “mature,” it is recognized as a beautiful woman. The BMC and BBC are both cute, but there are large differences in “showiness” and “maturity”.

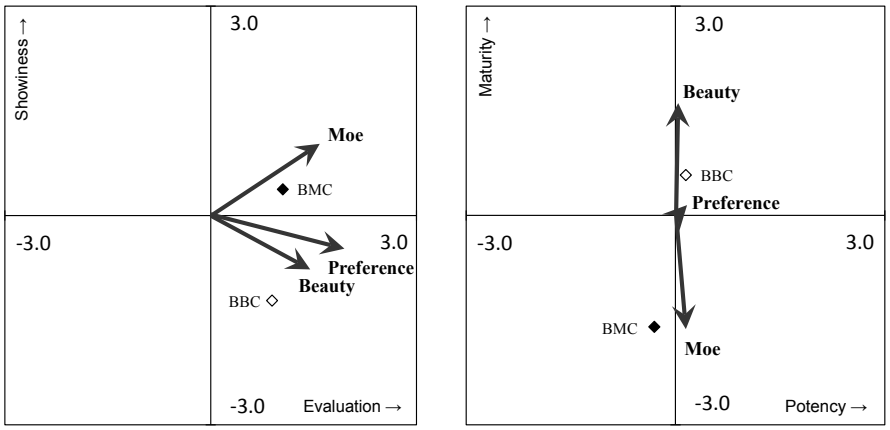
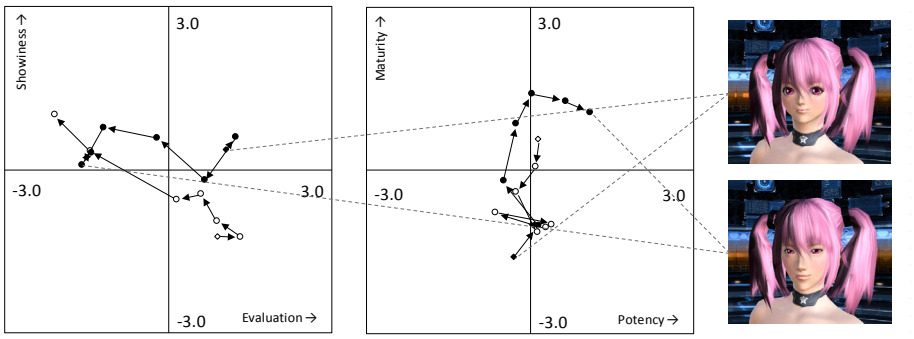


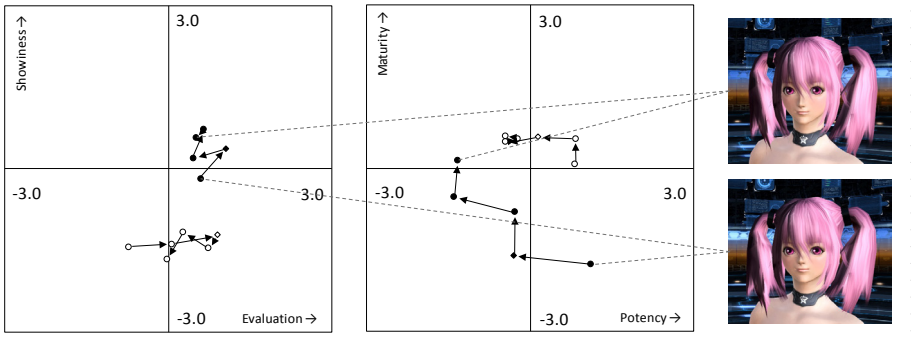
Figure 2: The results of multiple-regression analyses. The vectors show the relations between four factors of evaluation, showiness, potency and maturity vs. the degrees of Moe, beauty, and preference.

Each panel in Figure 3 shows the relation between each component and impression of the face. In most of the panels, the plots of the faces are divided largely into two groups; one group is based on the BMC and the other is based on the BBC. This result implies that the impression of the character is not changed significantly, even if only one parameter of a facial component is varied. In Panel (a), it is shown that the position of a stimulus moves largely on the evaluation dimension through the morphing process. This suggests that the balance of the facial components is important for the evaluation factor. In Panels (c) and (d), the position of a stimulus moves largely on the evaluation dimension by varying the eye opening and the distance between eyes. This implies that these two parameters are very important to determine whether a face is recognized as cute or uncute.

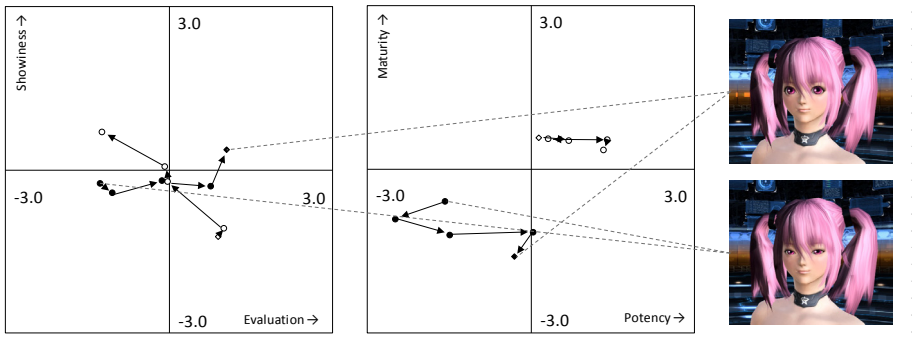
The positions of the stimuli also showed that the hair color and the iris color changed the showiness greatly. These results implied that the showiness is deeply correlated with colors, i.e., a character with showy colors on her hair and irises tends to be perceived as showy. On the potency dimension, the impression of a character varied systematically with the eye opening, nose length and face shape. These results suggested that a character with big eyes, a round face and a short nose tends to be perceived as powerful. On the maturity dimension, it was suggested that a character with a sharp face and small pupils tends to be recognized as mature, and vice versa.



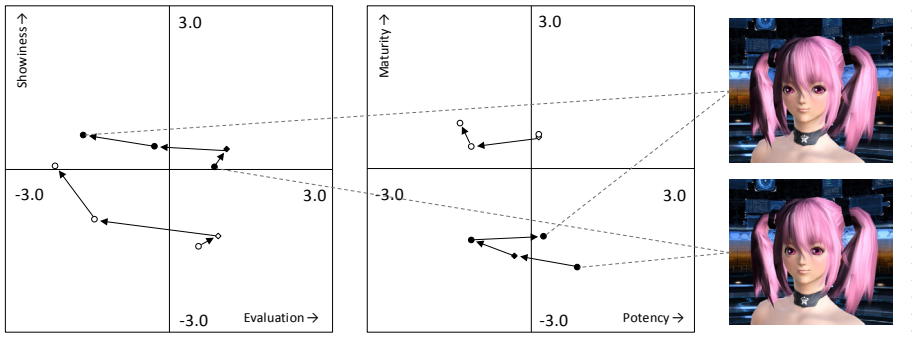
(a) Change of the viewers' impressions by morphing processes.



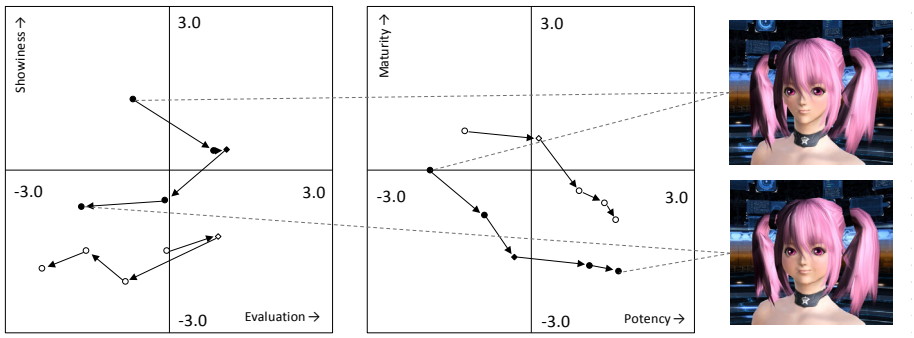
(b) The effect of the nose length on the viewers' impressions. The arrows direct from short to long noses.



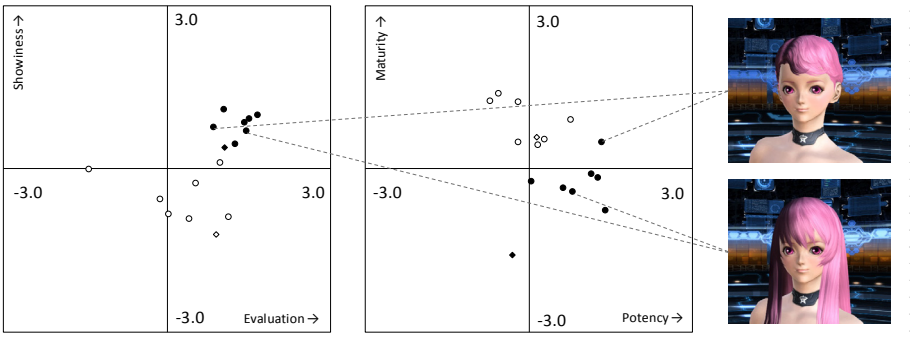
(c) The effect of the eye opening on the viewers' impressions. The arrows direct from a narrow to wide openings.



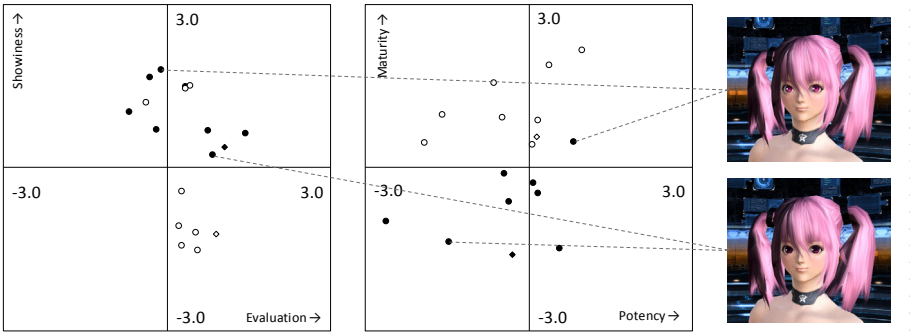
(d) The effect of the distance between eyes on the viewers' impression. The arrows direct from short to long distances.



(e) The effect of the face shape on the viewers' impression. The arrows direct from a shape to round shapes.



(f) The effect of the hair style on the viewers' impressions.



(g) The effect of the type of pupils on the viewers' impressions.

Figure 3: Effects of facial components on the viewers' impressions.

4. CONCLUSION

In the present study, it was shown that a cute, showy and childlike character evokes Moe emotion. On the other hand, a cute, gentle and mature character is recognized as a beautiful woman but does not evoke Moe emotion. The results of the perceptual experiment also suggested that there are tactics to design a Moe character as follows: First, choose showy colors for the hair and irises. Then, set her face shape round and set the size of her pupils large. Finally, balance the other parameters of the character until she is recognized as cute.

In the next stage, the correlation between the parameters which construct a face and the impression perceived for the face should be quantified.

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BIOGRAPHY

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KEER2014, LINKÖPING | JUNE 11-13 2014
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Investigation of Kansei Added Value in Book Publishing Filed by Using AR Contents

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Abstract: Many practices about using AR (augmented reality) contents have been reported in education fields, and the usefulness of teaching materials made by AR technology was verified. However, the study cases about using AR contents for book publishing are still scarce. With the publication of eBook, the possibility of AR contents increases and the synergistic effect could be expected. This study introduced the AR contents into book publishing field, gives three-dimensional depth to the visual information of two-dimensional original that in order to create multimedia "pleasure". We targeted parent and child as our custom, and developed character AR contents to the picture-book. Readers can acquire the 3D data and of characters and compounds on the picture-book by using iPhone or iPad. We made comparative experiments by using manufactured AR contents. As the results, there was a tendency that the story in picture-book forms and with AR contents increased the understanding than the story written only in the text. Moreover, by adding AR contents to the 2D picture-book form, "pleasure", "fun" and "unpredictability" can be improved.

Keywords: AR contents, Book Publishing, Application, 3D contents.

1. INTRODUCTION

Augmented reality (AR) technologies have been in focus recently, and their application in real-world society is increasing. Moreover, with the spread of smartphones and tablet PCs, more applications of AR technologies to the content market are expected. There are several reports of research in AR in the field of education. Teshima, Kosugi et al. (2009) developed teaching aids for learning about maps using AR and demonstrated their effectiveness compared to methods that

only use photographs or printed materials. They showed that displaying a virtual object juxtaposed over a printed page effectively promoted learning. In another example, Kondo et al. (2006) developed an AR teaching aid that uses computer graphics to show the structure of the brain in 3D.

Nevertheless, there have been few examples of research related to AR for books in general, and there is considerable room for discussion. Further, there is a need to evaluate AR content considering the cases where AR is linked with a tablet PC.

In this research, we developed an AR app for books in cooperation with a general publishing company, searched for new methods to use AR with mobile devices, and examined the effectiveness and market value of introducing an AR app for books.

2. AR APP DEVELOPMENT

For this research, we used Xcode by Apple, Inc., as an integrated development environment (IDE), and used Objective-C as the programming language. For a system development kit (SDK), we used Metaio SDK by Metaio, GmbH, and created an app exclusively for iOS devices.

For the content, we cooperated with a general publishing company to use a title called Genshoku Yagai Yousei Zukan (“Color Field Guide to Fairies”), which is being developed on the publishing company’s web site and as a magazine. We created an AR app for tablet PCs that juxtaposes three-dimensional computer graphics (3DCG) images of fairy characters over printed paper.

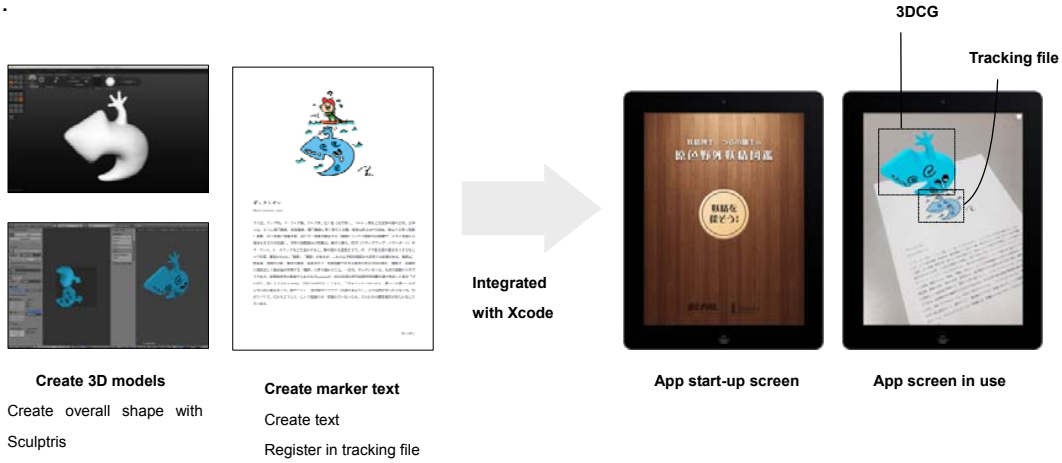

Figure 1: Overview of experimental AR content used in this

Figure 1 shows an overview of the experimental AR app used for this research. By directing a camera linked to the AR app at a text passage including markers for character illustrations, users can view 3DCG models of fairy characters juxtaposed over the marked text. Moreover, because the 3DCG models move in coordination with the orientation of the text, users can freely move the text to view the character from multiple perspectives.

2.1. 3D Model

To show the effectiveness of AR content over printed media, we created two 3DCG models using the Sculptris and Blender 3D-modeling software programs. We created 3DCG models with less

than 20,000 faces, which the AR app could read. Then, we used Blender to adjust the size, apply texture, and perform shadow mapping. We wrote the models in the MD2 format, which can be read as AR content.

2.2. AR App

In the AR app system, first, the app recognizes an image marker printed on paper. Next, the app processes the position information of the marker and displays a 3DCG model juxtaposed over the printed page.

To make the AR app display the 3DCG models produced, we used Xcode to read the 3DCG models into the AR app. To facilitate the display of multiple characters within the app, we applied an ID to the loaded 3DCG models to allow specifying multiple fairy characters. Moreover, to use fairy character illustrations as image markers, we registered them as tracking files. To allow the tracking files to handle multiple displays, we used the same ID as that for the corresponding 3DCG model. In this manner, a corresponding 3DCG model could be displayed juxtaposed over any image marker. Furthermore, the startup screen was created such that it could handle both vertical and horizontal orientation to allow users to hold the device in any position as they operate the app.

3. EVALUATION EXPERIMENT

3.1. Experiment Overview

To demonstrate the relative effectiveness of printed-paper content and content using the AR app, we conducted an evaluation experiment. The experiment was conducted twice for each subject. The AR app was evaluated by 32 subjects between the age group of 10‐20 years using a questionnaire. Moreover, to investigate the effect on the brain waves of the subjects using the AR app, we used the simple brainwave measurement device, MindSet, manufactured by NeuroSky, Inc., during the test. In the experiment, MindSet was embodied as a headphone, with the left ear pad functioning as the ground electrode, and the arm section electrode measuring the voltage at a position corresponding to FP1. The measured brainwaves are immediately amplified, and the environmental noise and effects of muscle movements are eliminated before being outputted in 8 bandwidths, such as α and β waves, by performing a Fourier transformation. Finally, all subjects were required to sign an agreement that they would treat the experiment content as confidential information in accordance with a confidentiality obligation in joint academic and industry research.

3.2. Experiment Method

For the experiment environment, a room with a light gray color scheme and daylight fluorescent lamps was used to avoid sensory stress on the subjects. The desks used for the experiment only had the content to be used in each test placed on them. To ensure that the electrodes would operate normally on the subjects, they were wiped using alcohol before the experiment. The subjects' hair was tied back with hairpins to ensure that it would not entangle in the electrodes. Next, MindSet was mounted as per the instructions in the operation manual. The subjects were asked to adjust the position of the pads and the arm to fit the device to their heads.

The text was presented face down so that the content was not visible. To ensure that the subjects were in a relaxed condition, they were required to close their eyes. Brainwave measurement commenced when a meditation (level of meditation) meter and an attention (level of concentration) meter had stabilized. Five seconds after this stage, on a signal, the subjects turned the text over and viewed it for one minute. Then, they were asked to fill in an evaluation sheet, and

after taking a break for as long as they preferred, the next experiment was performed.

Each subject made an evaluation of the two characters, structured in three steps. Experiment 1: A written response describing the character (the “description text”); Experiment 2: A written response with an illustration of the character (the “illustration text”); and Experiment 3: A written response with an illustration of the character and the AR app (the “AR text”). The subjects were made to view each character for 1 min and then respond in five steps using the evaluation sheet. The evaluation sheet comprised 15 evaluation statements in total, covering “desire” (four statements), “interest” (two statements), “ease of viewing” (one statement), “self-comprehension” (six statements), and “sense of fatigue” (two statements). The evaluation values ranged between +2 and −2. The results of Experiment 2 were evaluated relative to the results of Experiment 1, and the results of Experiment 3 were evaluated relative to those of Experiment 1 as Experiment 3-1, and those of Experiment 2 as Experiment 3-2.

In the analysis, the results from Experiment 1 were assigned five points for “strongly agree,” four points for “somewhat agree,” three points for “neither agree nor disagree,” two points for “somewhat disagree,” and one point for “strongly disagree.” The results from Experiment 2 were added to the results of Experiment 1. The results from Experiment 3-1 were added to the results from Experiment 1, and the results from Experiment 3-2 were added to the results from Experiment 2.

Next, Tukey’s test was used to perform a multiple comparison of the results for each evaluation statement in order to clarify the significant difference between each experiment.

3.3. Experiment Results

Figure 2 shows the results of the questionnaire used in the experiment. There were 32 valid responses. With respect to the collated results, in Experiment 3-1, description text vs AR text, and Experiment 3-2, illustration text vs. AR text, 11 out of the 15 evaluation statements had an average score above the median score of 3. In particular, with respect to the statements related to “desire” and “interest,” the scores from Experiment 3-1, description text vs. AR text and Experiment 3-2, illustration text vs. AR text were higher than the scores from Experiment 2, illustration text. Moreover, with respect to the statements on self-comprehension, “This text was interesting,” “From text I could describe the form of the character,” and “The character had cute hair,” had the highest scores for Experiment 3-2, illustration text vs. AR text. These results demonstrate the effectiveness of introducing the AR app for books.

However, the response scores for the “ease of viewing” statement, “I was not sure where to look,” and the “self-comprehension” statement, “The content was serious,” were lower in Experiment 3-1, description text vs. AR text compared with Experiment 1, description text, and lower in Experiment 3-2, illustration text vs. AR text compared with Experiment 2, illustration text. Furthermore, the scores for the “self-comprehension” statement, “I read the text actively,” were lower in Experiment 3-2, illustration text vs. AR text compared with Experiment 2, illustration text. The reason for these differences is thought to be that the line of vision tends to focus on the AR character when operating the AR app.

We performed a verification using Tukey’s test to clarify the effect of the presence of the AR app. In the average response scores relating to “Desire” and “Interest,” there was a significant difference ($\alpha(64) = 3.733$, $p < 0.05$). This clearly showed desire for books using the AR app was stimulated by displaying 3D characters juxtaposed over the printed page. It was also made clear that subjects approached books using an AR app with interest.

There was also a significant difference (α (64) = 3.733, p < 0.05) in the average response scores for the "Self-comprehension" statements, "This text was easy to get used to," "From the text I could describe the form of the character," and "The character had a cute air." This showed that the subjects' level of self-comprehension was improved by the AR app.

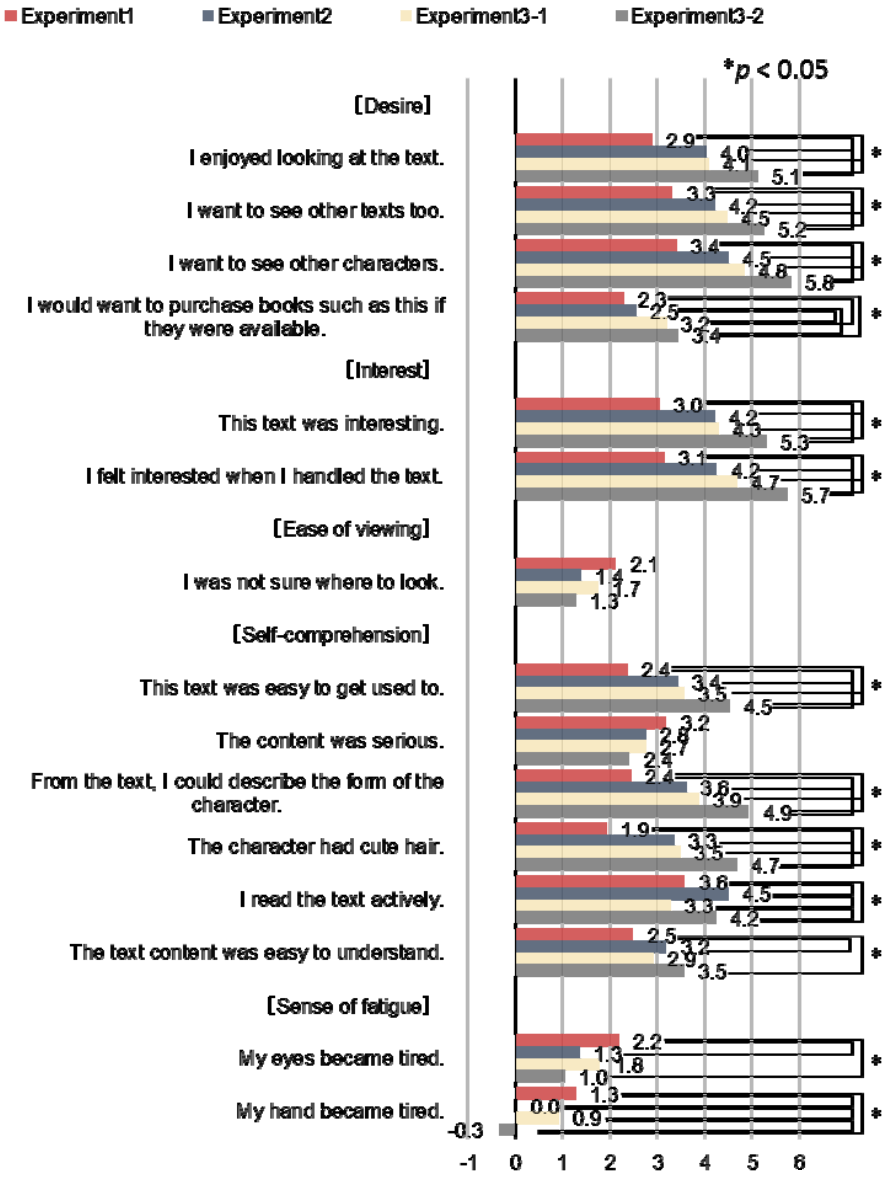

Figure 2: Results of subjective evaluation

Figure 3,4,5 shows the collated results of the brainwave measurements in the experiment. The first five seconds of data was discarded from the data of each experiment. To find the levels of meditation and concentration in each experiment, we calculated the average value of the data for one minute and the total value for the subject. As a result, both the level of meditation and the level of concentration were found to be lower in Experiment 3 than Experiment 1. Because the level of concentration is associated mainly with the ability to focus visually on a single point, this result shows that the subjects were looking back and forth between both the printed paper and the AR app because the viewing content was increased.

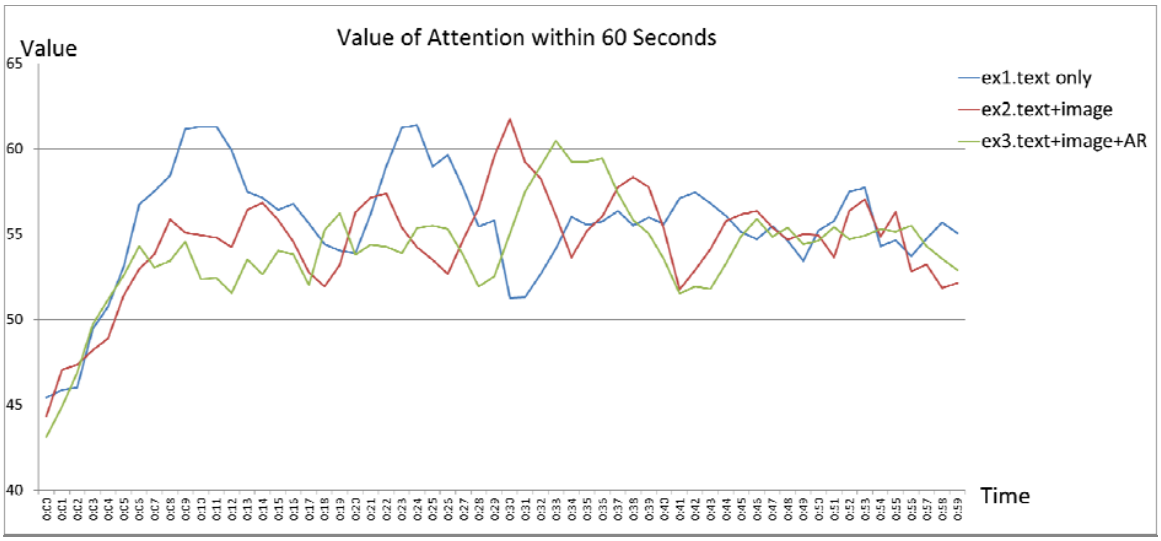

Figure 3: Moving average value of "Attention" within 60 Seconds

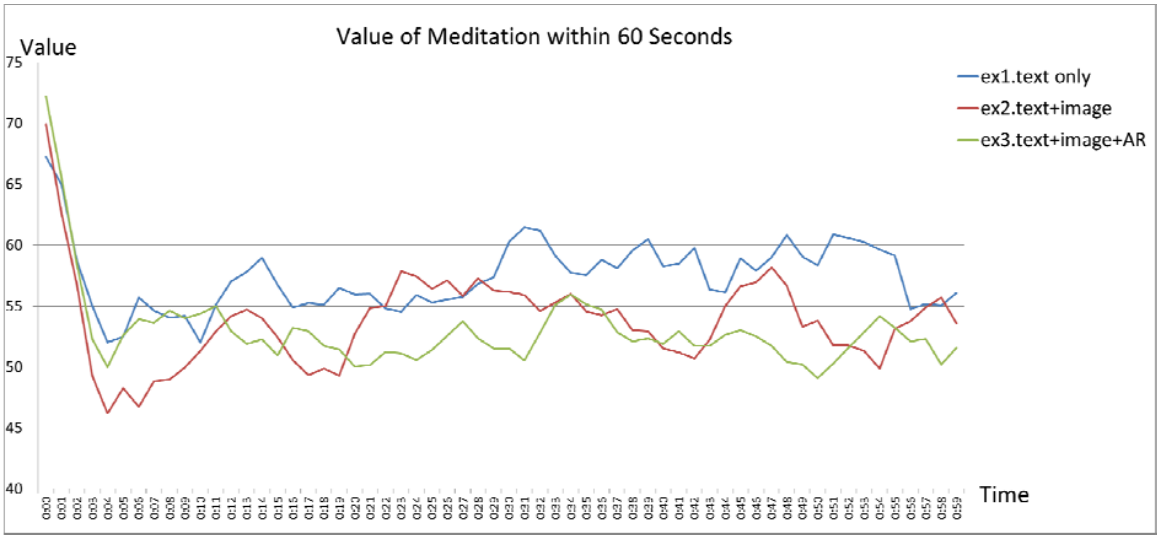

Figure 4: Moving average value of "Meditation" within 60 Seconds

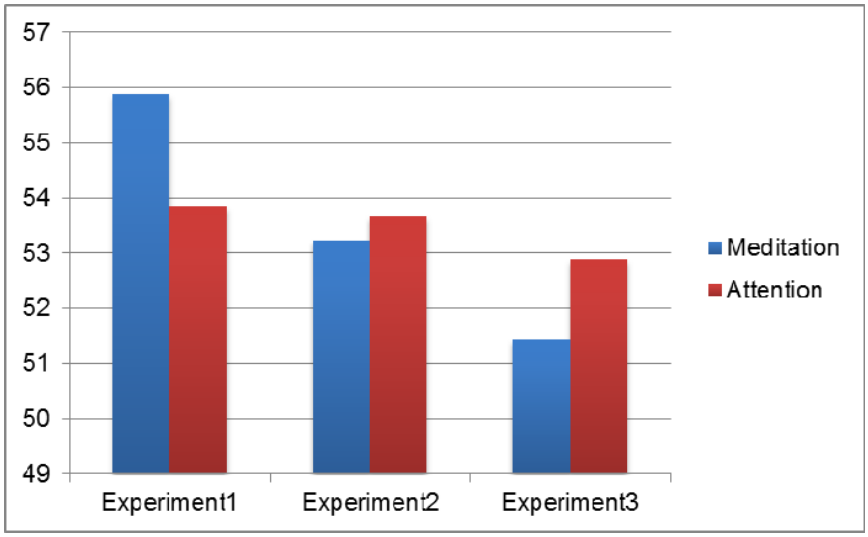

Figure 5: Collated results of brainwave measurements

Furthermore, the level of meditation was higher than the level of concentration in Experiment 1, but the level of concentration was higher than the level of meditation in Experiment 3. From this result it can be seen that introduction of an AR app stimulates brain activity.

4. CONCLUSION

In this research, we cooperated with a general publisher to develop an AR app for books to identify new methods of operating mobile devices and to investigate the effectiveness and market value of introducing an AR app for books. We found that introducing an AR app for books stimulated the users' desire and made them approach their pursuits with interest. Further, we showed how such an introduction could have market value by stimulating the desire to purchase books. Finally, we demonstrated that users looked back and forth between the printed media and the AR app, and therefore, their level of concentration increased above their level of meditation, and their brain activity changed from quiet to excited.

In our future work, we could include improving the 3D characters with the goal of increasing the desire and interest of the subjects. Moreover, this research used a single printed sheet of A4-sized paper to investigate the effectiveness of the AR app; however, actual application for books will require conducting further experiments using text in book form.

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BIOGRAPHY

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Structural Comparison of Impression about a Character-Agent Derived from User Empathy

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Abstract: In today's information-communication society, it is important to establish a good relationship between humans and computers. Several human-agent interaction studies have succeeded in creating a more profound relationship with people, such as fostering empathy with agents. However, none of these studies has examined how human empathy is affected from the impressions formed about agents. We conducted an experiment to collect emotional response to a character-agent from participants. Then, we compared attitude structure to the agent between empathic and non-empathic groups of the participants. The results show that empathic participants evaluated the character-agent from various aspects and did not bestow low scores, unlike non-empathic participants.

Keywords: Human-Agent Interaction, Character-agents, Empathy, Impressions.

1. INTRODUCTION

In today's information-communication society, it is important to establish a good relationship between humans and computers. Many studies in the area of affective computing and affective engineering have made contributions in this regard. In particular, methods to foster human empathy to computer agents have been developed, where empathy is a more profound level of human-agent interaction. For example, Imai & Narumi (2004) proposed a communication strategy called *Directed Interaction*. In interactions between a human and an agent, the human shares the same sensation with the agent by speculating on the sensation that the agent has expressed. In the process, the human acquires the viewpoint of the agent through “mind reading” that is induced by the agent’s affective utterance.

By designing the interaction between humans and agents on the basis of this strategy, humans are drawn into communication with the agent. However, the empathy evoked in the interaction is

limited to sharing information about sensations only. In ordinary communication, information about emotions is often used and is important for enriching the conversation. For example, emotional responses to color stimuli (color emotions), which are used to express objects' identities, include information about feelings in addition to sensations. Thus, we focus on empathy in the sense of sharing feelings. When empathy allows for feelings to be shared, humans' attitude to agents is expected to change from impersonal to personal. That is, the attitude to the agents is expected to allow humans to consider such agents as well-rounded characters. In the current study, we experimentally conducted user assessments to a software agent; then, we made comparisons between users who expressed empathy (empathic users group) and users who did not express empathy (non-empathic users group) in order to observe the differences in attitude to the agent.

2. EXPERIMENT

2.1. Procedure

We conducted an experiment to collect assessments made of a character-agent by empathic and non-empathic users. The users were asked to browse single colors with a software agent on web pages displayed on a thin-film transistor (TFT) monitor (Figure 1). Assuming interaction with an agent that provides information and assists with retrieval, we confined the issue to the impression of a character-agent displayed on the computer. The character-agent responded with a positive, neutral, or negative behavior to each color. The behavioral expressions were defined along with empirical data obtained from a previous study that measured emotional response to color stimuli.

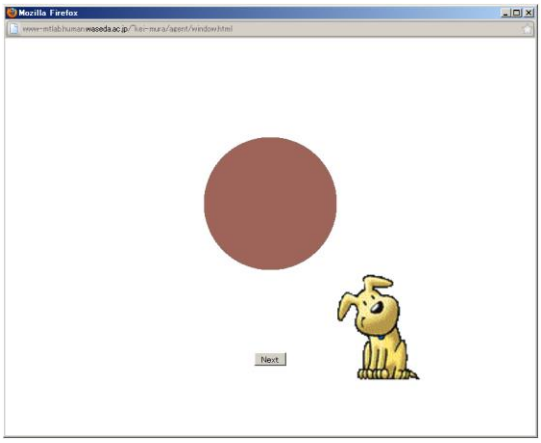

Figure 1: Character agent displayed on a screen

The experiment procedure is summarized as follows. First, the participants (27 university students) received an explanation that the goal of the experiment is to evaluate their impressions of a software agent; in addition, the participants were informed that they would browse web pages that displayed single colors and instructions from the agent. Second, the participants entered their names and e-mail addresses into an instruction page and browsed the web pages with the agent. The agent indicated on the initial instruction page: "Let's begin browsing various colors together. The colors are displayed in the center of the pages." On the final web page, the agent indicated: "I'll tell you about the most impressive color. I'll send an email about it soon." Last, the participants answered questionnaires that were composed of three categories of question items. The first category asked the participants for their impression of the color that would be sent by the agent. The second category asked the participants for their impression of the agent's personality. The last category asked the participants about their attitude throughout the experiment.

2.2. Agent Behavior

The character-agent was embedded in the web pages through support of a Clippy.js (http://www.smore.com/clippy-js) library, which is a JavaScript implementation of the Microsoft Agent. For this experiment, we chose the dog character *Rocky* and modified the script to define his behavior. When a single color is displayed on a web page, Rocky turns his eyes to the colored area and adopts a thinking posture; then, he expresses his attitude in a positive, neutral, or negative manner (Figure 2). The positive expression is presented as Rocky turning his face toward the user with a vigorous wag of his tail. The negative expression is presented as Rocky turning away from the colored area and prostrating on the ground. The neutral expression is presented as Rocky making no significant movements after the thinking posture.

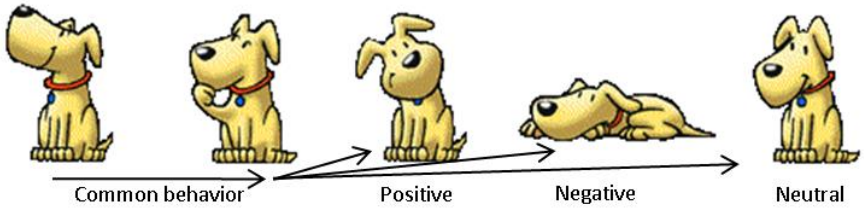

Figure 2: Sequence of the character agent's behavior

These behavioral expressions were matched to 15 single colors according to the reference described in this paragraph. The 15 single colors were composed by combining three hues (red, green, and blue) and five tones (dark, deep, vivid, brilliant, and light). A total of 30 web pages were prepared using the colors twice. The colors were ranked by a factor score of warmth estimated from a previous study (Muramatsu et al., 2011). We assigned the top three of these 15 colors to the positive expression, and the last three to the negative expression. The remaining colors were randomly matched to a positive, neutral, or negative expression with respective probabilities of 33% in order to prevent easy speculations of the agent's behavior.

2.3. Question Items

The question items in the first category of the questionnaire were adopted according to previous studies (Gao et al., 2007; Muramatsu et al., 2011). There are 12 adjective pairs used to evaluate color appearance: light-dark, soft-hard, warm-cool, turbid-transparent, deep-pale, vague-distinct, heavy-light, vivid-somber, strong-weak, passive-dynamic, gaudy-plain, and striking-subdued. The second category contains the following 20 adjective pairs: attractive-unattractive, close-distant, warm-cold, friendly-unfriendly, thoughtless-thoughtful, sociable-unsociable, responsible-selfish, inconsiderate-considerate, diligent-lazy, unsuccessful-successful, careless-careful, introvert-extrovert, strict-tolerant, unfaithful-faithful, attentive-inattentive, flexible-stubborn, exclusive-coordinative, assured-unassured, weak-strong, and rude-respectful were derived from a previous study by Fukayama et al. (2002); mechanical-humanlike and empathetic-unempathetic were also added to the list of 20, for a total of 22 adjective pairs. The question items in the third category considered (a) empathy, (b) friendliness, (c) naturalness, and (d) preference for dogs. All question items were answered with a seven-point rating.

3. RESULTS

3.1. Color Emotions and Agent's Personality

We analyzed data from the completed questionnaires of 25 participants (17 male and 8 female); the responses of the other two participants were discarded because their forms were incomplete.

First, we revealed the structure of the emotional response to colors that the participants imagined corresponded to the personality of the agent. The rated data from the first question category (12 pairs of adjectives) were analyzed by factor analysis (maximum likelihood method, promax rotation). As a result, four factors each related to brightness, saturation, activity, and clarity were extracted as listed in Table 1. A weak positive correlation between the second factor and the third factor was observed (Table 2).

Table 1: Factor loadings of first question category

	Factor 1	Factor 2	Factor 3	Factor 4	Commonality
heavy-light	0.92	0.04	0.25	0.14	0.76
deep-pale	0.81	0.28	0.16	-0.06	0.58
light-dark	-0.66	0.44	-0.05	0.01	0.69
strong-weak	0.57	0.28	-0.30	-0.17	0.60
soft-hard	-0.48	0.38	0.39	0.18	0.71
gaudy-plain	0.02	0.91	-0.09	-0.09	0.85
vivid-somber	-0.10	0.82	0.01	-0.12	0.70
striking-subdued	0.35	0.77	0.08	0.20	0.68
passive-dynamic	0.21	-0.04	1.04	-0.09	1.00
vague-distinct	-0.01	-0.16	0.11	0.72	0.53
warm-cool	-0.08	0.29	-0.38	0.64	0.69
turbid-transparent	0.31	-0.26	-0.11	0.48	0.46

Table 2: Correlation between factors of first question category

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1.00	-0.15	0.11	0.08
Factor 2	-0.15	1.00	0.38	0.09
Factor 3	0.11	0.38	1.00	0.04
Factor 4	0.08	0.09	0.04	1.00

Similar to the first question category, we conducted the factor analysis (maximum likelihood method, promax rotation) to the rated data from the 22 adjectives pairs of the second question category. As a result, four factors were extracted, as listed in Table 3. The factors were interpreted and called the factor of unfriendly properties, the factor of diligent properties, the factor of coordination, and the factor of non-dominance based on their factor loadings. Moderate negative correlations between the first and the third factor and between the first and the fourth factor were found. Moreover, a moderate negative correlation between the second and the third factor, and a moderate positive correlation between the third and the fourth factor were observed (Table 4).

3.2. Comparison of Emotions and Attitudes

After the basic analysis of the first and the second question category described in the previous section, we compared the participants' color emotions and attitudes toward the agent. We classified the participants into empathic and non-empathic groups; the former group is considered to have expressed empathy toward the agent, and the latter group is considered not to have expressed empathy toward the agent. The participants were classified on the basis of their response to the question item "warm-cold". Ten participants who scored three or less on this question were

classified as empathic, and nine participants who scored five or more were classified as non-empathic. The other six participants who scored four were excluded in this analysis. Then, we compared the distribution of the factor scores obtained from the factor analysis of the second question category between the empathic and non-empathic groups.

Table 3: Factor loadings of second question category

	Factor 1	Factor 2	Factor 3	Factor 4	Commonality
attractive-unattractive	1.05	0.16	0.05	0.14	0.85
close-distant	0.98	-0.04	0.32	0.08	0.79
warm-cold	0.82	0.13	0.05	0.16	0.50
friendly-unfriendly	0.72	0.11	-0.32	0.21	0.64
thoughtless-thoughtful	-0.54	0.19	0.25	0.01	0.68
sociable-unsociable	0.53	0.01	-0.28	0.01	0.48
responsible-selfish	0.49	-0.14	0.02	-0.22	0.48
inconsiderate-considerate	-0.38	0.16	0.00	0.36	0.51
diligent-lazy	-0.14	-1.14	0.58	0.07	0.80
unsuccessful-successful	-0.04	0.71	0.30	-0.18	0.76
careless-careful	0.26	0.70	0.21	-0.02	0.49
introvert-extrovert	-0.10	0.65	-0.12	-0.30	0.35
strict-tolerant	-0.20	0.49	-0.32	0.34	0.53
unfaithful-faithful	-0.19	0.25	0.16	0.23	0.40
mechanical-humanlike	0.16	-0.19	0.69	-0.11	0.35
attentive-inattentive	0.38	-0.04	-0.54	-0.08	0.71
flexible-stubborn	0.38	-0.02	-0.51	0.03	0.57
empathetic-unempathetic	0.53	0.12	-0.58	-0.24	0.92
exclusive-coordinative	0.06	-0.12	0.37	-0.03	0.10
assured-unassured	0.08	-0.67	-0.20	0.98	0.96
weak-strong	0.01	0.13	0.52	-0.76	0.68
rude-respectful	0.26	0.25	0.13	0.71	0.65

Table 4: Correlation between factors of second question category

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1.00	0.33	-0.58	-0.43
Factor 2	0.33	1.00	-0.44	-0.21
Factor 3	-0.58	-0.44	1.00	0.52
Factor 4	-0.43	-0.21	0.52	1.00

The distributions of empathic and non-empathic groups are shown in Figures 3 and 4, respectively. Here, the factors indicate indices of friendly properties, diligent properties, coordination, and dominance by inverting the polarity with respect to the first and fourth factor scores. The panels in the upper right show the correlation coefficients, and the panels in the lower left show the scatter plots. In the non-empathic group, the correlation coefficients are high in a combination of each of the first, second, and third factors, and the scatter plot is distributed over the first and third quadrants. Low correlation coefficients are observed in a combination of factor four and the other

factors, and the scatter plot is widely distributed over all quadrants. On the other hand, the scatter plot of all combinations of the four factors is widely distributed in the empathic group. Last, when comparing the average of the four items in the third question category between the two groups, statistically significant differences are not observed in all items (Table 5).

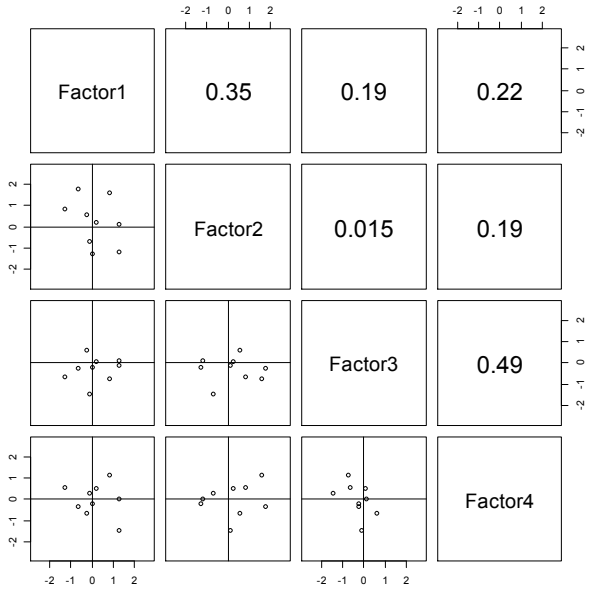

Figure 3: Scatter plot of factor indices in empathic group

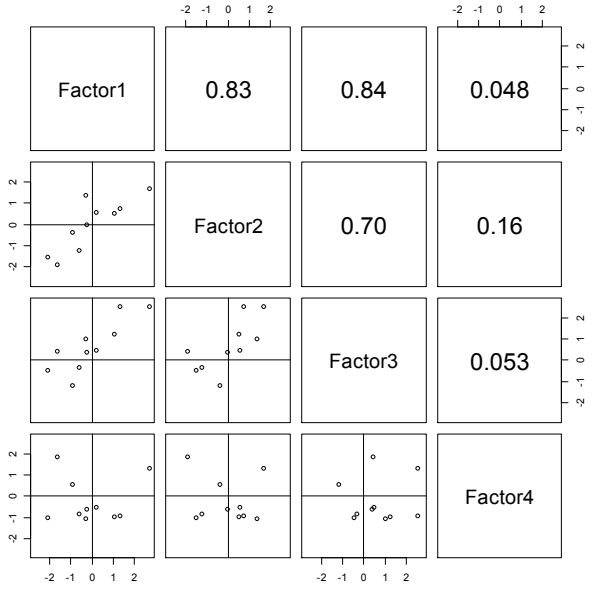

Figure 4: Scatter plot of factor indices in non-empathic group

Table 5: Comparison of scores in third question category between empathic and non-empathic groups

	empathy	friendliness	naturalness	preference for dogs
Empathic	3.11	3.89	3.22	4.89
Non-empathic	3.40	3.60	3.40	5.30

4. DISCUSSION

4.1. Occurrence of Empathy and User Attitude

The structure of color emotions that participants imagined is different from the structure of color emotions that are described in the three factors that correspond to lightness, chroma, and hue in previous studies (Gao et al., 2007; Muramatsu et al., 2011). However, the adjective pairs that consist of the first and the second factors are similar to the factor that corresponds to the lightness and chroma in previous studies. Moreover, pairs of adjectives that consist of the third and fourth factors are derived from the factor that corresponds to hue because they are similar to the hue factor. Thus, we consider that there is no significant distinction between the structures of the current and previous studies. Therefore, by screening the upper and lower scores in the question item "warm-cool," the participants were adequately divided into empathic people who speculated on the color emotion assumed in the agent's behavior, and non-empathic people who speculated on the color emotion opposite to the assumed behavior.

According to the distribution of indices, strong correlations were observed among the first, the second, and the third factors, whereas they are not correlated to the fourth factor (Figure 4). This indicates that the structure of attitude to the agent in the non-empathic group is formed mainly by two factors. On the other hand, the structure of attitude to the agent in the empathic group consists of four factors, because there are weak correlations between the first and the second factors, and between the third and the fourth factors (Figure 3). These weak correlations suggest that the people in the empathic group evaluate the agent from more varied viewpoints than the non-empathic group. Further, according to the scatter plots of the two groups, fewer samples in the empathic group are distributed in the third quadrant than in the non-empathic group. This suggests that the empathic participants are more likely to bestow higher scores to all indices than the non-empathic participants. Because attitudes to the agent are different in each group as described previously, the occurrence of empathy in individuals is implicated in their attitude to the agent.

4.2. Designing Empathic Interactions

In designing empathy in human-computer interactions, important suggestions are provided from the results of our experiment. One suggestion is that empathy can be evoked by sharing the feelings that are expressed through the agent's behavior and without providing explicit information about sensations, as adopted in the Directed Interaction. The other suggestion is that users' empathy can be enhanced positively, and multilateral evaluations can be conducted according to the users' attitude to the agents. Although the empathy observed in our study occurred only with empathic users, its occurrence seems to be operable by designing agent behavior based on shared feelings. Therefore, sharing the knowledge of feelings will become a priority when designing empathic interactions.

In the sense of sharing knowledge, content-oriented approach, such as ontology engineering in artificial intelligence, is effective. Ontology engineering is one of the methodologies that support describing knowledge systematically. From the knowledge-based viewpoint, "ontology is defined as a theory (system) of concepts/vocabulary used as the building blocks of an information processing system" (Mizoguchi et al., 1995). Once the knowledge of feelings is described on the basis of an ontology as attempted by Muramatsu et al. (2011), it is not an exaggeration to say that humans and computers can share the knowledge to have empathy. This will result in more sophisticated interactive systems that aim for the realization of human-computer interactions at a more profound level.

5. CONCLUSION

In the current study, we compared structures of attitude to the agent between empathic and non-empathic groups of participants. The structures of attitude to the agent were analyzed through factor analysis, and the participants were categorized on the basis of measurements of emotional responses to color stimuli (color emotions). The results of the comparison showed that the empathic participants evaluated the character-agent from more varied aspects, and were likely to bestow higher scores than the non-empathic participants. Consequently, empathy seems to be implicated in positive and multilateral evaluations. In future work, we will develop a method to design empathic interactions on the basis of ontological engineering.

ACKNOWLEDGMENTS

This work was supported by JSPS KAKENHI Grant Number 25730170.

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BIOGRAPHY

Keiichi Muramatsu has been a research associate of the Faculty of Human Sciences, Waseda University, since 2012. He received his Doctor of Human Sciences from Waseda University in 2014. He was a Japan Society for the Promotion of Science (JSPS) Research Fellow (DC2) in 2010-2012. His current research interests are ontological descriptions on the structure of the human mind in the research fields of aesthetics, color science, and learning sciences.

Tatsunori Matsui has been a Professor of Knowledge Science and Artificial Intelligence Lab at the Faculty of Human Sciences, Waseda University, Tokyo, Japan, since 2004, after contributing for seven years as an Associate Professor to the Graduate School of Information Systems, the University of Electro-Communications, Tokyo, Japan. Currently, his research interests are Kansei Information Science, Artificial Intelligence in Education, Mathematical Analysis for Educational Data, Statistical Science, and more. He is a member of IEEE, ACM, IEICE, IPSJ, JSAI, JSiSE, and more.

3A - Evaluation 1

KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

A theory-based framework of branded product emotions

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Abstract: Design of a branded product requires an effective understanding of how the consumers perceive and make sense of products and the brand. Kansei Engineering is an approach that takes the consumers perception and emotions into account through the Kansei words and provides information about the relation between perceptual concepts and physical properties of the product. However, the consumer perception related to non-physical aspect of the products (such as brand association) is not considered in the KE approach. This paper introduces the "branded product emotion framework" to help an understanding of the relation between brand image and Kansei concepts. According to this framework the consumer emotional responses to a new branded product can be evoked by consumers' perception of the physical properties of that specific product (Kansei), by the associations to the brand and by the association to the product class. The objective of the framework is helping to achieve a better analysis of the factors that are contributing to generate or affect the emotions and evaluations that consumers make of a branded product and reduce the risk of overlooking those emotions that brand elicits without the intermediation of the product. The frameworks is helpful in the design process of branded product in which the members of the design team, especially product designers and engineering designers, should collaborate and communicate around the brand value and the Kansei concepts to justify the design decisions and implement these concepts into a new product.

Keywords: Branded products, Kansei Engineering

INTRODUCTION

In today's market, product success is determined by consumer satisfaction that is achieved by satisfying the consumer needs (Smith & Smith, 2012) and taste. Beyond technical performances the visual attributes of products attract consumers and entice them to inspect a product more closely and consider a purchase (Seva & Helander, 2009). Companies, that are able to provoke certain emotional responses through the product appearance and to create a bond between consumers and the product, gain competitive advantages on the market and increase their product success.

Brand is an identifier of the products of a company amongst others. It is a factor that influences strongly the choices for consumers. Brand simplifies purchasing decisions, offers quality assurance and reduces perceived risks involved in the purchase (Karjalainen, 2003) and therefore contributes to elicit emotional responses from the consumer. Companies use design to create brand

recognition (Karjalainen & Snelders, 2010) and also to make consumers feel more attached to products (Aaker, 1996).

It is challenging to make sure that the consumer perceptions of the physical properties of a branded product (e.g. color, shape, material, surface texture) do not conflict with the emotional responses that the brand company initially intended. The difficulty for companies is first to understand the factors contributing to the generation of emotional responses by consumers when they face a new branded product and second to establish links between product properties and the consumer perceptions.

To address these difficulties many studies have been carried out on how consumers perceive and make sense of products (Blijlevens, 2009; Crilly, et al., 2004; Crilly, 2011; Petiot & Yannou, 2004) and on how the consumer emotions are affected by a product. The objective of these studies was to provide designers with useful information about the "side-effect" of their product design decisions on the way consumers will emotionally respond to the product. This information can help designers both in anticipating (and avoiding) the unwanted emotional responses and in stimulating the intended emotional response to make better products (Desmet & Hekkert, 2009).

Kansei Engineering (KE) takes consumer feelings and emotions into account through the Kansei (Japanese for emotional or affective) words and helps the product designers to find out what the design concept should or should not include to respond to the consumer feelings. For example the relationship between the different coloured areas and the aesthetic degree of the product (influenced by the coloured components and display angles) can be studied by KE approach (Hsiao et al., 2008). KE has been widely applied from measuring the product experience in food industry (Kang & Satterfield, 2009) and packaging (Barnes et al., 2008) to the design of E-commerce website for visualizing the information (Lokman & Noor, 2006).

Kansei concepts refer to perceptual concepts and the semiotics that are used to express consumer perceptions of products. For the branded products both Kansei concepts and brand values generate emotional responses, but the relation between brand values and Kansei concepts needs to be clarified.

This paper develops the "branded product emotion framework" to help an understanding of the relation between brand image and Kansei concepts. After a literature review on the models that address the product emotion and consumers perception, we present our model and explain it using some examples.

Literature review

In literature two different approaches take consumer emotions into account: theory-based and pragmatic-based approaches. The theory-based approaches aim to provide insights to facilitate the study of emotional responses by characterizing the emotion elicitation process (Desmet & Hekkert, 2007) and modeling how consumers perceive and experience a product (Crilly et al., 2008; Crilly et al., 2004; Warell, 2008). For example Desmet's **model of product emotion** (Desmet, 2003; Desmet and Hekkert, 2007) presents four main parameters that contribute to the eliciting process of emotions: appraisal, concern, product and emotion. The main assumption of this model is that the emotional responses are the result of an appraisal process in which people appraise (i.e. evaluate) a product based on their concerns (i.e. the points of reference in the appraised process that can match or mismatch a product). For example the reason of attractiveness of an umbrella for a person can be due to his/her concern for staying dry.

The **Visual product experience (VPE)** of Warell (2008) is inspired by the basic product emotion model of Desmet and provides a model for perceptual and visual product experience. In VPE model the product experience is composed of sensorial, cognitive and affective modes.

Crilly et al., (2004) propose **a framework for the consumer response** to the visual form of product, using the basic element of Shannon theory of communication (Shannon, 1948). In the model of Crilly et al. (2004), the design process is seen as a process of communication in which the intention of the designer or the design team is embedded in the product. The product is perceived by the consumers within an environment. This perception leads to cognitive, affective and behavioral responses, where cognitive response is composed of aesthetic, semantic and symbolic aspects. Response to the design message takes place within the consumer's culture context.

The pragmatic-based approaches aim to identify and capture the direct link between the consumers emotional responses and the product properties (Desmet & Hekker, 2002; Nagamachi, 1995). Many of pragmatic-based approaches rely on verbal and non-verbal questionnaires such as the classic Kansei Engineering approach (Nagamachi, 1995). Alternative techniques such as facial expression coding and infrared thermography (Jenkins et al., 2009) are also helpful to capture emotional responses. Desmet (2002) use a non-verbal self-reporting approach that is implemented in a software called product motion measure (PrEmo).

Although these approaches are very useful to understand the factors contributing to the emotional responses (theory-based approaches) and help to build links between the consumer perception and physical properties (pragmatic-based approaches), they do not provide a clear insight into the relation between emotional responses to the brand and to the consumer perception of the physical product.

There are a few studies that have addressed brand as a distinct element that affects the interpretation and sense making of the physical product properties by consumers. For example the relation between brand strategy and product design has been addressed in "semantic transformation" proposed by (Karjalainen 2004). This model describes how qualitative brand descriptions, that are transformed into value-based design features, generate the intended meaning of products (Figure 1). This allows for an in-depth analysis of how a design can communicate the brand message. The model suggests a triadic relationship among a perceptible object, for example a design feature, shape, color, referred to by Karjalainen as *Representament*, an *Object* (of reference, brand value), and an *Interpretant* (for example the user).

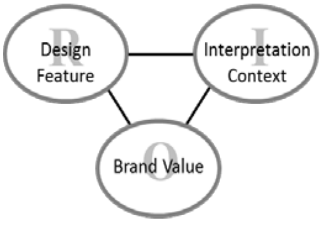

Figure 1**: The R-O-I framework for the analysis of Brand references in Design**

According to this model, the product can have elements (or features) that create association and link the product to brand values. Likewise, the brand values (and their representations in different products) affect the interpretation of the product elements (Karjalainen 2010). But from the model the relation between brand values and Kansei concepts are not clear.

Some other researches have looked at the brand values and Kansei concepts (in generation of emotional responses) using the Kansei Engineering (KE) approach. As the original KE approach did not explicitly consider the brand values, the researchers have adopted a method to link the brand values to Kansei words. For example Barnes et al. (2008), Dong, Xie, & Ding (2010) and Kongprasert (2010) use a hierarchy of words so that each 'high level' Kansei word is described by some other 'low level' words until they are related to a physical property (see Figure 2). The brand values are taken into account for the Kansei word selection and the highest level is held by the brand values.

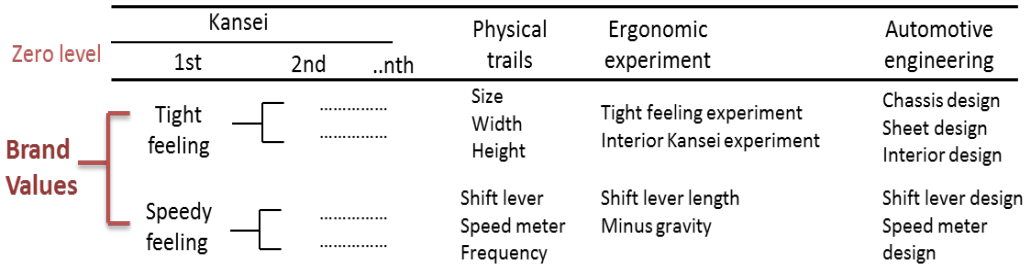

Figure 2: **Kansei Engineering flow, Nagamachi 2002**

In such a hierarchical structure of words (as shown in Figure 2) the high level concepts (brand values) can be assured if the lower level concepts (Kansei words) are met by the physical properties. For example consider a car company that wants to communicate its brand value and creates the brand image in the minds of consumers as "dynamic". Dynamic image can be achieved by creating a "tight feeling" and "speedy feeling" for consumers of the car. The tight feeling can be generated through specific physical properties such as size and height in the design of the car. This affects the design of internal product components to achieve that specific size to generate a tight feeling and create a dynamic image for the brand.

The risk involved in such a method is that it may lead to overlook those emotions that brand elicits which are not intermediate in the product.

Kansei is concerned with the perceptions coming from the product itself. We argue that the emotion related to the brand should be differentiated from the emotion related to the product perception.

It has been well established that products generate emotive responses. These emotional responses are influenced by the product class as well as the association that users make with the brand, based on personal beliefs, values and emotions toward the brand.

For example see Figure 3 for "feminine PUMA sport shoe". The product is "feminine" not "masculine". The culture and the user's background are very important in this interpretation. The perception of "feminine" of the shoe varies with cultures and through the ages. The "PUMA" brand can be recognized from the logo or the red line on the shoe. A direct association to the brand such as previous experiences with other PUMA products can generate emotive responses (i.e. it is a "PUMA" shoe not any shoe). Furthermore the class of the product generates feeling about the expected function (i.e. a "sport" shoe).



Figure 3: **Example the emotional responses to a branded product**

Framework for branded product emotions

In order to better understand the relation between brand and Kansei we presents a framework (Figure 4) inspired from the "Visual Product Experience (VPE)" model of (Warell 2008) and Desmet's model of product emotion (Desmet 2003, Desmet and Hekkert 2007) as well as the "Semantic Transformation" model of (Karjaleinan 2004) described before.

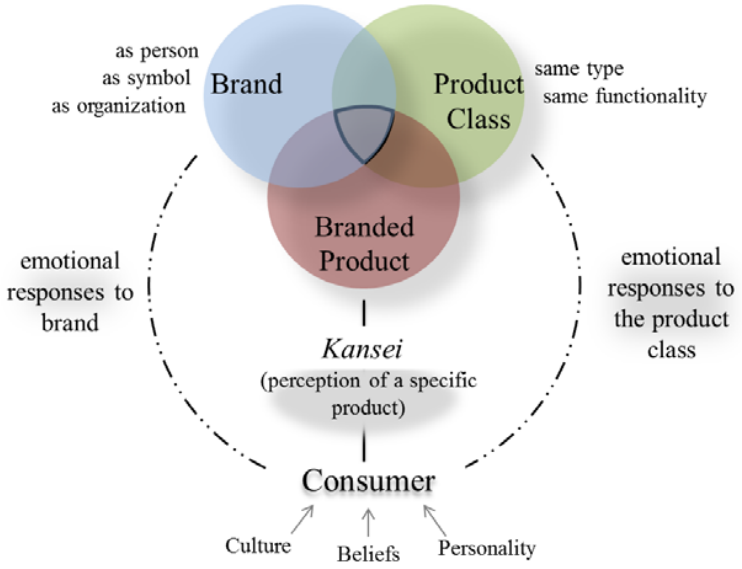

Figure 4: **Framework of new branded product emotions**

According to this model the consumers emotional responses to a new branded product can be evoked by the consumers perception of the physical properties of that specific product, by the associations to the brand and by the association to the product class. In addition, according to (Crilly et al., 2008) factors such as the consumers' cultural background, beliefs, values and personalities are also important to be taken into account, because these affect their emotional

responses.

In this model Kansei concepts are semantic words to describe the consumers perception of product's physical properties such as shape, weight, specific features or its packaging.

Product class is the label for all the products with the same core functionality (e.g. all the sport shoes, all the mobile phones). Products that are grouped in the same class share typical basic elements and similar functions. They may have variations of color, shape or brand name. The product class elicits emotional responses through the expectation it creates in the mind of consumers and through the evaluation of the new product compared to other products that perform the same or comparable functionality or have similar elements. The range of products grouped in the same class is dependent on how broad the definition is. For example for foot wear products, a product class may include sport shoes whereas a broader classification may include all type of sport and party shoes as well as slippers.

The consumers emotional responses can be generated through the attachments users have to brand and their experience of previous products of the same brand. It can be related to the image that consumers have of the brand personality, the organization and what the brand symbolizes for consumers (for example the feeling of buying and using the best).

When the consumer perception of physical properties of product aligns with the emotional responses to the brand value, the brand values and the brand's image is reinforced in consumer's mind. For example if honesty is a brand value (Figure 5), a large clear window on a plastic bag that shows the actual product, is a visual indicator that the product and the brand are trustworthy and honest (Kang & Satterfield, 2009).



Figure 5: **Intersection, reinforcement of brand image and Kansei concepts**

However consumers perception of a product (Kansei concepts) is not always necessarily aligned with what the brand intends to communicate (see Figure 6). For example "modernity" might not be the intended brand image that a DVD-player manufacturing company wants to create. But a DVD-player that is angular, metallic-looking and is made of a smooth material is perceived as modern (Blijlevens 2009).

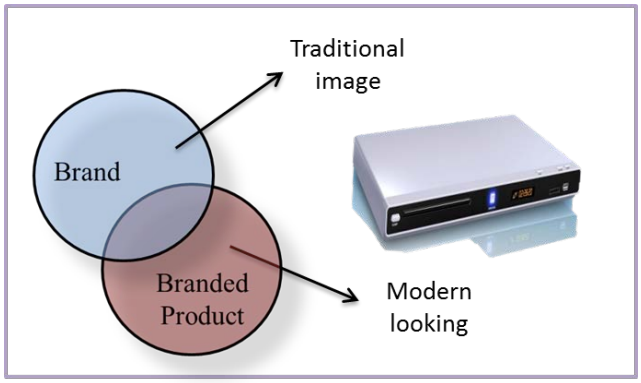

Figure 6: **Example where Kansei and brand values are not aligned**

When Kansei (consumer perception of the product) and the intended emotional responses that the brand company wants to create do not align, the product perception and the brand image can either complement or contradict each other. For example a brand that conveys the value of “prestige” and lacks the “modernity”, can gain “modernity” by introducing products that have modern design.

It is especially challenging when consumer perception of the product properties and the brand image coming from other aspects of brand value are incompatible and contradict each other. This will cause difficulties for consumers to form an image of product and brand and will negatively affect their attitude towards the brand (Rompay, Pruyn, & Tieke, 2009).

The case of complementing or contradicting emotional responses may also happen when some properties of the product do not share the functionalities expected from the product class. For example as it is shown in Figure 7, high heels are not expected for a product in sport shoe class (or shoes grouped in party shoe class are not expected to carry sport looking). This kind of products sends a mixed message that leads to ambiguity for assigning the product to a product class. In psychology literature the term “cognitive dissonance” is used to describe the feeling of discomfort resulting from two conflicting beliefs (or perceptions).



Figure 7: **Example where the perception of product class and the Kansei are not aligned**

Sometimes the emotional response arising from the product class might be in conflict with the emotional response coming from the brand value. For example “rigidity” is the intended image that the Tecnifibre brand tries to communicate to consumers (Figure 8). Rigidity is embedded in the

“inflexible” structure of Tecnifibre tennis rackets. However, the design of a tennis bag implies “flexibility” coming from the product class of sport bags. This requires a design solution that incorporates both “flexibility” and “rigidity” in the product.

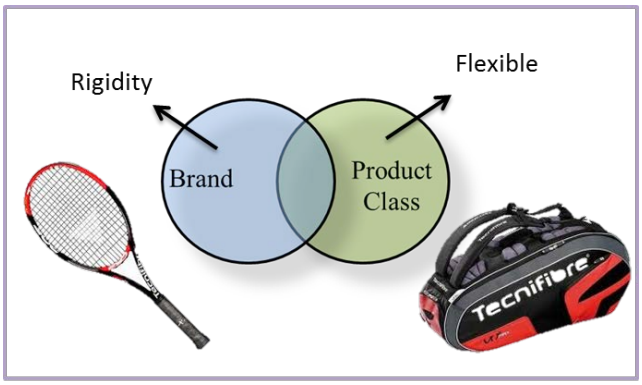

Figure 8: **Example of when brand value and the product class are not aligned**

Discussion

Like other theory-based approaches, our ‘branded products emotion model’ provides insights and understanding to analyze the factors that are contributing to generate or affect the emotions and evaluations that consumers make of a branded product.

Once the relation between brand image and Kansei concepts are clarified, the important point to consider is that for the design of a branded product, the members of the design team, especially the product designers and the engineering designers, should collaborate and communicate together to implement the brand value and the Kansei concepts into the new product throughout the design process.

Appling the brand knowledge in the design of a new product is an intuitive process. The communication of such tacit and implicit knowledge is difficult. Likewise the knowledge related to consumer perception and Kansei is also tacit. Although Kansei Engineering can provide input information and to some extent make this knowledge explicit by linking emotions and perceptions to physical properties of product, the implication of such knowledge in the design of a new product is not entirely evident. For example, Kansei concepts are context dependent. The meaning of “soft” changes from one product to other and it is difficult to say that there is an absolute link between for example the “rounded shape” and the “soft impression” in different products. The communication of Kansei concepts among the members of the design team is difficult because Kansei concepts are subjective. The subjective nature of Kansei concepts means that different people have different interpretations, which gives room for ambiguity.

In addition to the challenges related to the communication of brand values and Kansei concepts, general factors contributing to a potential communication breakdown among the design team should be considered. This includes different sets of principles, goals and training (Pei et al. 2010), thus different viewpoints on the design of the product (Bucciarelli, 1994). The use of different design representations expressing different types of information (Eckert & Clrakson, 2004) and different technical languages (jargons) (Eckert & Stacey, 2001) are also challenging. The impact of a company’s organization and configuration (e.g. locations of design department and engineering department, task definition of each department, chronologic order of activities etc.), could also act as barriers.

Conclusion

This paper presents a model of the emotional responses of consumers to a new branded product. In summary, the purpose of using particular shapes, curves, colours or elements in the design of a new product can be related to the intention of communicating the brand value and foster the brand image in the minds of consumers or to create recognition. The design decisions can be also related to the intention of generating emotions and perception related to a specific product (Kansei concepts). It is important that physical properties of the product do not generate contradicting Kansei and brand-related emotions. Furthermore, consumers emotional responses to a branded product might not be generated only due to its physical properties, but also due to the consumers' understanding of the brand in general and due to the evaluations of the product class. The consumers' cultural background, personality and beliefs are also contributing to how they perceive and emotionally respond to products.

The model provides the basis for future studies by raising interesting questions about how to identify and manage the compatibility and potential contradiction of brand image and product perception. It is important to understand the brand evolution and its future objectives defined by brand developers, and consider these objectives in the design of new products. For example if the objective of the brand company is to communicate a new value to the consumers, the design of all the new series of its products need to embody the new value.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Three heuristic approaches for predicting future lifestyles

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Abstract: For innovation, sometimes it is necessary to imagine future lifestyles in order to design corresponding products, services, or systems. However, it is very difficult for design students to characterize the future and there is no such simple method to help them to do so reasonably. This paper hypothesizes that future is predictable based on historical contexts and any future lifestyle is the extension or the contrary of the current one. For easily predicting future lifestyles, this paper proposes three heuristic ways. They are Analogical Reasoning (AR), Timeframe Reasoning (TR), and Causal Relationship Reasoning (CRR). Each of the reasoning approaches provides a simple way of imagining a specific future lifestyle. The formula of AR is “A1 : B1 :: A2 : B2”. The formula of TR is “Now > Next > Future > Ideal”. In addition, the formula of CRR is “Cause 1 > Effect 1 = Cause 2 > Effect 2”. Obviously, they help to infer future lifestyles in different ways of thinking. There are four items in each of the three approaches. The designer who applies any of the three approaches must define the first three items and then infer the last one as a particular future lifestyle. These three heuristic approaches are taught in several courses including Sensational Product Engineering, Form Design, and Color Design. This research finds that both graduate and undergraduate students in Industrial Design can apply AR, TR and CRR to efficiently generate uncommon but reasonable ideas of vivid future lifestyles.

Keywords: Future Lifestyle, Future Trend, Future Reasoning, Future Prediction.

1. INTRODUCTION

As a very good example of experiencing the coming world in our current daily lives, people watch science fiction movies that provide amazing visions of the future. One well known movie series and its popular example of future technology is the transporter in the Star Trek universe. Wikipedia (2014a) describes that “Transporters convert a person or object into an energy pattern,

then "beam" it to a target, where it is reconverted into matter". Although the transporter is a fictional teleportation machine in reality, it encourages scientists to discover all potentiality to afford as well as to deny it. In this case, future scenario gives people insights to imagine future technology. Not surprisingly, it is what industrial designers do every day.

For innovation, sometimes it is necessary to imagine future lifestyles in order to design corresponding products, services, or systems that will come true after years. However, it is very difficult for design students to characterize the future and there is no such simple method to help them to do so reasonably. For easily predicting future lifestyles, this paper proposes three heuristic approaches. They are Analogical Reasoning (AR), Timeframe Reasoning (TR), and Causal Relationship Reasoning (CRR). The author has both graduate and undergraduate students in Industrial Design apply the three approaches to test their usefulness.

2. LITERATURE REVIEW

2.1. Predicting Future Lifestyles

In science, a prediction must be a rigorous and accurate statement that points out what will (not) happen under certain conditions. A prediction is made scientifically, for example, through repeatable experiments or observational studies (Wikipedia, 2014a). Shuttleworth (2009) discusses how prediction is made in several disciplines including medicine, physics, astronomy, and archaeology. For example, Einstein and Hawking apply mathematical theories to predict how the universe behaves based on their thoughts. Quantitative models powered by computer technology now can enormously and accurately predict weather, natural disasters, economy, and political survey. However, any successful future prediction relies on extensive research ranging from history, current trends, long-term environmental changes, technology advancements, regional and international political evolution and more (FutureTimeline.net, n.d.).

Because this paper specifically focuses on predicting future lifestyles, the author hypothesizes that future is predictable based on historical contexts and any future lifestyle is the extension or the contrary of the current one. This hypothesis is partially founded on a pseudoscience called "psychohistory" derived from the Foundation fiction series by Isaac Asimov. It says that, in the fiction, historical events can be theoretically remodeled by a mathematician to simulate history in the present as well as extrapolate the present into the future (Wikipedia, 2014b). Furthermore, the website of Business Insider posts 15 trends that are shaping the future. Among the 15 trends, seven are shown in Table 1. For example, 90% of all internet traffic in 2017 will be video. People will start to record or measure every move they make (SAP, 2013). Obviously, future lifestyles are exactly the extension or the contrary of the current ones.

2.2. Analogy

The use of analogy is to transfer relational information from a known domain, to a different domain that needs answer or explanation (Vosniadou & Ortony, 1989). The identification of relational information among possible relations of the two domains results in the creation of an analogy (Casakin & Goldschmidt, 1999). To simplify, an analogy can be regarded as a likeness of relation. For example, A : B :: C : D is interpreted as A is related to B like C is related to D. This formula implies that there is a higher or more abstract concept that makes equally well for A : B and C : D. When analogizing in many cases based on this formula, A, B, and C are given and D has to be determined (Pierce & Gholson, 1994). To solve a specific problem, analogical reasoning makes people retrieve information of former problems and corresponding solutions as a means for

Table 1: Examples of future lifestyles (SAP, 2013)

Present Lifestyles	Future Lifestyles
■ 29% of Millennials find love through Facebook while 33% are dumped via wall posts or text messages.	■ Social media makes it a lot easier to break up with people.
■ Typical mobile users check their phone 150 times per day.	■ People will check their phones every 9 minutes (or stare at their phones longer).
■ People are watching more and more video online.	■ 90% of all internet traffic in 2017 will be video.
■ 66% of Millennials will look up a store if they see a friend check-in.	■ People will be curious about what our friends do and where they go.
■ Millennials trust strangers over family and friends. They lean on user-generated experiences for purchase decisions.	■ People will listen to complete strangers when deciding what to buy.
■ Wearable devices have grown by 2 times month over month since October 2012.	■ People will start to (record or) measure every move they make.
■ The amount of time parents spend with their children continues to go up in the US.	■ Dads will be getting better about sharing the housework.

searching the target solution. Scholars believe that analogical reasoning is the core element of problem solving and creative thinking (Ball, Ormerod, & Morley, 2004).

The application of analogical reasoning is prevalent academically. In science and engineering, not surprisingly, analogy is a critical approach for organizing schemes, such as Moody charts and Periodic Table. In creative thinking, analogy plays an essential role. For example, disassembling a watch as a case review to figure out how to mix fuel and air in the car is absolutely a fruitless exercise for students in Mechanical Engineering (McAdams & Wood, 2002). Likewise, students in Industrial Design realize that a bicycle helps the human body to move further and faster than before with convenience. By implication, a latest computer will help the user to complete more tasks and faster than before with less effort (Hey et al., 2008). Actually, design problems are commonly viewed as prototypical cases that are either complicated or ill-defined. Accordingly, designers rely on analogical reasoning. That is, prior knowledge and experience helps designers to search for practical solutions (Chi, Feltovich, & Glaser, 1981).

Gentner and Markman (1997) state that analogical reasoning is the process of mapping knowledge from one situation to another. This mapping fosters new inferences and promotes insights for solving problems. The capability for solving problems is more creative when the reasoning maps two very different domains at the first glance. Moreover, there are theories, methods, or tools established based on analogical reasoning. One well known example is the Theory of Inventive Problem Solving (TIPS) or TRIZ. It is an analogy-based problem-solving theory as well as an idea-generating method applied in Mechanical Engineering and Product Design. TIPS creatively maps design problems and working principles derived from a large amount of patents of U.S.S.R. It makes it possible that design principles have proven successful in the past can be applied to solve new problems (Altshuller, 1984).

3. THREE APPROACHES

3.1. Analogical Reasoning (AR)

AR provides a simple way of imagining a specific future lifestyle. Its reasoning formula is “A1 : B1 :: A2 : B2”. For example, as shown in figure 1, assuming that A1 is defined as a carrier pigeon, B1 is a postman who drives a mail truck, A2 is a fax machine, and B2 is unknown. One designer can think about the difference between a postman and a carrier pigeon, and then apply the difference to redesign a fax machine as well as to define B2. If the designer assumes a postman differs from a carrier pigeon in professional human resource, B2 could be express service involving human deliverer such as DHL. If the difference between a postman and a carrier pigeon is systematic process, B2 could be an email system that we use nowadays. However, if the designer feels that B2 just defined is not so futuristic, what he or she needs to do is to replace A2 with B2 and then redo the reasoning process over and over again until good ideas generated.

This research finds that two undergraduate students in Industrial Design can apply AR to efficiently think out uncommon but reasonable future lifestyles. For example, one student came up with that the difference between a fax machine and a postman is micro-electronic application. That is, a bigger mail truck evolves into a smaller fax machine and a postman is replaced by wire networks. Hence, rather than larger computer monitors or cell phone screens, people will check emails or surf online on their clothes or skin in the future. The other student described DHL delivers in a way that directly contacts or touches customers. This is what USPS seldom does. So, rather than typing texts or sending emails to friends on a touch screen, in the future, people will talk to their cell phones that send their voice to their friends. And then those friends will listen to the voice messages based on his or her best timing.

3.2. Timeframe Reasoning (TR)

The formula of TR is defined as “Now > Next > Future > Ideal”. The symbol “>” here indicates “progress” rather than “more than”. To predict a specific future lifestyle or a design idea in the future, three items including *Now*, *Next*, and *Future* must be well defined by designers while *Ideal* is unknown. One designer needs to think about the difference between any two of *Now*, *Next*, and



Carrier Pigeon		Postman		Fax machine		Express Service / Email System / ?
A1	:	B1	::	A2	:	B2

Figure 1: Examples of Analogical Reasoning

Future. Then, *Future* is upgraded based on the difference in order to define *Ideal*. Similar to AR, if the content of *Ideal* is not satisfied, the designer should regard *Next*, *Future*, and *Ideal* as well-known contents and then apply the reasoning process over and over again until the result (new *Ideal*) is acceptable. Alternatively, the designer can regard *Future* as unknown. Afterwards, *Ideal* is deteriorated based on the difference in order to define *Future*.

Figure 2 shows examples of TR that illustrates the advancement of Iron Man. Since Mark II, each type of Iron Man is designed for solving the primary problem of the previous type. For instance, Mark I's problem is that Tony needs Yinsen's help to suit it up in the cave. Then, Mark III with the suit-up gantry indicates that Tony cannot bring it elsewhere. Subsequently, Mark V is portable as a suitcase but Tony needs Hogan's help to carry it. It is amazing that Mark VII can rapidly and precisely suit up on Tony. However, it is too bulky. As a result, Mark XLII, the latest type of Iron Man, is designed for making it modular and smaller. Obviously, the difference between any two consecutive types of Iron Man is that the new type moves easier and suits up faster. Therefore, it is possible to generate ideas of new Iron Man based on TR.

In this case, three undergraduate students in Industrial Design applied TR to generate ideas of new Iron Man. One student proposed Mark XLII's problem is that it works well only after it assembles as a complete Iron Man. The new Iron Man will make it possible that its modules operate, such as attack and defense, individually and collaboratively. Another student presented that the new Iron Man, one or few parts, will enable to suit up on different people for transporting them or saving their lives. The other student mentioned that Tony needs to build up several different types of Iron Man with different functions. It obviously takes time and expenses resources. Therefore, Tony will apply modular design to the new Iron Man series. That is, for example, there is a minimum of 20 modules any group of which can assemble different type of new Iron Man with specific function. Besides, after one module suits up on Tony, another module can suit up on it. The



Mark I	Mark II	Mark III	Mark V	Mark VII	Mark XLII	
Now >	Next >	Future >	Ideal			
	Now >	Next >	Future >	Ideal		
		Now >	Next >	Future >	Ideal	
			Now >	Next >	Future >	Ideal

Figure 2: Examples of Timeframe Reasoning

other modules or parts that do not suit up on Tony are just with him in order to assist or protect him.

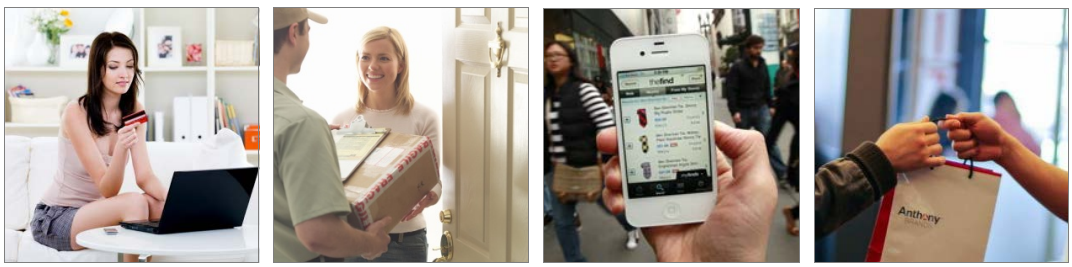
3.3. Causal Relationship Reasoning (CRR)

CRR is apparently used to infer the relation between cause and effect not only in the past or right now but also in the future. Its formula is “Cause 1 > Effect 1 = Cause 2 > Effect 2”. Again, the symbol “>” here means “progress”. When CRR is applied, either Cause 2 or Effect 2 is unknown while the rest must be defined by the designer. The designer needs to expand on the relationship between Cause 1 and Effect 1. Then, according to the relationship, the designer proposes the most likely Effect 2, if unknown, based on Cause 2 that is just defined. Different from AR and TR, if the resulting inference is not satisfied, better Cause 1 and Effect 1 are needed to replace the original set. The designer needs to start over the reasoning process rather than redoing it over and over again.

Figure 3 shows examples of CRR for inferring future lifestyles. These are done by two undergraduate students in Industrial Design. For instance, because any driver will probably encounter or involve in traffic accidents at any time in the future, it is necessary to install and use dashboard camera at all times in order to protect his or her rights and interests. By the same token, because any woman takes risks walking at night or in dangerous area, it is necessary to install and use “walking camera”. Actually, the idea of walking camera not only secures the owner but also helps to build the street view, similar to that of Google Map, based on the viewpoint of a passenger in addition to a car. The second example relates delivery to shopping. For instance, if someone buys a product online at home, the product will be delivered to his or her home. In the same way, if someone buys a product on a touch screen on the way to somewhere, the product should be delivered, as soon as possible, to the person on the way. This service will absolutely provide consumers a better shopping experience.



Traffic accident		Dashboard camera		Personal security		Walking camera
Cause 1	>	Effect 1	=	Cause 2	>	Effect 2



Shopping at home		Delivery to home		Shopping on the way		Delivery to individual
Cause 1	>	Effect 1	=	Cause 2	>	Effect 2

Figure 3: Examples of Casual Relationship Reasoning

4. CONCLUSION AND DISCUSSION

This paper presents three approaches, including AR, TR, and CRR, for primitively reasoning future lifestyles. The three approaches have been taught in several courses including Sensational Product Engineering, Form Design, and Color Design. Many graduate and undergraduate students apply them to generate ideas of vivid future lifestyles. These lifestyles range from product concept such as car styling and car interior functions to future trends such as color schemes and living habits. According to the author's practical application in class, AR, TR, and CRR are capable of helping design students to think about design or product ideas in the future.

However, the three approaches need to be adjusted and improved for better effectiveness. For example, these approaches are only tested by relatively few groups of students so far, more tests involving more subjects dealing with different types of reasoning or future trend are required next. It is the only way, after all, to make these approaches become methods that are more reliable and can be applied in most cases. In addition, these approaches imply a novel way of visualized thinking. In fact, they enable visualized reasoning that is different from and more powerful than Brainstorming or Brainwriting for idea generation. For this valuable and creative purpose, the format and process of these approaches need to be redesigned. The author plans to make it more clear and manageable as a set of worksheets or application program in the near future.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Product novelty impact on user Kansei

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Abstract: This paper presents an experimental study that assesses the impact of novelty appraisal on user´s emotional feelings and in their evaluation of user experience with commercial products. After actual interaction with 4 products differing in two levels of design typicality of design in two categories of products (cameras and highlighters) participants used a SD method for the evaluation of user experience quality, and a two-dimensional mood scale survey for assessing their own emotional feeling. Likewise, participants were asked if they had seen and if they had used the products before, obtaining three cases: 1. who had already used it before (no novelty), 2. who had seen it but not used it (relative novelty) and 3. who had not seen it before (absolute novelty). The previous experience of participants with the particular product defined the degree of novelty appraisal, confirming that typical products were more likely to be appraised as known and atypical ones as novel.

Results on emotional feeling measures showed slightly higher pleasure levels for the not novel cases and significantly higher arousal for the relative novelty cases. For the quality of experience evaluation, the highest scores for the no novelty cases were “practical”, “useful”, “predictable” and “easy to understand”; the relative novelty cases were “interesting”, “creative”, “satisfying” and “like”; and the absolute novelty cases were for “interesting”, “creative”, “new” and “innovative”. These findings suggest that visual stimulation prior the first use interaction has an arousal enhancing effect in the experience of use, accompanied by qualities related to novelty.

Keywords: Novelty, Typicality, User Experience, Emotion.

1. INTRODUCTION

Also supported by the framework of product emotions of Desmet (2007), the appraisal theory perspective proposes that emotion is a result of the judgment of the significance of a product depending ones' concerns. When a stimulus characteristic is perceived as fulfilling some personal concern, it will cause an emotion (positive or negative). Novelty is defined as one of the evaluation checks (Scherer, 1984), as well as intrinsic pleasantness, goal compliance, coping potential and norm-compatibility, each one can be related to a respective basic concern of the person: attitudes, goals, standards and knowledge. Novelty is determined by the previous knowledge of users, upon which expectations regarding a product are built.

In this context, an experimental research aimed at explore the interactions between the novelty of a product, the cognitive constructs in terms of perceived qualities of the user experience, and the emotional feeling derived from the experience, could mean a contribution for the understanding of the mechanism of emotion appraisals. Also, represent an opportunity to reflect on the role of novelty in user experience, Is novelty a positive value by itself? How does it interact with other external factors and properties of the product?

1.1. Appraisals

Appraisal theory claims in its essence that emotions are elicited by evaluations (appraisals) of events and situations (Roseman, 1984). Since the same situation might be able to elicit different emotional reactions in different individuals, and one person may react differently to the same situation in different point in time, it results very helpful to consider emotional reaction as elicited by a distinctive pattern of appraisal. In this perspective is considered that the emotion is not caused by the situation itself, but by the interpretation of it. The situations, persons, environments objects that we met in our daily experiences are evaluated by the emotional process, according to which we develop behaviors

1.2. Typicality

Typicality can be defined as the degree to which an object represents a category. This characteristic can be determined by three factors (Barsalou, 1985) similarity to one ideal of the category, similarity to a central tendency of the category, and frequency of encounters as member of the category.

Hekkert and colleagues´ (2003) experimental research proved the relationship between typicality and novelty regarding aesthetic preference of products, finding that both factors are equally important in explaining the aesthetical preference; as more typical a stimulus, the less perceived as novel and as more novel, the less typical. It was also found that typicality and novelty were not perfectly opposed, so it is possible to obtain a balance of the two for eliciting aesthetic preference.

There are somehow divergent postures regarding the aesthetic evaluations of typical stimuli. For some, an effect of preference for the typicality has been found and proven using a wide variation of types of stimuli, such as paintings (Hekkert & van Wieringen, 1990), furniture (Whitfield & Slatter, 1979), music (Smith & Melara, 1990) human faces (Langlois & Roggman, 1990) and advertising images (Sanabria, 2012). These theories are also compatible with Zajonc´s (1968) research on mere exposure effect, that state that unreinforced repeated exposure to stimulus increases their positive affect. This effect has been explained arguing that the familiar is preferred over the novel because it implies to avoid the risk of the unknown inherent to novel stimuli.

2. EXPERIMENTAL STUDY

2.1 Objective

The present experimental study had the objective of assessing the impact of product novelty in users´ inner emotional feeling states and subjective impressions based on actual interaction.

2.1. Experiement outline

A total of 32 Japanese students (16 female, 16 male) of graduate and undergraduate levels from the University of Tsukuba participated voluntarily.

2.1.1 Hypotheses

1. Products appraised as novel will elicit higher arousal and pleasure levels than products appraised as not novel.

2. Products appraised as novel will be evaluated with higher scores in user experience qualities than products appraised as not novel.



Figure 1: Framework of the study

2.2. Measures

The use experience quality with the product was measured using a Semantic Differential (SD) method, consisting of 18 pairs of antonym words in a 7 level scale (see Table 1). The scale corresponded to: 0="neither one", which was situated in the middle; and 1="slightly", 2="moderately", 3="highly" for each side corresponding to each word. The words selected for this evaluation included both instrumental and non-instrumental qualities of the interaction experience. The words were selected after considering previous research on user experience evaluation (Hassenzahl 2005, 2007, Karapanos, 2008; Jordan, 2000; Hekkert, 2006) to compose an original array of words. The printed version used for the experiment presented the words in random arrange of the right and left columns and it was written only in Japanese.

The emotional feeling response of the participants was measured using the "Two dimensional Mood Scale for Self-monitoring and Self-regulation of Momentary Mood States" (TDMS) (Sakairi, 2013). This method consists on evaluating on a chart the own momentary mood by giving a score in a 6 level Likert scale to 8 different mood words. The words used are: Energetic, Lively, Lethargic, Listless, Relaxed, Calm, Irritated and Nervous. The scale gave scores from "Not at all"=0 to "Extremely"=5. The scores given for the different words are used to calculate a measurement of the Vitality, Stability, Pleasure and Arousal indexes (see Table 2).

Table 1: Words used for use experience quality measure (SD)

Necessary	Unnecesary
Cheap	Expensive
Creative	Not creative
Innovative	Not innovative
Interesting	Not interesting
Simple	Complex
New	Common
Human-like	Machine-like
Practical	Unpractical
Unpredictable	Predictable
Easy to understand	Difficult to understand
Easy to use	Difficult to use
Useful	Useless
Reliable	Unreliable
Satisfying	Not satisfying
Beautiful	Not Beautiful
Like	Dislike
Good	Bad

Table 2: Measures and score calculation of TDMS

Measurement index	**Word rating calculation**
VITALITY	(Energetic+Lively)-(Lethargic+Listless)
STABILITY	(Calm+Relaxed)-(Irritated +Nervous)
PLEASURE	PLEASURE+STABILITY
AROUSAL	VITALITY-STABILITY

2.3. Procedure

1. Feeling self-assessment (before interaction)

Participants rated their own emotional feeling using the TDMS to obtain a baseline measure before the product interaction. Participants filled the TDMS on the original paper survey, evaluating their own feeling according to the 8 words (Energetic, Lively, Lethargic, Listless, Relaxed, Calm, Irritated and Nervous) in a 6-level Likert scale (0 to 5).

2. Product interaction

According to the counterbalanced order, the researcher took the corresponding product from a bag away from participant sight and placed it on the table in front of the participant. Then, participants were instructed to take it and use it freely as long time as they wanted. Participants are instructed to tell when they are finished the interaction.

In this stage the time of interaction was measured from the moment the user was given the product to the moment in which the participant notified finishing the interaction.

3. Feeling self-assessment (after interaction)
After the interaction stage, the emotional feeling was again measured using the TDMS, in the same way they had before the interaction.

4. Experience evaluation
The experience quality evaluation is obtained using the SD method. Participants rated the 18 pairs of words according to the 7 level Likert scale on a printed piece of paper in order to evaluate their experience with the product.

5. Previous knowledge evaluation
Participants responded YES or NO to the next two questions in a written questionnaire: (A)“Have you seen this product or a very similar before?” and (B) “Have you used this product or a very similar one before?”.



Fig 2: Experiment procedure

2.4. Stimuli

The distinction in levels of design typicality considered the perceptual and functional characteristics of the samples in the degree to which they corresponded to a central tendency in their category. Accordingly, the typical design displays common characteristics and family resemblance corresponding to the central tendency, while the atypical design sample is characterized as different to the central tendency. An important remark here is that both typical and atypical designs had to remain perceived as members of the same category of products, therefore the atypical sample should not be as radically different from the central tendency than it could be perceived out of the category.

The parts of the product were a focal point to distinguish the central tendency and consequently their typicality. The parts of the product represent perceptual features related intrinsically to their function and user behavior (Tversky, 1984). On each category, a range of 30 commercial products available was analyzed and compared to define one central tendency. (See Annex 1) The shape of the basic parts forming the structure of the products was sorted and the most frequently found shapes were identified to define a central tendency. Samples corresponding absolutely to these characteristics were considered as typical. Samples that did not displayed the basic part in the prototypical shape, were found radically different from the central tendency, and therefore were discarded as they might be perceived outside the category. As a result, the samples chosen as atypical shared the basic characters for being considered in the category of products but had different features as way of use, functionality and shape, the atypical camera takes 360° panorama pictures by spinning around, while the atypical highlighter has a tip that allows drawing 3 different kinds of lines.

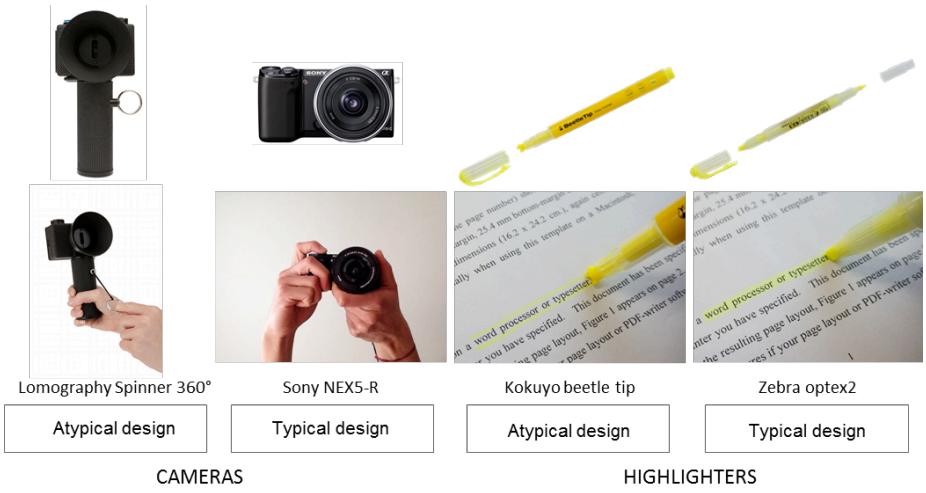

Fig.3: Samples selected as stimuli

2.5 Results

The influence of previous experience factor was calculated on a one-way ANOVA of the emotional feeling scores after interaction in four categories. The only one that showed a significant difference was the arousal ($F(2,125) = 3.07$, $p = 0.049$). A post hoc Tukey HSD test showed that the only significant difference was between the “seen but not used” group and the “used before” group.

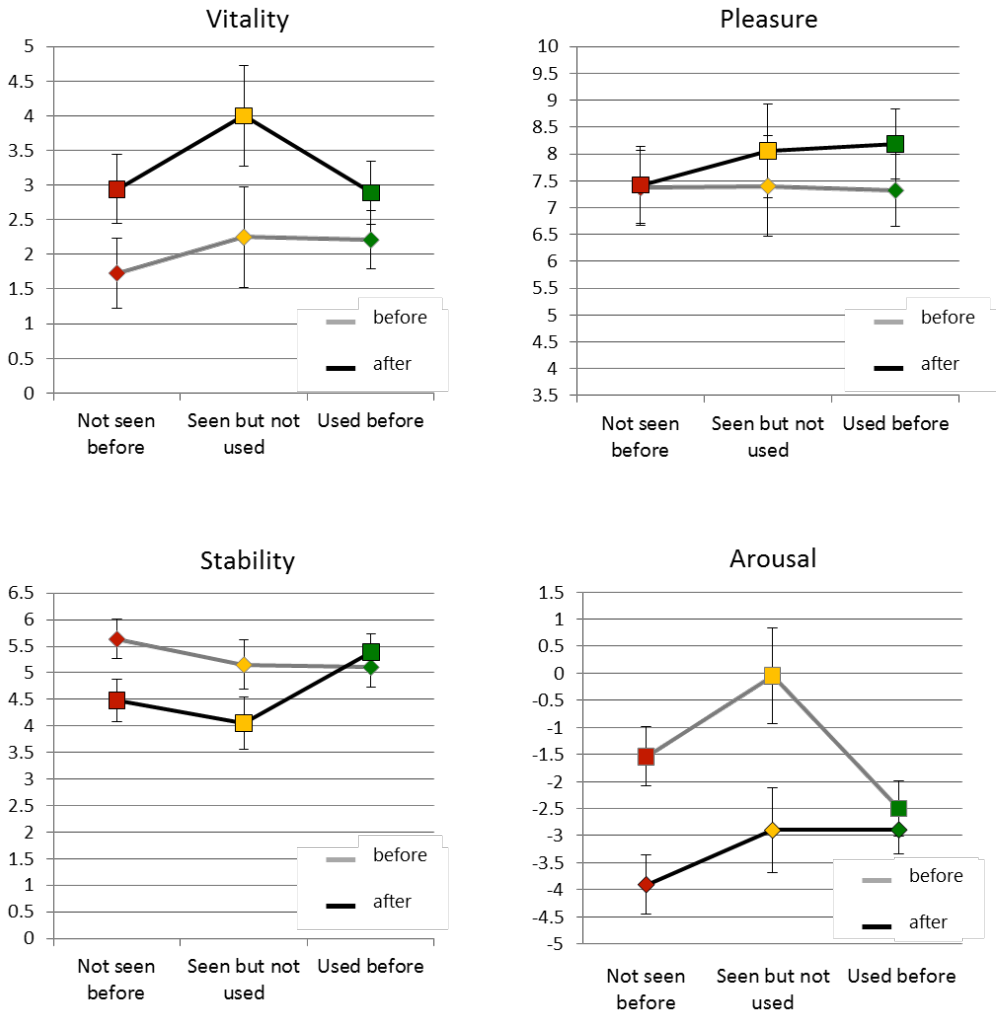

Fig 4: Emotional feeling scores according to the previous experience factor

2.5.1 Typicality and previous experience

The emotional feeling evaluations performed before and after the interaction with the 4 products by the 32 participants, resulted in a total of 256 evaluations. From this total, the half corresponded to the ratings of the typical products and the other half to the atypical ones. Participants were asked if they had seen and if they had used the product (or an extremely similar one) in the past; therefore, resulting feasible cases were labeled according to three levels: “not seen before”, “seen but not used before” and “used before”. Table 1 shows the count of cases and its proportion in each group.

Table 2: Distribution of correspondence of “typicality” with “previous experience” levels

FACTOR	LEVELS	N	PREVIOUS EXPERIENCE LEVELS		
			Not seen before c (%)	Seen but not used before c (%)	Used before c (%)
Typicality	Atypical	128	102 (79.68)	18 (14.06)	8 (6.26)
	Typical	128	2 (1.56)	22 (17.19)	104 (81.25)
	TOTAL	256	104 (40.62)	40 (15.62)	112 (43.76)

2.5.2 Experiment factors influence on interaction time

The time variable was related to the experiment condition factors using one-way ANOVA. The typicality factor did not show any significant difference ($F(1, 126) = 0.939$, $p = 0.33$). The factor of types of products showed a significant difference ($F(1,126) = 25.03$, $p < 0.001$) so that cameras ($m = 113.84$s, $SD = 62.445$) registered longer periods of time during interaction than highlighters ($m = 68.20$s, $SD = 37.762$). The previous experience with the product factor also showed a significant influence on the times of interaction ($F(2,125) = 4.918$, $p = 0.0087$), so that the “seen but not used” cases registered the longest times ($m = 116$s, $SD = 8.022$), followed by the “not seen before” ($m = 98.44$s, $SD = 43.956$) and the “used before” ($m = 75.21$s, $SD = 48.692$) in the third place. After a Tukey HSD post-hoc test, the only significant difference found was between the “seen but not used” and the “used before” ($MD = 40$, 95%CI (7.04/74.53), $p = 0.013$).

2.5.3 Analysis of user experience evaluation ratings.

The pairs of words (18 items) used to evaluate the experience quality in the semantic differential method were reduced using a principal component analysis based on the scores obtained after the evaluation of the 4 samples of products by the 32 participants. As a result, three components displayed eigenvalues greater than 1 and were used to perform varimax rotation. These three components accounted for the 73.32% of the total variance. The items were allocated to a component if they showed a loading greater than 0.65. Accordingly, the first component had 9 items and was labelled as “instrumental satisfaction”; the second component had 4 items and was labeled as “novelty quality”; the third component had 3 items and was labeled as “approachability”.

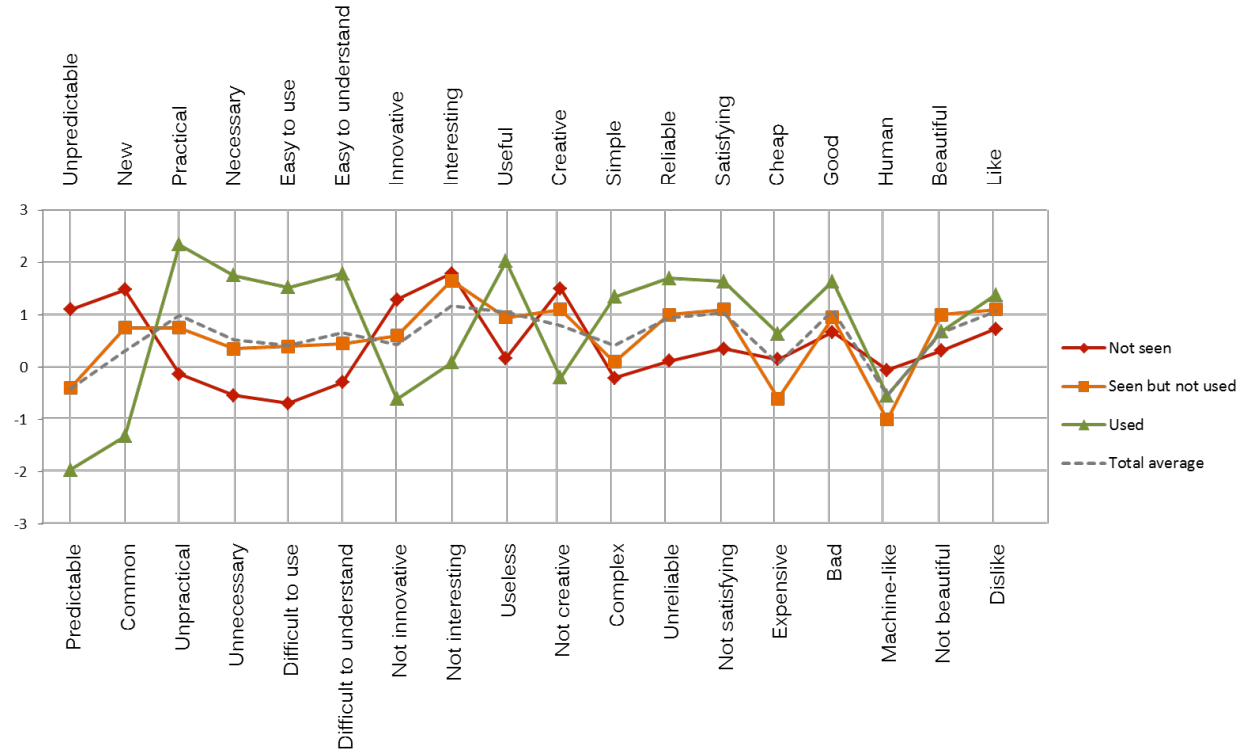

Fig 5: Emotional feeling scores according to the previous experience factor

The scores of SD method by the factor of "previous experience" were analyzed through ANOVA, and a Post hoc test to know the significant differences among its three levels. After assessing the statistical significance of the three combinations among levels, words were grouped according to the number of significant differences (from three to none).

Table 3: Summary of SD evaluation and emotional response among three levels of previous experience

(0) Not seen before	(1) Seen but not used before	(2) Used before
Unpredictable		Predictable
Difficult to use		Easy to use
		Practical
New		Common
Innovative		Not innovative
Interesting		
Creative		
	Expensive*	
		Necesary
		Useful
		Easy to understand
	Reliable	
	Satisfying	
		Simple
		Good

* Only 0.1 above the neutral level

3 DISCUSSION

An experimental approach based on interaction with real products was applied for evaluating the effect of product novelty on emotional feelings and evaluation of qualities of user experience. The measurement of these two parameters, linked to the particular level of previous experience of the user with the product allowed to explain the effects of the novelty appraisal. The two hypotheses are confronted to the results of the experiment as follows:

1. Products appraised as novel will elicit higher arousal and pleasure levels than products appraised as not novel. This hypothesis was supported for the arousal, but not for the pleasure.

The analysis of the emotional feeling scores among the levels of previous experience showed a statistically significant difference only for the arousal measurement. This difference was found between the “seen but not used”, which obtained the highest score among the three cases, and the “used before”, which obtained the lowest. This result supports the theories that novelty is accompanied by an autonomic arousal caused by the conflict of adaptation to the new stimulus (Berlyne, 1960). Regarding pleasure, contrary to the proposed hypothesis, the highest mean score was obtained by the case of “used before” followed by “seen but not used” and “not seen before”. Effect of mere exposure or an improvement of process fluency can be the reason for this increased pleasure response towards the familiar product.

2. Products appraised as novel will be evaluated with higher scores in user experience qualities than products appraised as not novel. The results do not support this hypothesis completely.

The analysis of the evaluation of qualities of user experience among the levels of previous experience of the participants did not show a tendency of general high scores vs. low scores; the results of each case had their own set of particular attributes (Table 3). In other words, rather than be divided in bad or good, they displayed different characteristics. Upon these differences, it was possible to get a better picture of the whole phenomenon of novelty. Instrumental qualities like “easy to use”, “practical”, “useful” and “easy to understand” were found as characteristic for the case participants had used the product in the past. Qualities like “new”, “innovative”, “interesting” and “creative” were shared between the participants who had not used the product before (“not seen before” and “seen but not used”). Besides, in the case participants had not seen the product before, they distinguished the experience as “difficult to use” and “unpredictable”. Additionally, the evaluation of the qualities of “reliability” and “satisfaction” of the participants who had seen the product before but used it for the first time in the experiment (“seen but not used”), were as high as those who had used the product before.

4 CONCLUSION

This study analyzed product novelty as an appraisal dependent of the participant´s previous experience, and used typicality (resemblance to a central tendency) as a factor for triggering it.

The nature of the three cases of previous experience regarding the product can be explained through the interplay of two elements: change and expectation. Novelty implies a change in regard to the previous experience, something new that has not encountered before. Expectation consists of the mental representation of what is likely to happen, which is predominantly derived from previous experience. Regarding these elements, the case in which participants had previous experience of use (“used before”) with the product, there is no change, because the stimulus is not

new, and experience is found to be congruent with the expectation about it. For the other two described cases, “not seen before” and “seen but not used” the product was used for the first time, implying a change in regard of the previous experience for both, however the element of expectation marks a substantial difference: in the case participants had not seen the product before, they face an unexpected situation, while participants that had at least the antecedent of having seen the product, they knew what to expect of it.

1. Not seen before: unexpected change situation
2. Seen but not used: expected change situation
3. Used before: expected situation without change

This fact can explain the main two results obtained of emotional feeling evaluations. The “seen but not used” cases were distinguished for having the highest arousal and highest vitality levels: the impact of the novel stimulus was supported by the expectation built over the previous visual experience. The other result was that of the “used before” cases, which were characterized for had increased in stability, while the other two decreased. The “used before” cases corresponded mostly to the interaction with typical designs, so its feeling response seems to support the effect of repetitive exposure reflected in increased familiarity, and expressed in a preference for typicality.

The distinctively positive impact found in the case participants experienced the use of products for the first time supported by previous visual exposure (“seen but not used”) seems to go along with the idea that the novelty appraisal has better effects when perceived in a relative level. The other two cases described in the study can be interpreted as absolute (or extremely close to absolute) levels of novelty and not novelty; for those cases of “not seen (and not used) before”, novelty is exceedingly high and for those of “used before” cases is null. The positive impact of the stimulus is related to the relevance derived from degree of familiarity, as Berlyne states it “we are indifferent to things that are either too remote from our experience or too familiar.”

In the field of design, these insights can be interpreted in the sense that a novel product, not just for being novel, will be relevant. The priority would be to cover user needs for achieving satisfaction, and as a result from a creative process conceive a novel product. If the core of the novel product is just its newness, it would likely achieve a quick peak of preference and will turn the tide vanishing in the same way. As mentioned by Loewy, there has to be a point in which the product design gets its “most advanced, yet acceptable (MAYA)” point, to be successful, that is, a relative degree of change, supported by the expectations of target users. In this sense, when proposing new ideas is important to know well which are the expectations and mental schemas, perceptions and ideals of users.

One more field of interest in this research is communication and advertising. A complex mixture of elements come to play, but novelty, repetition and the changing psychological effects that has on the perceiver are fundamental to convey an effective, appealing and engaging message. The mechanism of advertising itself uses stimuli in massive exposure and repetition to which consumers feel familiarity and preference for some time. It may occur that the stimulus becomes indifferent and start reducing its positive value. It seems a good strategy to maintain essential elements in the stimulus for keeping the recognition and pleasurable response, but along time add changes, new arranges and new elements that keeps it update and with arousal potential.

The present experiment was based on the evaluation of the interaction with products occurring one single time, but a new perspective of research could include subsequent interactions to understand its changes over time. In this experiment the context of use was reduced to laboratory conditions, but there is the opportunity for future research to include the context as a relevant factor. The closer to actual conditions of the phenomena, the more reliable, complete and helpful it would be.

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6. ANNEXES

Annex 1: Sample screening for highlighter markers

1  Crown line maker	2  Zebra Highlighter Sparky 1	3  Bic Brite liner	4  Pilot Spotliter	5  Propus highlighter cartidge
6  Zebra optex 2	7  Pilot spotlitter 2	8  Zebra optex care	9  Tombow coat	10  Stabilo navigator
11  Tokai Osto	12  Muji knock system highlighter	13  Zebra knock highlighter	14  Pentel Handy line S	15  Sharpie Accent Retractable Highlighter
16  Sharpie mini accent	17  Sharpie Smear Guard Blade	18  Stabilo Boss	19  Pilot frixion soft color	20  Mitsubishi pro mark view
21  Propus window soft color twin type	22  Staedler textsurfer gel	23  Kokuyo Beetle tip	24  Flag Highlighter With Memo Sticker	25  Parallelogram Shape Highlighter Marker
26  Triangle Highlighter	27  Capsule highlighter marker	28  Highlighter Fluorescent Marker Graffiti Pen School Office	29  Needle syringe shape highlighter injection pen	30  5-In-One-Hand-Highlighter

Annex 2: Sample screening for cameras

1  Sony Cybershot DSC RX100	2  Canon Powershot s120	3  Nikon 1 J2	4  Leika 18489	5 
6  Sigma DP2	7  Casio EX-ZR800BK	8  Sony NEX-5R	9  Samsung NX1000	10 
11  Canon EOS M	12  Pentax k-01	13  Fujifilm X-A1	14  Olympus PEN E-P5	15 
16  Panasonic LUMIX DMC-FZ70-K	17  Pentax K-5II 18-135WR	18  Nikon D3100	19  Lomography Holga	20  Lomography La Sardina
21  Lomography spinner 360	22  Sony Cyber-shot DSC-TX30	23  Clap 380	24  Fujifilm FinePix XP200	25  Canon Powershot D20
26  Lomography oktomat	27  Lomography Blackbird fly	28  Casio Exilim EX-TR15	29  Ricoh Theta	30  Panono

A Study of Rational and Emotional Product Properties

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Abstract: This study is about understanding the factors affecting how designers recognize rational and emotional product properties based on variation of product properties. The target sample of this study is the electronic fan which is categorized into five different styles: Function, Friendly, Fun, Fancy, and Feeling. Two experiments have been carried out to examine the differences and relationship of the rational and emotional product properties. Experiment one is for the purpose of selecting the representative products of rationality, neutrality, and emotion. In experiment two, products which are most frequently selected in experiment one are regarded as reference indicators, and the remaining samples are arranged in the order of rationality, emotion, and impact factor. The expectation is to acquire different design inspirations from the result of this study based on different characteristics and control variables of these products of five different styles. The two main purposes of this study are: (1) to explore how these five kinds of product design styles affect the perception of rationality and emotion, and (2) to explore the differences in impact factors of five kinds of product design styles on the perception of rationality and emotion, and to infer future product design trend based on the found differences from the era of five product design styles. The distinction between the form characteristics of rationality and emotion has been found in this study, and the "Feeling" style has indicated the design trend beyond traditional fan structure. Another finding is that, there is the perception of rationality in the technological sense, and the perception of emotion will appear after the addition of "feeling".

Keywords: Product Property, Rationality and Emotion, Product Style, 5F

1. INTRODUCTION

Product personality (i.e., the set of human personality traits that are used to describe a product variant (Govers & Schoormans, 2005) can also explain the inferences about functional attributes that people draw from the appearance (Ruth Mugge, 2011). In this study the product properties of rationality and emotion will be investigated, together with their impacts on the five kinds of product

design styles based on the perceptions of experimental subjects (who have received professional design trainings) with respect to product rationality and emotion. In this study the five kinds of product design styles are the five English words starting with F representing the styles formed by product design characteristics developed in five different eras, which are Function, Friendly, Fun, Fancy, and Feeling. The two purposes of this study are as shown below:

1. Investigation of impacts of five kinds of product design styles on the perception of rationality and emotion. The perceptions of designers with respect to rational and emotional product properties will be understood through generalization of rational and emotional properties of these five styles such that the product design behavior can reach better balance between rationality and emotion, which shall lead to the perfection of product design.
2. Investigation of the differences in the impact factors of these five kinds of product design styles with respect to perceptions of rationality and emotion. The trend of future product design style will be inferred based on the changes discovered from the era evolution of these five kinds of product design styles.

2. LITERATURE REVIEW

The evolution of product style

Product appearance is a major determinant of product personality and that people will get an idea about the personality of the product just by a casual glance of the product (Brunel & Kumar, 2007; Govers, Hekkert, & Schoormans, 2002; Mugge et al., 2009). The generation of different product styles in different era has been recorded in the history of design. In this study the styles generated in different eras are set to be the research objectives in order to investigate the impacts on perception of rational and emotional product properties.

Lin (2005) said that the five product style-5F could be defined based on features of different eras. In the 1930s, technology determined the trends of design and shape. At that period of time when functionalism was dominant; “form follows function” became the primary guiding principle in design. After World War II, people were getting tired of this kind of design. Therefore, in the 1950s, owing to the rise of ergonomics, “form follows friendly” was the mainstream of designing. Until the 1980s, design of “user friendly” replaced the style of its previous era thanks to the appearance of personal computers. Later, in pursuit of changes and new styles, “form follows fun” came to the stage. The personalized device was the next characteristics of design, so “form follows fancy” emerged. The 21st century is the time of digital technology. The key factor of design at this period is humanity. In other words, the design principle is shifted to “form of feeling.” 5F was short for the above descriptions.

The aforementioned five different styles generated in different eras have been listed in Table 1 based on the five English words starting with “F” together with the key descriptions of important events in the history of design.

Table1. The explanation of 5F style by Design History

F1	**F**unction	Simple geometric Machine Aesthetic.
F2	**F**riendly	Human Factors and Ergonomics, focusing on the interaction of people and equipment universal design.
F3	**F**un	Design will be centered on the individual and the postmodernism instead modernism.
F4	**F**ancy	In a globalized environment, product designers need to find out the identify ability for the unique personality of a product.
F5	**F**eeling	21st century, smart technology products seemed to be everywhere in our lives, technological advancement affect the product design style which needs more pleasurable emotional design.

3. RESEARCH METHOD

The design of this experiment is for investigating the impacts on the perceptions of rationality and emotion of five different product design styles. There will be two major experiments with the following purposes: Experiment 1 is for finding out the representative rational, neutral, and emotional samples of five kinds of product design styles, and for determination of impact factors of rationality, neutrality, and emotion. Experiment 2 will be carried out one week after Experiment 1, where the samples with high frequencies in Experiment 1 will be used as the reference indicators with fixed positions of rationality, neutrality, and emotion. And then the experimental subjects will arrange the remaining samples in the order of rationality, neutrality, and emotion based on the styles of reference indicator samples.

3.1. Experiment samples

The criteria for sample selection of electric fans and the control variables are as shown in Table 2. F1 (Function) is mainly about table fans with consistent functionality. F2 (Friendly) is mainly about stand fans with consistent functionality. F3 (Fun) is mainly about humorous, cute, and joyful products with style of fun. With the most control variables, F4 (Fancy) is only for the new style of “Tower Fan” with uncontrolled form. F5 (Feeling) is also an uncontrolled diversified style. In this study the five kinds of product styles are also known as “5F”. Ten samples will be selected from existing products for each of the five styles, thus there will be a total of 50 experimental samples.

Table2.The samples selected of 5F and control variables

5F	Fan samples selected (all begin with home fans)	Control Variable
F1:Function	The general table fan appeared in the 1920 s to 1930s setting the most important and basic function and form in fan.	Function
F2:Friendly	The stand fan appeared In the 1950s. The high stand design because of desk fans needed to rely on a table or platform which is consistent with the desired height.	Function
F3:Fun	From the 1970s retro to the 1990s USB fan, as well as modern Japanese cartoon style, etc., funny products are a popular style.	None
F4:Fancy	The tower type electric fan was developed from the late 1990s until the 21st century. Because of its fashion type without fan blades and not occupying space it is chosen as the fancy representative.	function, material, color & era
F5:Feeling	For either the DYSON bladeless fan (airflow multiplier), or the wooden fan, 21st century fan design displays coexistence and common prosperity with technology and humanity as the sharing philosophy of cultural development and Earth Resources.	None

3.2. Experiment I: indicator samples of rationality/neutrality/emotion and their impact factors

In experiment 1 the representative rational/neutral/emotional products will be selected as indicators. Three fans will be selected from pictures of each of the five product styles representing the most rational/neutral/emotion samples, thus there will be a total of 15 most representative sample pictures. The situation of this experiment is as shown in Figure 1.

3.2.1. Experimental subjects: the experimental subjects in this study are a total of 40 junior and senior students (20 male students and 20 female students) in the Department of Industrial Design of National United University.



Figure 1. The situation of experiment 1

3.2.2. Materials: the pictures of 50 samples will be printed out in colors as cards of A5 size.

3.2.3. Steps:

(1) These 50 product picture cards will be divided into 5 groups in accordance with 5 styles such that there will be 10 product picture cards in each group aligned on the table as shown on the left of Figure 2.

(2) The experimental subjects will then select the most representative rational, neutral, and emotional products in accordance with their own design experiences and product perceptions, and fill them in the questionnaires.

3.3. Experiment II: arranging the sequence of all samples from rational products to emotional products based on the styles of reference indicator samples

In order to avoid the learning effect, experiment 2 will be carried out one week after experiment 1, where the samples with high frequencies in experiment 1 will be selected as the reference indicators with their positions fixed, and then the remaining samples will be arranged in the sequence from rational (represented by the first position), neutral (represented by the fifth position), to emotional (represented by the tenth position) based on the positions of reference indicator samples.

3.3.1. Experimental subjects: the same 40 students in experiment 1 during the first week

3.3.2. Materials: the same color printed product picture cards used in the first week.

3.3.3. Steps:

(1) Among the 15 representative rational/neutral/emotion products obtained from experiment 1, there are one minimum two maximum samples in each of the 5 styles with statistic result N greater than 17, such that they can be selected as the reference samples with fixed position. They are: the rational F1-08(N19) and emotional F1-09(N17) of F1, the rational F2-04 and emotional F2-03(N18) of F2, the neutral F3-05(N17) of F3, the emotional F4-07(N30) of F4, and the emotional F5-03(N20) of F5.

(2) A total of 10x5 = 50 empty squares will be drawn on the table for the 5 kinds of product styles corresponding to rationality, neutrality, and emotion.

(3) The pictures of reference samples F1-08, F1-09, F2-04, F2-03, F3-05, F4-07, and F5-03 will be placed at the “fixed” positions.

(4) Except for these reference samples, all other samples are classified in accordance with 5 kinds of product styles, and the experimental subjects will place them into the empty squares corresponding to the properties of rationality, neutrality, and emotion in accordance with the reference samples. Their numbers will then be filled in the questionnaires. The experimental

situation is as shown in Figure 2.



Figure 2 . The situation of experiment 2

4. RESULTS AND DISCUSSIONS

4.1. Experiment I: representative rational/neutral/emotional products and their impact factors

This experiment is about the perceptions of experiment subjects with respect to the rational and emotional properties of five product design styles, and the commonalities and differences of representative rational/neutral/emotional products will then be compared in order to figure out the impacts of product styles on the perceptions of rationality and emotion. F1R represents the rational product of F1 (Function), F2N represents the neutral product of F2 (Friendly), and F3E represents the emotional product of F3 (Fun). Other codes can be determined based on this principle, and the results are as shown in Figure 3:

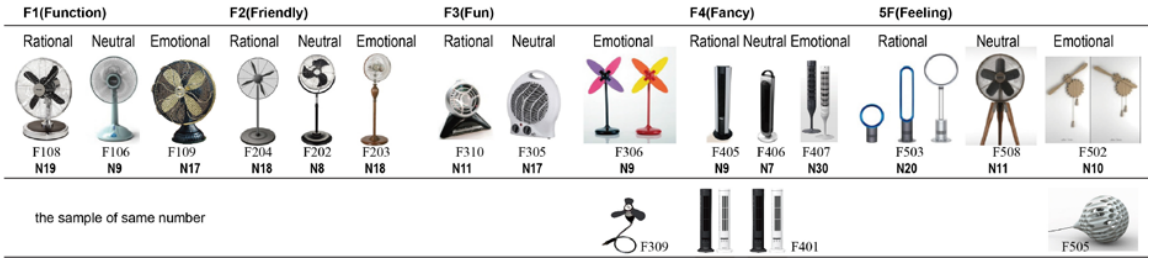

Figure 3. F5 representative rational/neutral/emotional samples selected in experiment 1, where those in the lower row are samples with the same number which were not selected.

4.1.1. Commonality: The commonalities of all 5 representative rational products are: straight-line design, with the color-material combinations of silver metal (cold color), blackish-grey plastic (colorless), and silver blue baking paint. The commonalities of all 5 representative emotional products are: curved-line design, with the color-material combinations of golden and copper metal (warm color), wood-color plastic, high-color plastic (warm color), and crude wood color and material. The commonalities of all 5 representative neutral products are: straight-line or curved-line design, with the color selection of either color-less, cold-color, or warm-color. The material selection is mainly based on plastics, followed by metal and wood. Therefore, the commonalities of

representative neutral products are weaker as compared to rational and emotional products.

4.1.2. Difference: there are some differences which can be found from the results of observation of each of the five product styles and the variables determined for experimental products, which can be compared with the ones with greater numbers in the second point. F1 and F2 are basic table fan and stand fan with identical control variables, so the ones with greater numbers are distributed among rational F1R, F2R and emotional F2E, F1E with similar numbers (17, 18, 19). The styles of F3, F4, and F5 are more diversified as compared to F1 and F2. F4 has the most control variables, with the form of line as the only uncontrolled variable. There are no control variables for F3 and F5. The result indicates that the representative product of F4E, F4-07, is the one with the greatest number (N=30) of all 15 samples. The reasons is that, as for the simple single variable of form of line, the cylindrical curved lines of F4-07 with waist line is the most representative emotional feature as compared to other forms of line. The one in F3 with the greatest number is the representative neutral sample of F3-05. This is different from other styles, where the greatest numbers usually fall within the rational or emotional samples. The preliminarily determined reason for this is that, the variation of overall style based on combination of form, material and color of the style of F3 (Fun) has led to decentralized selections by the experimental subjects such that the perceptions of rationality and emotion cannot be centralized on one particular product. However, as compared to other products, the form/material/color of F3-05 is more regular without any fancy feature such that it is selected as the representative neutral sample. Another style with significant variation and without any control variable is F5 (Feeling), with the greatest number falling on the rational F5-03. The preliminarily determined reason for this is that, it is the innovative product introduced by renowned brand with the sense of modern technology such that it has become the rational selection. The representative emotional products of this style are the two products (F5-02 and F5-05) with an identical number (N10), where there is significant difference in functionality and form/material/color. This is an interesting phenomenon, which probably indicates that the F5-Feeling style in the 21st century itself is a diversified style, and it can be even more diversified with changing emotional properties.

4.2. Experiment II: the sequence of all samples based on reference indicator

Based on the questionnaire results of experiment 2, the one with the highest distribution frequency will be obtained based on the modal number of SPSS statistic software as shown in Figure 4. The ones marked with bracket in the figure are reference samples with fixed positions, and the number N is shown below the sample number. The samples in the dotted line on the left are those without the greatest numbers which have been excluded. At this stage the samples with the greatest numbers in experiment 1 will be placed at the fixed reference positions of rationality or neutrality or emotion, and the sequence of the rest of samples will be arranged based on the degree of rationality and emotion. When there are reference samples of product properties available for main experimental subjects, their determination of product properties can be based on a kind of image commonality, which will generate the impacts as described below:

The description of the results of five styles:

F1-Function: F1-09 is the reference sample of emotional product. F1-10 is the GE antique fan which is ranked 9th, and F1-03 is the Tatung classic fan which is ranked 8th. Their common features are that they are both made of metal, with the form of large arcing blade cover with metal concentric protective frame, and the fan base in round shape with similar curvature. F1-08 is the reference sample of rational product, and the commonality of F1-05 (which is ranked 2nd) is the narrower blade with the curve close to straight line, and the cold colors.

F2-Friendly: F2-03 is the reference sample of emotional product with sleek wooden touch. F2-01

is the GE antique stand fan which is ranked 9th, and F2-05 is the stand fan with warm color and smooth surface. The dark grey F2-04 with sharp tips of blades is the reference sample of rational product, and the ones ranked 2nd and 3rd are both F2-09 with square base and dark grey color. The ones ranked 4th and 5th are both F2-08 with light blue blades in round shape, and the fan bases in criss-cross pattern.

F3-Fun: there are no reference samples for rational or emotional products. The integrally molded F3-05 with curved surface is the reference sample for neutral product. The ones ranked 8th, 9th, and 10th in the emotional category are all F3-08 with pink flower appearance, while the one ranked 1st in the rational category is the USB fan of F3-09, which is also the representative neutral sample rank 6th. The ones ranked 2nd and 3rd are both blue F3-03 in airplane shape. The penguin-shaped F3-02, pressure bell-shape F3-04, and the most emotional sample F3-06 and the most rational sample F3-10 are all excluded from the selection.

F4-Fancy: F4-07 with arc curve is the reference sample for emotional product. The one which is ranked 9th is the F4-02 with the same curved waist line. F4-02, F4-03, and F4-08 are all ranked 8th. The one selected as the rational reference sample is the most rational product in experiment 1, which is F4-05 with slim side and flat front surface.

F5-Feeling: Dyson blade-less electric fan F5-03 is the reference sample for rational product. F5-10 made of pure metal strips is ranked 2nd with the greatest number in experiment 2 (N27). The ones ranked 8th and 7th are 507 and F5-09 with compact ratio with bionic shapes. The one ranked 10th in the emotional category is F5-02, which is also the most emotional product in experiment 1. The one ranked 9th is F5-06 made of white ceramic cone-like objects. The one ranked 8th is F5-04 made of metal and leather based on the image of flower. The ones ranked 5th and 6th are the neutral samples F5-08 and F5-01 which are both based on the combinations of thick wooden structures

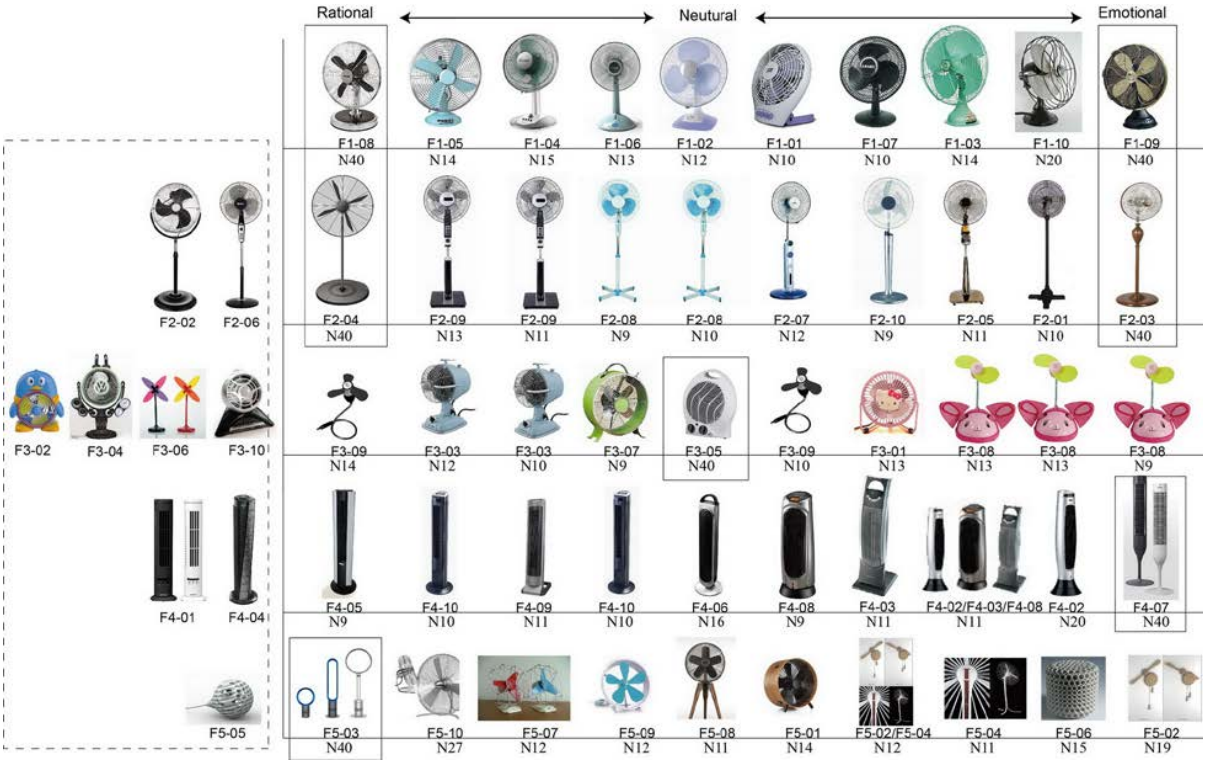

Figure 4. The results of experiment 2 (The sample number and the number N are listed below the picture. The ones circled by the frames are indicator samples, and the ones on the left circled by dotted line are those excluded.

balloon shape, which is listed as the most emotional sample in experiment 1 along with F5-02.

5. CONCLUSION

This study is about investigating the rational and emotional properties of 5 product styles in order to find out the impacts of product style on the perceptions of rationality and emotion. In experiment 1 the representative rational/neutral/emotional samples are selected, and in experiment 2 the samples with high frequencies in experiment 1 are selected as the indicator samples with fixed positions, and then the sequence of the remaining samples (from rational to neutral to emotional) will be arranged in accordance with the positions of those indicator samples. The cross-analysis will be conducted based on the reference factors for judgment in order to confirm the impacts on perceptions. The conclusion is as shown below:

The conclusion of this study is as shown in Table 3. Each of the five product styles is equipped with the three major elements of basic functionality and basic form of product—form, material, and color. However, from the perspectives of Function, Friendly, Fun, Fancy, and Feeling, it can gradually be found out that the impact factors of rationality and emotion will also vary. The changes in the impacts of three major style elements, the emphasized features of style, the details of 3D shape, and the impacts of technology and feeling have been clearly shown in this study.

Table 3. Summary of rational and emotional properties of 5 styles

	Rational	Emotional
F1 Function F2 Friendly	1.Straight line design with material-color combinations of silver-metal (cold color), dark grey-plastic (colorless), and silver blue baking paint. 2. Characteristics of rational properties are more consistent, making them easier for judgment.	1. Curved line design with material-color combinations of golden/tan-metal (warm color), wooden color plastic, high color plastic (warm color), and crude wood color and material. 2.Characteristics of emotional properties are less consistent, making them more difficult for judgment. 3.Antique fan is in the category of emotional property.
F3 Fun	4.Among all five styles, it is the most difficult to figure out the consistency of rationality and emotion in this style.	5. The emotional style is leaning toward femininity.
F4 Fancy	6. This is the one with the most control variables, and the representative rational/neutral/emotional samples in both experiments are consistent. 7. Cylinder based on straight line design which is the categories of both neutral and rational properties.	7. Cylinder based on curved line which is in the category of emotional property.
F5 Feeling	8. The consistency of rational property is very high, which is composed of three characteristics of geometric form, delicate metal touch, and metallic color. 9. F5-03 is the most rational representative sample based on blade-less design due to technology evolvement.	8. The specific form has gone beyond the traditional basic fan structures of blades and stand. The design concept is based on creating a sense of "wind". 9. F5-02 is the most emotional representative sample with almost zero airflow generation. It is only for creating a sense of wind.

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BIOGRAPHY

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Chiu Wei Chien is a senior industrial designer and part-time lecturer of department of industrial design, National United University. She is also a doctoral program of graduate school of creative industry design at National Taiwan University of Arts. Her articles on product design and emotional design are about 8 publications. She has presented at 5 international and national conferences. Her recent research is about the cognition of product properties of rational and emotional.

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Rungtai Lin Ph.D. is a professor of graduate school of creative industry design at National Taiwan University of Arts. His articles on aesthetics, and cultural creative design are in more than 20 publications. He has presented at more than 10 international and national conferences. He has been granted NSC (National Science Council) research fellow since 2009. His recent publications include "Transforming Taiwan Aboriginal Cultural Features into Modern Product Design: A Case Study of a Cross-cultural Product" (International Journal of Design), "Designing Friendship into Modern Products. In: Friendships: Types, Cultural, Psychological and Social, Editor: Joan C. Toller, NY: Nova Science Publishers, Inc. (ISBN: 978-1-61668-008-4)".

KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Designing Watch by Using Semiotics Approaches

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Abstract: Today industrial design is one of the most important pervasive components of design which covers many various field of activity. In the process of product design, understanding the impression of a whole design target is an essential issue. When a consumer is faced with an interactive product or interface, the designer need to have a thorough knowledge of the use of semiotics when attempting to convey feeling and emotions to the consumer. Designer work towards a product to be achieved with the help of representations of semiotic means, used according to identifiable aesthetic, criteria and cultural factors. In this area, Kansei engineering technique are being successfully applies in consumer product design. A Kansei engineering study applied to watch (as a case study) with especial attention in the selection of semiotics is presented. This study used most frequently selected kind of watch (from view point of shapes, sizes, colors, and material) which has been chosen by customers. Ten type of watches and total of twenty opposite Kansei words were used in the experiments. One hundred participants were asked to measure the intensity level of feeling using semantic differential method, toward Kansei words. Participant ask them about each watch if it's kind or rough, reliable or unreliable, positive or negative and etc. This step specified which signs refer to which result in user mind. In a reverse process this study could find for a specific judgment which signs are needed and which signs are more interest than the others.

Keywords: Semiotics, Kansei Engineering, Watch, Meaning, Cognition Science.

1. INTRODUCTION

In postmodern ages, products meaning changes from functional value to emotional value. This means it is possible that your glasses or your hat become your friend or your enemy. Also today

they make proportional reaction in user. This different kind of value, that is result of postmodern culture, is a semiotic value, which personalize product and make an emotional connection is in front of modern decoration. In this thinking the products are seen as a symbol to show people they are distinct similarities. The semiotic perspective of design focuses on viewing products as signs capable of communication. Vihma [1995] states that products are perceived in two ways; as presentations of themselves, and as representations of something else. While Vihma makes a distinction between the aesthetic and the semiotic part of the experience, another view represented by, e.g. Osgood et al. [1957], includes the meaning of the form in the notion of aesthetics [Warell, 2008]. Semiotics theory in product design, according to diverse side of each target group, must be consider before the practical phase of each project, and the lack of this consideration seems to be a mistake, however, still these studies is being ignored. Eckert [2000] reinforce the link and semiotic coherence between the consumers end values, functionalities in any domains of influence, and product attributes as form, color, texture, and usability principles [Bouchard et al., 2007]. Semiotics is not widely institutionalized as an academic discipline. It is a field of study involving many different theoretical stances and methodological tools. Semiotics represents a range of studies in art, literature, anthropology and the mass media rather than an independent academic discipline. Those involved in semiotics include linguists, philosophers, psychologists, sociologists, anthropologists, literary, aesthetic and media theorists, psychoanalysts and educationalists [Chandler, 1999]. With this in mind, the present study aims to identify the group's aesthetic taste and life style, and sought to clarify the relationship between physical and metalize external signs in members of the target group. Given these relationships can help us better understood the language of products in the indigenous culture.

2. THE MEANINIG OF THE SIGN

Sign, mark, password or code, is a group of symbols that can be made in a way which people to find them meaningful (Mohsenian Rad, 2004) and something observable or visible that swap by a relationship with another items. Necessarily, signs have to be physical aspects which be able received by one of the human senses, and also signified could be physical, mental, real, imaginary, natural or synthetic. Every word and gesture can be seen as a sign. Semiotics not only include signs in everyday life, such as traffic signs, symbols or pictures, but also study everything that replace with another. This definition also includes our material culture such as architecture, furniture and product. Saussure [1983] says the dual nature of the sign include signifier and signified. The relationship between the signifier and the signified is referred to as signification. Signifier is word, form, external world objective, and anything that can be seen, heard or touched. Signified is content, concept, what in the face of the world, understood and felt. On the other hand, the sign is the whole that results from the association of the signifier with the signified [Saussure 1983]. Pierce [1997], unlike him, attention to process and interpret of signs or more than signs. In his view, semiotic requires three elements: sign, evidence, and interpreted. In the other words, in the Pierce theory the points of semiotic triangle are icon, index and symbol. Short [1997] also made a very complex system which is based on the various types of relationships between them.

3. SIGN IN PRODUCTS AND THEIR EFFECTS

In industrial design, any design can be considered as a medium that contains several levels of different messages for its audience. Signs might be cause to improve the value of product and

facilitate communication processes between products and human. Many studies shows that the main symbolic function effects are 1) enhance the immaterial value, 2) facilitate reciprocal interaction between human and product, 3) personalizing product, 4) create an identity for product, 5) becoming user friend, and 6) add meaning to the functional and aesthetic aspects of the product [Burdek, 2005]. Signs in real life more than they appear help us to introduce concepts. They are symbols of the meaning of the abstract mind and our judgment is based on knowledge and background from which they are formed. Signs make our mind conditional, and if we do not aware they will trick us. Set of signs called genre. Genres make it possible to classify signs and their features. On the other hand signs have different meanings in different times and places. Signs are divided into two categories: implicit and explicit. Explicitly refer to the most direct meaning, and implicitly refer to something beyond the form and exterior.

4. METHODOLOGY

Kansei engineering method has been used in order to accommodate the physical characteristics and Kansei words, which strongly related to the semantic differential questionnaire. Kansei engineering is a way to convert the feelings and emotional impact to production parameters. It was developed in the 1970s [Nagamachi, 1997] and defined as a technique for translating the human Kansei into product design elements. This method has the ability to measure different emotions and show their relationship to the actual production characteristics. Therefore, there is possible to design products that it shows emotions and moods. Today this approach of design has been known as one of the pillars of professional development by the Royal Statistical Society. A proposed method to explore the aesthetic value is using questionnaires or interviews based on the sharp polarization technique. This means that respondents are asked to relate things into one valuable pair of contrasting traits. An easier way is to create two contrasting characteristics to judge. It should be noted that every time just one feature consider to not to make responsive feel puzzled. This way helps us to recognize dominant aesthetic interest groups, use to measure and classify them according to a predetermined framework and the analysis. Also this discovery give us standards and rules for behavior and thoughts of a member of target group. Some of the distinct aesthetic values in a range of bipolar adjective based on objective aesthetic values are: organic, soft, roundish, high, heavy, low light, easy, contradictory , sparsely, and based on subjective aesthetic values are: exciting, duplicate, comics, antiques ,traditional, different, romance ,complete, spiritual, fantasy.

4.1. Target group

The target group is a group of women belonging to the age between 25 to 30 years. The present study emphasis the aesthetic tastes and preferences of the target group and the result will be matched with the features of the watches. Selecting watch as a case study for this research has been one of the best options, because watch is a luxury product and its functional value is at a lower level than it's symbolic. Watch is in a close communication with its users and also is a symbol of her/his social status and cultural character. On the other hand, watches are routinely used and almost in every conditions and situations are with user, also having several watches for one person is not too abnormal, that this is proof of the positional feature of watches. Another reason to choose the watch was its variety of structural elements (surface, hands, numbers, and wrist), as components of a face that can be in different compositions and make variety of characters.

4.2. Kanseiengineering phases

Kansei engineering model proposed by Schutte has been used in this study [Schutte, 2004]. At this model the appropriate product for the target group was selected. Then, initial demands and new product features are generally determined through interviews. According to this model, for the choice of Kansei words, at first one hundred words describing was collected through open interviews. Then twenty antonyms pairs of them were chosen to design the questionnaire. Five point semantic differential scale [Osgood, 1957] has been used in this study (Figure 1). Semantic Differential applies both on linguistic expressions and product semiotics, i.e. the language of signs and sign-systems [Schutte, 2005].

Table 1: One hundred collected Kansei words

powerful	artificial	imposing	sad	dependent	jealous	coordinated	delicate	repetitive	happy
fantasy	emotional	disappointed	immature	rough	mild	imaginary	updated	silly	nature
expensive	naive	smart	brave	strange	depressed	outdated	uninterested	intimate	sloopy
simple	banal	worthless	ambitious	amazing	odious	hasty	modern	weariful	secluded
comfortable	nostalgic	reclusion	amorously	lovely	excited	chic	mysterious	social	desirable
energetic	satisfynig	sharp	realistic	relaxing	rude	reliable	honest	dengerous	good tempered
fashionable	aristocratic	crafty	wise	enjoyable	annoying	innocent	boring	unreliable	interesting
ordinary	vulnerable	sedate	gaudy	efficient	paradoxical	renitent	moody	luxe	apathetic
weak	novel	ordered	stylish	patient	wary	jolly	attractive	joyful	authentic
classic	crowded	defiant	unobtrusive	wishy	lazy	mature	strict	passionate	serious

In the next step (extend the subsets) 500 watches were collected and decompose them to their elements. Then, according to the physical characteristics watches were divided into several groups. In each category, one was selected as the master because of having most of the group properties. Selecting watches as mentioned was according to physical characteristics such as color, form and material, and it has been tried to select watch from different styles and different characteristics. At the final step, combined physical and emotional semantic differences has been performed through words. Statistical procedures using mathematical and nonmathematical methods have been developed for use in Kansei engineering studies. It should be noted that the use of methods are depends on the context of the purpose of each study.



Figure 1: A sample of 5-degree Semantic Differential method used in this study



Figure 2: Eight product samples

5. RESULTS AND DISCUSSION

All data has been analyzed using statistical analysis software to find relation between sings and feeling of users regarding product samples with emphasis on semiotics approaches. The results of this study clearly indicated that there is significantly correlated between five adjective include: lovely, smart, social, good-tempered, and reliable. This also illustrate secret classify that user has been made in mind. Results showed that there is noticeable meaning in any signs. This can discover meaning of the main items like dark or bright colors, big or small screen, different font and etc. Extremely wise or emotional are less loved, but having average amount of emotional factors make watches more attractive. The criteria to be considered wise is using vertical lines and symmetry and order, beside this white is more wise than black. In bright composition all things are clear, as in the logical issues exist, but black is secretive and stimulates curiosity. This rules change about gray family. They have potential to be wise, emotional or a combination of them. Table 2 shows results in this study that can be summarized in the table.

The most important results in detail is presented here. There is a clear correlation between powerful and reliability, which watch number one is much more powerful is also more reliable. Watches which has numbers are more reliable, perhaps because they have no risk of confusion at the time recognizing. The watch number seven was chosen as the high lovely one, and also has second place in modernize. This should be caused by empty minimalist surface, which the appearance is brief and devoid of detail. The watch number eight and four have been exist at the end of being loved or hated. The watch number five with color combination of black and gold, with using a simple combination in surface, include ordinary font numbers known as the most nostalgic one. Greek numbers used in older watches when being used in the newest one cause more nostalgic look. Chromatic colors look happier, more passionate, intimate and exciting, but charts any watch that place in the last grade fantasy and emotion has been considered weak and inefficient. Dark watches and number one with square surface are the most impatient and numbers eight and seven with their colorful design are good-tempered. In general non-black watches and roundish surface ones look more optimistic, but for being loved it's not necessary to be good manner, just avoid of being cranky. Watch numbers one and three with metal strap and silver colors are the most powerful elected watch. Results indicated that smart is the most correlated trait with loved, clever watches are at the top of the being loved rank. Watch numbers two, five and seven are the most intelligent and with accurate at the watch composition will understand the smart usage of irony elements and intelligent combination of detail create clever appearance that this is user-friendly.

Table 2: Classified adjectives regarding the main watch properties

screen	small	wary, emotional,weak, delicate, vulnerable, sad, indifferent, serious
	large	powerful, defiant, rough, jolly, reliable, energetiv, social, happy
	dark	sad, odious, modern, moody, defiant, emotional, strange, secluded
	bright	wise, powerful, serious, reliable, strange, efficient, social, classic
	circle	emotional, good tempered, defiant, intimate, happy, social, smart
	square	wise, moody, powerful, rough, sad, indifferent, stylish, strange
	formic	fantasy, happy, emotional, defiant, unreliable, energetic, banal
number	simple	nostalgic, wise, smart, simple, efficient, sad, reliable, classic
	fantasy	emotional, good tempered, defiant, smart, passionate, social, intimate
	dot and line	modern, wise, indifferent, strange, smart, serious, sad, powerful
	numberless	strange, modern, indifferent, wise, wary, mild, sad, secluded
	grecian	nostalgic, classic, powerful, reliable, strange, serious, indifferent
wristlet	metal	powerful, wise, moody, rough, defiant, reliable, efficient
	plastic	unreliable, fantasy, happy, passionate, emotional, silly, simple, vulnerable
	leather	reliable, nostalgic, powerful, efficient, classic, social, smart, stylish
color	bright	happy, passionate, excitment, fantasy, unreliable, defiant
	gray family	indifferent, wise, mild, strange, efficient, modern, poweful
	white or black	defiant, rough, powerful, efficent, reliable, classic

Happy color and comic form of number eight make it a humorous watch. Square face in number one and black screen and no number or simple numbers in five and four watches are reason of serious appearance. The combination of silver and gold, due to the finding results shows luxury, what we can see in number one and six. Some watches are inefficient with pay attention to details, which can relate this judgment to its material. Emotional play with form and geometric measure is kind of de-familiarization and that feel courage in the face of the watch. Fantasy more than anything shows itself in bright and different funny usage of lines. From view point of social and isolated factor, this study shows that having numbers is the most important option to reach these factors. Numbers are like tongue in watches and seems that being empty and simple make watches sad. Black face, rectangular frame and less use of details intensify this feature. Although people don't like sad composition they also don't prefer exaggerate colorful happy ones. The middle amount of being sad or happy is more attractive.

6. CONCLUSION

Some of the Kansei words are more correlations with each other. They indicate which adjectives are in direct and which one is in inverse relationship. Watches with more details make to look more emotional and an empty surface is wiser in user mind. About feeling weak or powerful in face of watches, black ones look stronger than bright ones. Cool colors induce a feeling of power and warm colors are intimate. All the watch that have narrow wrist are considered delicate and watch that have thickened are more violent than the others. Have a strong and robust wrist vanish user fears about becoming open and also less delicate create more trust. Watches which exaggeratedly have been used plastic on their structure do not look very strong and reliable.

Watches which has small face has less powerful, while large screen size look more courage and bravery. Stimulating color, contrast and highlight are the elements in the composition of the energized watch. Thicker gauge, bright combining colors and bold use of color and sometimes underused, decorative elements and details of the watch shows more passionate.

All of the words divide in two groups, lovely and hateful. Noticing on this classify and physical feature of watches, it is clear to understand lovely elements and hidden meaning of signs. Results indicated that circle refers to emotional personality, and square refers to logical, as well as users with active and passive personality corresponding to chromatic and achromatic shapes, respectively. In a reverse process, this study could find for a specific judgment which signs are needed and which signs are more interest than the others. The result was that the target group prefer watches which their compositions are antithetical and amazing. In order to catch this taste, this research had to incorporate opposite features. Therefore, in the final design compound circle and square, chromatic and achromatic, roughness and softness have been considered. The results of this study can serve as references to the watch manufactures company, as well as watch designers for different markets and to design similar products.

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3B - Textile 1

Investigation of Appearance and Tactile Sensation Scales for Evaluating Clothes in Online Shopping

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Abstract: The purpose of this study was to develop scales to evaluate the appearance and tactile sensation of clothes in online shopping. First, 170 descriptive words were extracted from the existing literature on these areas. Then three groups of participants evaluated these words in terms of their appropriateness in describing the appearance and tactile sensation of clothes. These groups consisted of thirteen male students majoring in engineering (EMS), thirteen female students majoring in fashion design (FFS), and thirteen female students majoring in subjects other than fashion design (OFFS), respectively. Sixty-six appearance words and seventy-six tactile sensation words were selected by comparing the results of the three groups. We then carried out a cluster analysis based on the Kawakita Jiro (KJ) method, using appearance and tactile sensation words for the EMS, the FFS and the OFFS groups. Approximately about ten appearance-representative words and about ten tactile sensation-representative words were obtained for each group. The results of the appearance- and tactile sensation-representative words obtained from the EMS, the FFS, and the OFFS groups were compared, and common evaluation scales for the appearance and tactile nature of clothes were explored. Thus, eight common words indicating appearance, and nine indicating tactile sensation, were obtained as common evaluation scales.

Keywords: Evaluation Scale, Clothes, Online Shopping, Appearance, Tactile sensation.

1. INTRODUCTION

In recent years, online shopping of clothes has grown in popularity (Office for National Statistics, Statistical Bulletin, n.d.). However, because most of the retailers offer only visual information such

as pictures of clothes, there is a discrepancy between an item's visual impression and its physical comfort and appearance. In order to resolve this problem, visual and tactile measures capable of assessing the differences between impressions of clothes in pictures, and impressions of the actual items, are required.

In a previous study (Tomoharu et al. 2011), we carried out an experiment to identify the visual information of seeing the photograph of clothes and the tactile sense information of touching the actual cloth, evaluated by several observers. Observers were asked to look at an image fabric on display and select an actual fabric by blind touch. Two types of photographs were used as the fabric images, those with drapes and those without drapes. The results indicated that the existence or nonexistence of a fabric drape is a key visual factor that influences textures recognition. In another previous study (Tomoharu, Kou, Kazuya, Hiroko, & Miyoshi, 2013), we conducted a fabric identification experiment focused on the window size, to explore the effect of visual field size on the observation of drape fabrics. The results indicated that the window size during the observation of draped fabrics greatly influences the recognition of fabric textures. However, when the visual information and the tactile sense information could be not identified using the method of these fabric identification experiments, the judgment accuracy of fabric textures cannot be clarified. In order to solve this issue, it is necessary to compare the degree of Kansei impression received from the cloth image and the actual cloth.

Therefore, the purpose of the present study was to identify evaluation scales that can accurately express the appearance and tactile sensation of clothes, which apply to a wide range of people who participate in online shopping. Specifically, assessment words relevant to the appearance and tactile sensation of clothes were collected, and the appropriateness of these words for the degree of evaluating clothes was examined. These words were then clustered using various observer groups. Finally, the common-evaluation-words for appearance and the common-evaluation-words for tactile sensation were identified by investigating the similarity of these obtained words across the groups.

2. DETERMINING THE PROCESS OF EVALUATING SCALES FOR CLOTHES

The process of determining the evaluation scales that accurately express the appearance and tactile sensation of clothes in online shopping has been shown in Figure 1. The process of evaluating clothes' scales consisted of three steps, collection, evaluation, and clustering. In the first step, the assessment words which were used for evaluating the appearance and tactile sensation of clothes were identified from the several dozens of research papers (Mutumi, 2008; Mika & Akira, 2008, Kazuya, 2008, Zhebin, 2012, Shogo, 2013), and 170 assessment words were identified. The second step involved examination of the degree of appropriateness of the 170 assessment words for evaluating the appearance and tactile sensation of clothes in online shopping. This was determined by three kinds of observer groups to extract words representative of a wider range of online shoppers. The three groups consisted of thirteen male students majoring in engineering (EMS), thirteen female students majoring in fashion design (FFS), and thirteen female students majoring in subjects other than fashion design (OFFS), respectively. The degree of appropriateness of the words in evaluating the clothes' appearance and tactile sensation was evaluated using five grade scales (Figure 2) which are compliant with ITU-R quality (Recommendation ITU-R BT.500-13, 2012). Their ratings were then analyzed within each observer group and between the three observer groups. As a result, 66 appearance evaluation words and 76 tactile sensation evaluation words were obtained. In the third step, these appearance and tactile

sensation evaluation words were clustered in each observer group using the KJ method (Raymond, 1997), and about ten appearance representative words and ten tactile sensation representative words were obtained in EMS, FFS and OFFS. Eventually, eight common-evaluation-words were identified for appearance and nine were identified for tactile sensation. This was done by investigating the similarity in the appearance and the tactile sensation representative words that were clustered for each observer group, and by comparing the relationship between the obtained representative words and the results of other previous studies (Helen, 1966; Kimie, 2006).

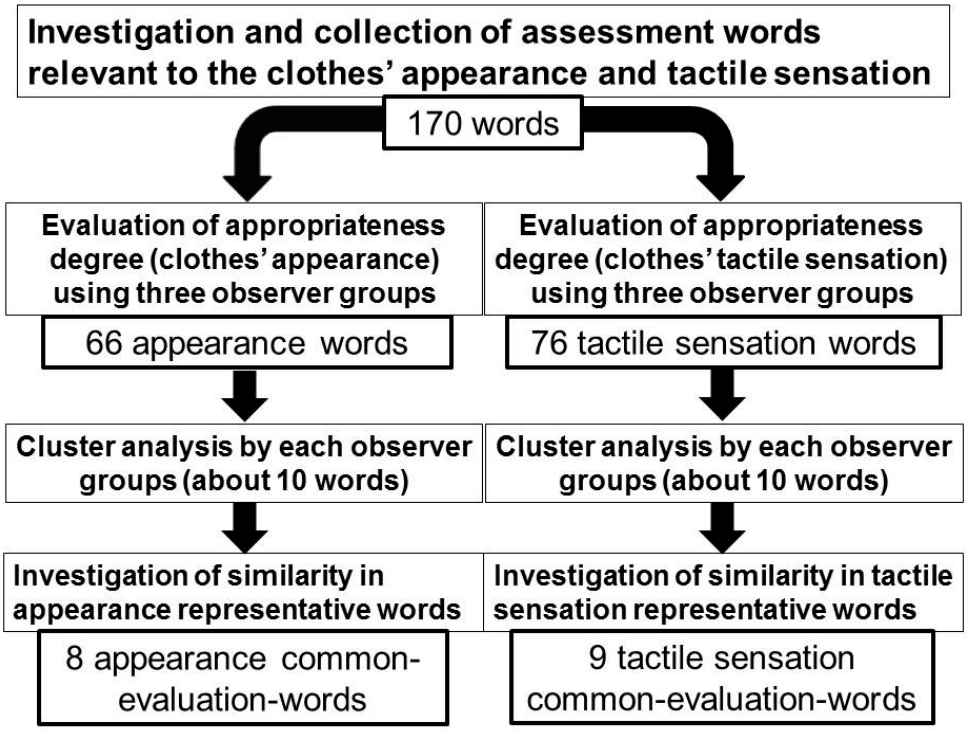


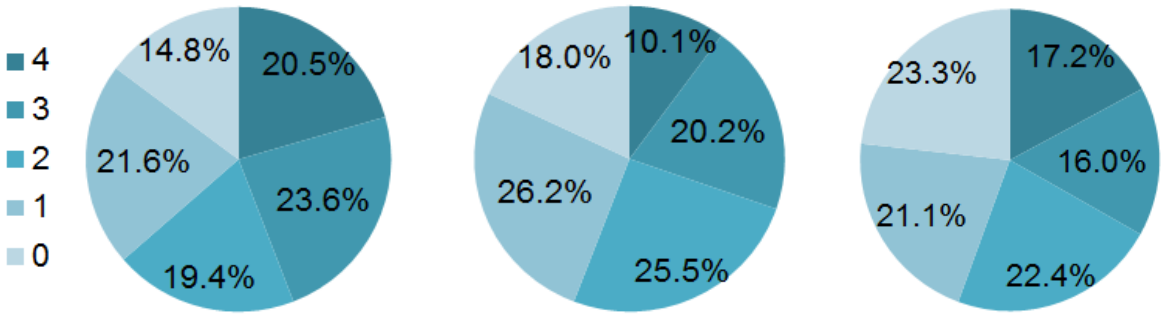
Figure 1: Process of determining evaluation scales for clothes



Figure 2: Five grade evaluation scales for the degree of appropriateness of the evaluation words

3. THE DEGREE OF APPROPRIATENESS FOR ASSESSMENT WORDS

The 170 assessment words identified from previous studies were evaluated by each of the three observer groups in terms of their degree of appropriateness, by using five grade evaluation scales. The occurrence rate for each observer group in terms of their evaluation of the degree of appropriateness of the evaluation words has been shown in Figure 3 and Figure 4, respectively.



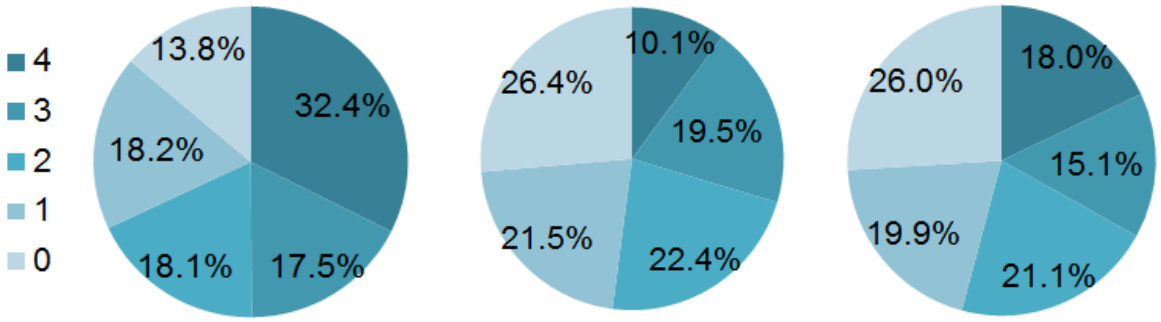
(a) FFS (b) EMS (c) OFFS

Figure 3: Occurrence rate for the degree of appropriateness of the words for appearance of clothes

Figure 3(a) shows that the FFS group had an equal distribution of words evaluated across the five grades of the degree of appropriateness. On the other hand, Figure 3(b) shows that the EMS group had a higher occurrence rate for the evaluations of “1: Poor appropriateness” and “2: Fair appropriateness,” and these rates occupied the half of their evaluations. Figure 3(a) and 3(b) indicate that the occurrence rate for "4: Excellent appropriateness" for the EMS group was about half of that of the FFS group. This indicates that the FFS group had a tendency to select a higher degree of appropriateness than did the EMS group. Figure 3(c) indicates that the OFFS group had a tendency to select a lower degree of appropriateness, as it had the highest occurrence rate for "0: No appropriateness" across the five grades. However, their occurrence rate for "4: Excellent appropriateness" was more than that for the EMS group, and less than that for the FFS group. The average value of the degree of appropriateness for the appearance evaluation words was about 2.1 in the FFS group, about 1.8 in the EMS group, and about 1.8 in the OFFS group. In order to reflect the judgment of the degree of appropriateness in each of the observer groups, the appearance evaluation words were extracted based on conditions that led to a more than average value for degree of appropriateness across the three observer groups. As a result, 66 appearance evaluation words were obtained.

With reference to tactile sensation, Figure 4(a) shows that the FFS group had a tendency to select a higher degree of appropriateness. Especially in terms of the cumulative occurrence rates for "4: Excellent appropriateness" and "3: Good appropriateness," they account for 50% of all the evaluations. On the other hand, Figure 4(b) shows that the EMS group had a tendency to select the lower degree of appropriateness. Figure 4(a) and 4(b) indicate that the occurrence rate for "4: Excellent appropriateness" by the EMS group was about one third of that of the FFS group. Similar to the findings for the appearance evaluation words, this indicates that the FFS group had a

tendency to select a higher degree of appropriateness as compared to the EMS group, in the tactile sensation evaluation words. From Figure 4(c), it is evident that the OFFS group and the EMS group had a higher occurrence rate for "0: No appropriateness" in five grade scales. However, similar to the trend observed for the appearance evaluation, the occurrence rate for "4: Excellent appropriateness" was higher for the OFFS group than that for the EMS group, and less than that for the FFS group for the evaluation of tactile sensation. The average value for the degree of appropriateness of the tactile sensation evaluation words was about 2.4 in the FFS group, about 1.7 in the EMS group, and about 1.8 in the OFFS group. In order to reflect the judgment of the degree of appropriateness of the tactile sensation evaluation words in each of the observer groups, words were extracted based on the conditions led to a more than average value for degree of appropriateness across the three observer groups. As a result, 76 tactile sensation evaluation words were obtained.



(a) FFS (b) EMS (c) OFFS

Figure 4: Occurrence rate for the degree of appropriateness of the words for tactile sensation of clothes

4. CLUSTERING APPEARANCE AND TACTILE SENSATION WORDS AND INVESTIGATING COMMON EVALUATION SCALES

The 66 appearance and 76 tactile sensation evaluation words which were judged as suitable for evaluation of the appearance and tactile sensation of clothes respectively, were summarized as a representative evaluation word using the clustering method (KJ method), by each of the observer groups that consisted of 13 participants. The clustering method of summarizing the appearance and tactile sensation evaluation word was performed in two steps. In the first step, some evaluation words with very high similarity were clustered. In the second step, these evaluation words were further summarized to about ten words for appearance and tactile sensation evaluation, respectively. As a result, the appearance representative evaluation words were identified for the FFS group (nine words), the EMS group (ten words) and the OFFS group (nine words). Similarly, the tactile sensation representative evaluation words were identified for the three groups, specifically, ten words for the FFS group, eleven words for the EMS group and eight words for the OFFS group. These representative evaluation words for appearance and tactile sensation, which were clustered in each of the observer groups, have been presented Table 1.

Table 1: Appearance representative evaluation words and tactile sensation representative evaluations clustered for each observer group

Observer groups	Appearance representative evaluation word	Tactile sensation representative evaluation word
FFS	"Suitable in winter," "Suitable in summer," "Casual," "Premium," "Classic," "Dislike," "Soft," "Unique," "Like," "Youthful"	"Warm," "Thin," "Smooth," "Rough," "Crisp," "Comfortable," "Stretchy," "Ductile," "Moist," "Uncomfortable"
EMS	"Thin/thick feeling," "Casual," "Formal," "Fancy," "Elegant," "Soft/hard feeling," "Brilliant," "Likable," "Slack"	"Thin/thick feeling," "Weightiness," "Rough/smooth feeling," "Comfortable," "Springy," "Soft/hard feeling," "Stretchy," "Flexible," "Dry/wet feeling," "Billowing," "Premium"
OFFS	"Suitable in winter," "Suitable in summer," "Casual," "Formal," "Good impression," "Bad impression," "Soft," "Vivid," "Murky"	"Winter," "Summer," "Smooth," "Uncomfortable," "Crisp," "Soft," "Comfortable," "Premium"

From Table 1, it is clear that the appearance representative evaluation words of the FFS group are similar to that of the OFFS group, while the EMS group exhibited a tendency to summarize the word of an opposite meaning. On the other hand, three observer groups showed different tendencies for the tactile sensation representative evaluation words. Therefore, similarities between the appearance and the tactile sensation representative evaluation words for each of the observer groups were investigated. In particular, results of the first step of the clustering method revealed a representative evaluation word with high similarity by comparing the similarity of the representative evaluation words for appearance and tactile sensation for each observer group. The common representative evaluation words were then examined by comparing the representative evaluation words across the three groups. As a result, eight appearance common-evaluation-words were identified: "Thin," "Thick," "Casual," "Formal," "Good impression," "Bad impression," "Soft," and "Vivid." Similarly, seven tactile sensation common-evaluation-words were identified: "Thin," "Thick," "Flat," "Rustic," "Crisp," "Soft," and "Stretch." This result suggests that "Thin", "Thick" and "Soft" in both meanings of the appearance and tactile sensation of clothes should be evaluated. Furthermore, the tactile sensation common-evaluation-words and the material axis (Kimie, 2006), which has been experimentally used in the fashion field, were investigated in terms of the common term. Conclusively, nine tactile sensation common-evaluation-words were obtained, by adding two axes: "Dry" and "Wet."

5. CONCLUSION

The purpose of this study was to identify evaluation scales that can accurately express the appearance and tactile sensation of clothes which apply to a wide range of people who participate in online shopping. Specifically, assessment words relevant to the appearance and tactile sensation of clothes were identified from the literature, and then these words were evaluated for their appropriateness in assessing clothes, and were clustered using various observer groups. Finally, appearance representative common-evaluation-words and tactile sensation representative common-evaluation-words were identified by investigating the similarity of these obtained words. As a result, eight appearance common representative evaluation words and nine tactile sensation common representative evaluation words were clarified.

ACKNOWLEDGMENTS

This research was supported by the JSPS KAKENHI Grant Numbers 24220012 and 25330316. I would like to express the deepest appreciation to Professor Masahiro Sugahara of Takarazuka University of Art and Design. He has given an advice about the relationship between the material axis, which has been experimentally used in the fashion field, and the obtained common representative evaluation words.

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Comparison of clothing evaluations by Japanese and Chinese experts

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Abstract: The salability in Japan of clothes designed and sold in China was evaluated by experts from both countries. The salability of clothes designed and sold in Japan was also investigated. Five Japanese jackets were purchased for evaluation from a department store in Tokyo, and 10 items of Chinese clothing (two dresses and eight jackets) were purchased for evaluation from a department store in Beijing. Seven Japanese apparel experts (two university professors, two designers, a pattern maker, and two merchandisers) and 10 Chinese apparel experts (eight university professors, an art director, and a designer) evaluated the clothing items. The experts were not informed of the item specifications, including price, brand, materials, and country of manufacture. The sample items were evaluated on the basis of their 1) materials, 2) colors, 3) silhouette, 4) design emphasis points, 5) designer ability, 6) pattern maker ability, and 7) sewing finish. Each point of evaluation was scored on a 0–2 or 0–3-point scale. Evaluators were required to specify the reason for each score they gave. Points were accumulated to give a general score. We found that Japanese experts focused on general design and sewing finish, while Chinese experts considered more general design points. Materials and sewing finish were evaluated independently of general design points. Thus, our results indicate that clothing is evaluated differently in Japan and China. We conclude that it is necessary to consider the respective evaluation points used in each country as we pursue globalization.

Keywords: Chinese Apparel, Japanese Apparel, Clothing Evaluation, Apparel Expert.

1. INTRODUCTION

The scale of the Chinese clothing market is currently greater than 12 trillion yen, which is second to that of the United States; China thus competes with Japan for second place. The growth rate of the clothing market in China is high [Ministry of Economy, Trade and Industry of Japan, 2013]. Although Japanese fashion products designed by Japanese companies are generally superior in the domestic market, their international presence is considerably small. With few exceptions, most such Japanese fashion products sell poorly in overseas markets, while many European and American luxury brands and a few Korean apparel brands have become famous and shown high sales in China.

Recently, at least 80% of the clothing sold in Japan is manufactured in China [Ministry of Economy, Trade and Industry of Japan, 2013]. While such clothes are considered to be of adequate quality, globally speaking current Japanese quality management standards are said to be too severe and excessively strict [Masuda T., 2010]. In addition, some industry observers believe that Japanese clothing does not sell well in the Chinese market because of differences in design and size [Sakaguchi M., 2006].

On the other hand, the Chinese apparel industry has gradually acquired high-quality manufacturing ability at low costs. Based on this ability, Chinese companies are now trying to enter global markets, including that of Japan [Clothes Industry Network in China, 2013]. To better understand the state of the global fashion market, therefore, it is necessary to know the current state of Chinese apparel in the global market. In the global market, Japanese market is one of the important market for Chinese apparel.

There are some studies on the consumer behavior and marketing in China [Aron O'Cass and Vida Siahtiri, 2013, Sylvie Laforet, Junsong Chen, 2012].The Chinese preferences of brands and body images were also investigated [Susan H.C. Tai, 2005, Bopeng Zhang and Jung-Hwan Kim, 2013]. The effects of consumers' appearance and body on their behavior for shopping were investigated [David Mellor et al, 2013, Luo Y, 2005]. However, those studies were not considered the characteristic of clothing itself. A popular clothing in China may not be popular in Japan or vice versa. Clothing preference is depending on the customers' Kansei. The Kansei will be different from the belonging countries. To understand the characteristics of the preferred clothing in each country will help designer and manufactures to make more satisfying clothing for customers' Kansei of each country.

To understand the difference of the preferred clothing, we investigated the characteristics of clothes designed and sold in China and Japan. The sample clothes were evaluated by clothing experts who has a carrier in apparel industry or education in both Japan and China. We assumed that they understand the customers' preference of each country. The experts described the points of evaluation on which the clothing experts from each country focus. If their focused points were different, it will show the difference of the preference of customers in each country. Thus, we compared these points of focus of both countries and clarified the differences. It will help designer and manufacturers to make clothing which satisfy customers in each country.

2. EXPERIMENTAL

To investigate the differences in clothing evaluation focus points between Japan and China, the salability of clothes designed and sold in Japan was investigated. Five Japanese jackets were purchased for evaluation from a department store in Tokyo, and 10 items of Chinese clothing (two

Table 1: Sample specifications

Sample name	Sample picture	Brand country	Retail price	Sample name	Sample picture	Brand country	Retail price
C1		China	CNY 850 (JPY 13,600)	J9		Japan	(CNY 4,528) JPY 72,450
C2		China	CNY 795 (JPY 12,720)	C10		China	CNY 3,128 (JPY 50,048)
J3		Japan	(CNY 1,575) JPY 25,200	C11		China	CNY 1,149 (JPY 18,384)
C4		China	CNY 589 (JPY 9,424)	C12		China	CNY 799 (JPY 12,784)
C5		China	CNY 1,068 (JPY 17,088)	C13		China	CNY 2,598 (JPY 41,568)
J6		Japan	(CNY 1,575) JPY 25,200	C14		China	CNY 2,897 (JPY 46,352)
J7		Japan	(CNY 1,838) JPY 29,400	J15		Japan	(CNY 1,811) JPY 28,980
C8		China	CNY 2,592 (JPY 41,472)	*Note: "J" refers to Japanese brand; "C" refers to Chinese brand. *Retail price was converted at a rate of 1 CNY = 16 JPY.			

dresses, eight jackets) were purchased for evaluation from a department store in Beijing. The specifications of the samples are shown in Table 1. Seven Japanese apparel experts (two university professors, two designers, a pattern maker, and two merchandisers) and 10 Chinese apparel experts (eight university professors, an art director, and a designer) evaluated the samples. Details about the experts are shown in Table 2.

The experts were not informed of the item specifications, including their purchase price, brand, materials, and country of manufacture. They examined the samples by observing them being worn and/or making put them on a dress maker dummy and by touching them. The sample items were evaluated on the basis of their 1) materials, 2) colors, 3) silhouette (shape and outline), 4) design emphasis points, 5) designer ability, 6) pattern maker ability, and 7) sewing finish.

Each point of evaluation was scored on a 0–2 or 0–3-point scale. Evaluators were required to provide the reason for each score they gave. Points were accumulated to give an average score out of a total score of 100. The evaluation point scoring was performed by principal component analysis (PCA) to investigate the structure of the evaluations.

Table 2: Apparel expert details in Japan and China

No.	Gender	Occupation	No.	Gender	Occupation
JE1	female	university professor	CE1	female	university professor
JE2	male	university professor/designer	CE2	male	university professor
JE3	female	university professor	CE3	female	university professor
JE4	female	university professor/designer	CE4	female	university professor
JE5	female	pattern maker	CE5	female	university professor
JE6	female	merchandiser	CE6	female	university professor/designer
JE7	male	merchandiser	CE7	male	university professor
			CE8	male	university professor/art producer
			CE9	male	university professor
			CE10	male	university professor

3. RESULTS AND DISCUSSION

3.1. Comparison of clothing evaluation results

The average scores (out of 100) of the samples as scored by the Japanese and Chinese experts are shown in Figure 1. The average of all scores for all samples was 47.5 by the Japanese experts and 70.1 by the Chinese experts, indicating that the Japanese experts were stricter in their evaluations than the Chinese experts. The score rankings are shown in Table 3. The rankings of the samples were also different depending on the country.

The Japanese experts gave higher scores to samples J9, C14, and J15, all with scores over 60. For samples C4, C11, C12, and C13, the Japanese experts gave lower scores, all under 40. The Chinese experts, on the other hand, evaluated samples C5, J7, C8, J9, C14, J15 all with scores

over 70. Sample C10 was given the lowest score (under 50) by the Chinese experts. Samples J9, C14, and J15 were highly evaluated by the experts of both countries. These results indicate that there are common points of evaluation with respect to generally highly evaluated clothing in both countries. However, while samples C4, C11, C12, and C13 were poorly evaluated by the Japanese experts, they were given mid-range scores by the Chinese experts. In contrast, samples C2, J3, and J6 were highly evaluated by the Japanese experts but given comparatively lower scores by the Chinese experts. These results indicate that there are some different evaluation points between the two countries.

3.2. Expert comments regarding their clothing evaluations

According to the comments provided by the Japanese experts, some of them scored sample C11 as being of poor quality because of its silhouette, sewing finish, and pattern. They also poorly evaluated the pattern and sewing on the shoulders and armholes of the sample. However, the Chinese experts did not object to this particular design of the shoulders and armholes, and poor sewing. Samples C12 and C13 were also poorly evaluated by the Japanese experts because of their poor sewing finish and defective aspects, such as pressing marks and wrinkles. In particular, they evaluated such samples as being regarded as low quality in the Japanese market. However, the Chinese experts noted only that the designer ability of these samples was comparatively low.

In addition, among the comments provided regarding samples J3, J6, and J7, the Chinese experts noted that such items could not be sold in China. The reasons they gave were that Chinese consumers had different preferences with respect to color and design. The color, sewing, and silhouette of sample J3, for example, was evaluated as being too ordinary—that is, not having any special characteristics—as well as being an outdated design. Samples J6 and J7 were also evaluated as unsalable in China because of their color and silhouette, which, the experts noted, looked like clothing of 10 years ago. The design was also evaluated as being an older fashion without any notable design emphasis points. Taken together, these results suggest that it is important to have designs that incorporate the preferences of Chinese consumers to be salable in China.

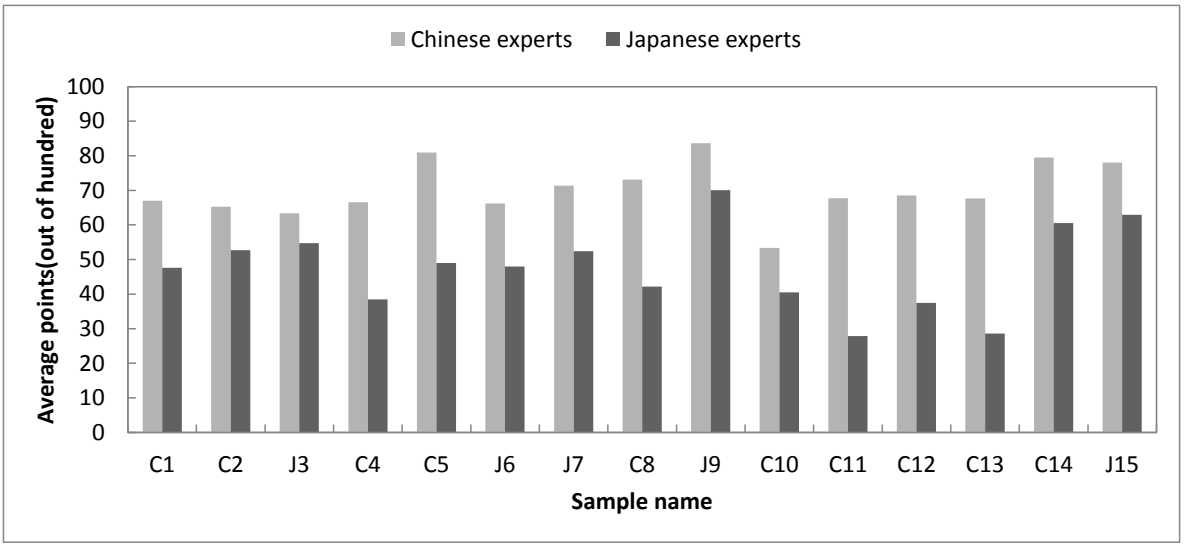


Figure 1: Average evaluation scores of samples (out of 100)

Table 3: Sample rankings according to the obtained scores

Sample	RANK	
	Chinese	Japanese
C1	10	9
C2	13	5
J3	14	4
C4	11	12
C5	2	7
J6	12	8
J7	6	6
C8	5	10
J9	1	1
C10	15	11
C11	8	15
C12	7	13
C13	9	14
C14	3	3
J15	4	2

3.3. Results of principal component analysis

We performed a principal component analysis (PCA) to summarize the evaluation structure of each evaluator group. The principal component loading results are shown in Table 4. The PCA results showed that the principal component loadings of the first principal component by the Japanese experts were as follows: silhouette 0.94, materials 0.89, designer ability 0.87, pattern maker ability 0.85, colors 0.82 and sewing finish 0.80. The contribution ratio of the first principal component was 63.8%. In the second principal component of the Japanese experts, the principal component loadings of design emphasis points showed a large value, -0.96. The contribution ratio of this second principal component was 15.4%. Therefore, the correlation of each evaluation item was high by Japanese experts, indicating that they evaluated the samples while taking into consideration each sample's general design qualities in a comprehensive manner.

The principal component loading results of the first principal component by the Chinese experts were as follows: silhouette 0.94, designer ability 0.89, and pattern maker ability 0.86. The contribution ratio of the first principal component was 57.3%. These results indicate that the Chinese experts took the factors of silhouette, designer ability, and pattern maker ability into consideration more compared with the Japanese experts. As for the results of the principal component loading of the second principal component by the Chinese experts, the characteristics of materials, sewing finish, and design emphasis points showed higher values than the others. The contribution ratio of this second principal component was 22.9%.

Figures 2 and 3 show a comparison of the principal component loading results of the first and second principal components by the Japanese and Chinese experts, respectively. Comparing both sets of results, we can conclude that the Chinese experts took design emphasis points into consideration more than the Japanese experts did, as shown in Figure 2. The Japanese experts, on the other hand, took the factors of materials and sewing finish into consideration more than the Chinese experts did, as shown in Figure 3. The relationship between the first and the second principal component results between Japanese and Chinese experts is shown in Figure 4. The

Japanese experts evaluated design emphasis points independently from the other evaluation items, while the Chinese experts evaluated materials and sewing finish independently from the other evaluation items. These results also show that the evaluation points are different depending on the country.

Table 4: Principal component loading of the first and second principal components

Experts / Variable	Japanese experts		Chinese experts	
	First principal component	**Second principal component**	**First principal component**	**Second principal component**
silhouette	0.94	0.03	0.94	-0.11
materials	0.89	-0.21	0.56	-0.65
designer ability	0.87	0.02	0.89	0.30
pattern maker ability	0.85	0.25	0.86	0.06
colors	0.82	-0.16	0.75	0.26
sewing finish	0.80	0.14	0.61	-0.72
design emphasis point	0.06	-0.96	0.58	0.69

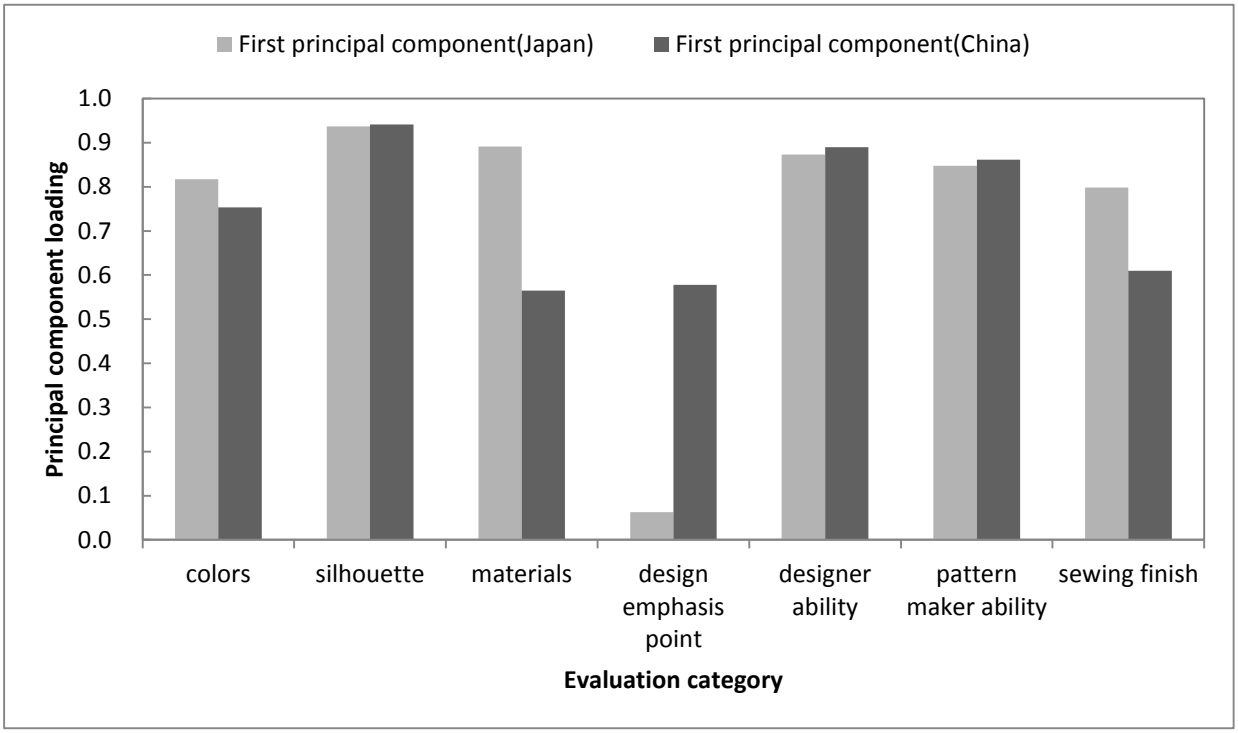


Figure 2: Comparison of principal component loading results of the first principal components by the Japanese and Chinese experts

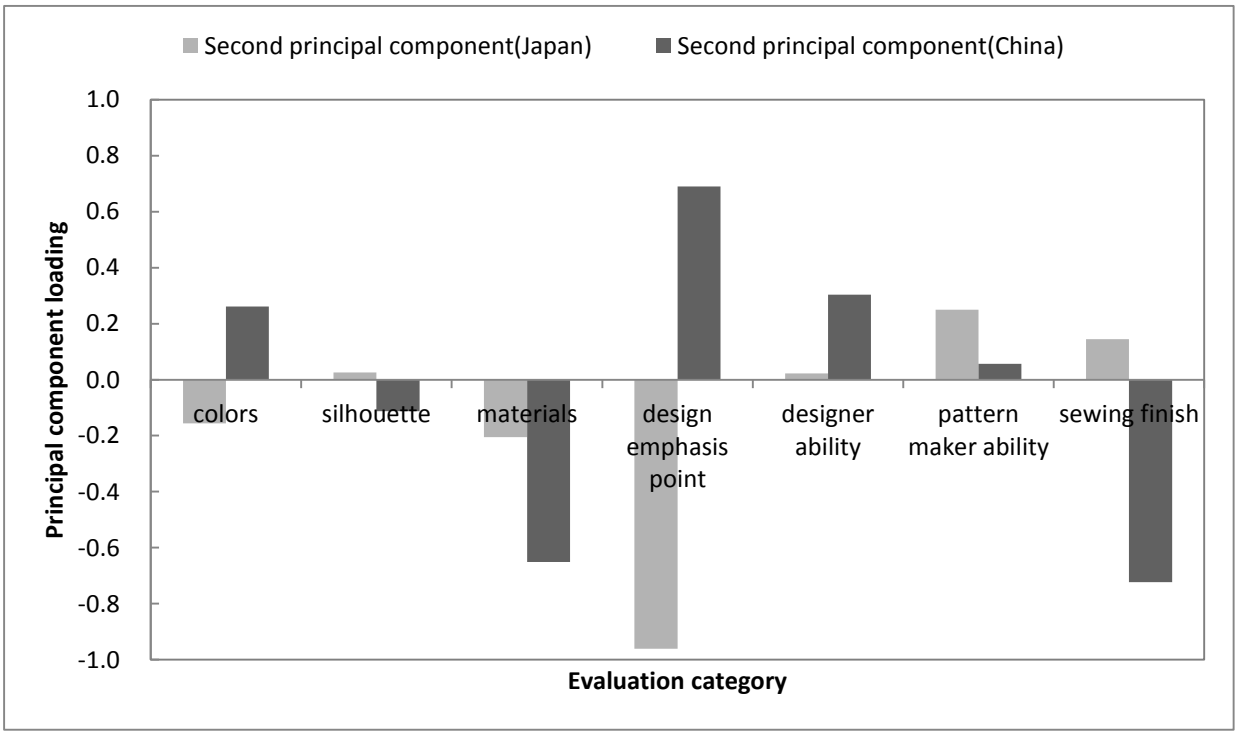
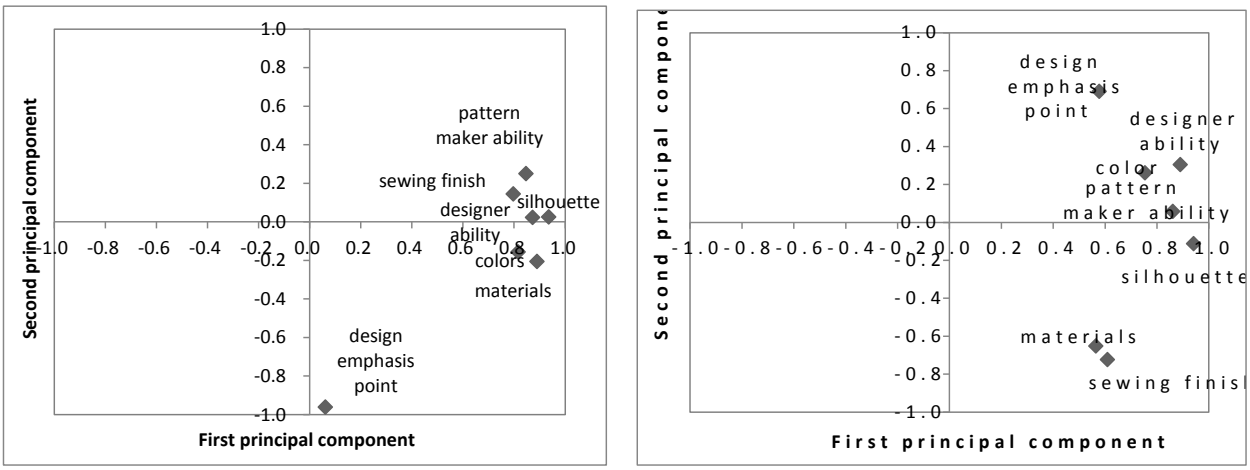


Figure 3: Comparison of principal component loading results of the second principal components by the Japanese and Chinese experts



(a) Japanese (b) Chinese

Figure 4: Relationship between the first and second principal component results for Japanese and Chinese experts

In conclusion, we found that the Japanese experts focused on overall design and sewing finish, while the Chinese experts tended to focus more on design emphasis points. The materials and sewing finish of the samples were evaluated by the Chinese experts independently from the overall design points. Thus, we can conclude that clothing is evaluated differently in Japan and China. We further conclude that it is necessary to consider the primary evaluation points considered to be most important in each country as we pursue globalization.

4. CONCLUSION

To investigate and compare the evaluation points considered to be more important by both Japanese and Chinese apparel makers when entering the Japanese and Chinese markets, apparel experts in Japan and China evaluated jackets and dresses that were purchased in China and a Japanese department store. Results showed that Japanese experts considered general design and sewing finish in a comprehensive manner when evaluating clothing. The Chinese experts, on the other hand, put more emphases on design points, while tending to evaluate materials and sewing finish independently. Taken as a whole, our results reveal that clothing evaluating viewpoints vary between Japan and China, despite there being some common points of evaluation. These results also will be related with the differences of customers' preference of each country. Further, our results clarified that it is necessary to take into account the evaluation points considered to be more important in each country when making efforts to increase the globalization of apparel products. This result will help designer and manufacturers to make clothing which satisfy customers in each country.

ACKNOWLEDGMENTS

This work was supported by JSPS (Japan Society for the Promotion of Science) fellows and JSPS KAKENHI Grant number 24220012 and 23240100.

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BIOGRAPHY

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Salability of Chinese apparel in Japanese department stores

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Abstract: To better understand the reasons for the salability of clothing now designed and sold in China and Japan, we asked Japanese experts to evaluate Chinese and Japanese brands of clothing currently for sale in the Japanese market. Ten items of Chinese brand clothing (two dresses, eight jackets) were purchased for evaluation from a department store in Beijing, and five Japanese brand jackets were purchased for evaluation from a department store in Tokyo. Seven Japanese apparel experts then evaluated all of the items; the experts were not informed of the clothing specifications. The items were evaluated on the basis of 1) material(s), 2) color(s), 3) silhouette, 4) design emphasis point(s), 5) designer ability, 6) pattern maker ability, and 7) sewing finish. Five of the Chinese clothing samples were judged as impossible to sell in Japanese department stores primarily because the sewing quality was incompatible with Japanese requirements, the designs were outdated, and the materials were of low quality. However, the other five Chinese clothing samples received high evaluations of salability in Japan on the basis of design and sewing quality. However, even for those samples evaluated as well designed, it was found that their salability in Japan could be improved through increased cooperation among designers, pattern makers, and production factories, and additionally, through improved sewing skills. The results of this study will help Chinese and Japanese apparel makers improve the salability of their clothing in both of those countries.

Keywords: Chinese Apparel, Japanese Apparel, Clothing Evaluation, Salability.

1. INTRODUCTION

While the Japanese apparel market remains relatively large scale, it has recently been experiencing saturation and reductions in size. Many global companies with products in both the low and high price ranges have been entering the Japanese market; according to 2010 statistics, the import penetration rate of clothing to Japan is 96%. Thus most clothing products in Japan are offshore productions. According to trade statistics, the value of imports of clothing and accessories in 2010 was 2,753 billion yen. Of these, imports from China comprised 76.4%, for a value of 2.1 trillion yen [Ministry of Economy, Trade and Industry of Japan, 2013]. It is assumed that most of the clothing products, imported from China and sold in Japan, are produced under the production control of Japanese companies. The quality of this clothing is sufficient to sell in Japan. China developed a strategy to enter such international markets in 2011 [Clothes Industry Network in China, 2013].

On the other hand, although Japanese fashion products are considered superior in the domestic market, few Japanese companies enter international markets, and thus the total international sales of such companies are considerably low. The situation is similar in the Chinese market. The Chinese apparel market, now worth more than 12 trillion yen, has become one of the more attractive world markets. European and American luxury and fashion brands have successfully entered the Chinese market. The success of Korean apparel in China is a remarkable example. It has become necessary for Japanese brands to enter the Chinese market to overcome Japan's current market saturation and reduction in size. For a Japanese brand to successfully enter the Chinese market, however, it is necessary to first understand the quality and design of the clothing that is currently being designed and sold in China.

The Chinese consumer behavior [O'Cass A. and Siahtiri V., 2013] and the marketing in China [Laforet S.and Chen J., 2012] were investigated to understand the Chinese apparel. The Chinese preferences of brands [Susan H.C. Tai, 2005] were also investigated. Zhang B. and Kim J. [2013] researched Chinese preferred body images. Mellor D. et al [2013] and Luo Y [2005] investigated the effects of consumers' appearance and body on their behavior for shopping. Even though those studies were researched on the Chinese customers and brands, the studies on the characteristic of clothing itself were less. Especially, the salability considered the clothing characteristic will be one important factor which may show the customers' preference. The preference is come up by Kansei. Clothing with high salability in China may not be sold well in another county or vice versa. It may be due to the different customers' Kansei depending on county.

The purpose of this study is to investigate the salability of Chinese apparel in Japanese department stores for Chinese and Japanese apparel makers. We asked Japanese apparel experts to evaluate the salability in the Japanese market of Chinese brand clothing currently being sold in China. By investigating the salability of clothing, we can understand the customers' preference. Furthermore, it helps designer and manufactures to make clothing which reflected the customers' Kansei.

2. EXPERIMENTAL

To gain knowledge about the quality and design of clothing now designed and sold in China, we asked Japanese experts to evaluate the salability of Chinese brand clothing in the Japanese market. We refer to Chinese brand clothing sold in China as Chinese apparel, and we refer to Japanese brand clothing sold in China as Japanese apparel. Ten items of Chinese clothing (two

Table 1: Sample specifications

Sample name	Sample picture	Brand country	Retail price	Sample name	Sample picture	Brand country	Retail price
C1		China	CNY850 (JPY 13,600)	J9		Japan	(CNY 4,528) JPY 72,450
C2		China	CNY 795 (JPY 12,720)	C10		China	CNY 3,128 (JPY 50,048)
J3		Japan	(CNY 1,575) JPY 25,200	C11		China	CNY 1,149 (JPY 18,384)
C4		China	CNY 589 (JPY 9,424)	C12		China	CNY 799 (JPY 12,784)
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J6		Japan	(CNY 1,575) JPY 25,200	C14		China	CNY 2,897 (JPY 46,352)
J7		Japan	(CNY 1,838) JPY 29,400	J15		Japan	(CNY 1,811) JPY 28,980
C8		China	CNY 2,592 (JPY 41,472)	*Note: "J" refers to Japanese brand; "C" refers to Chinese brand. *Retail price was converted at a rate of 1 CNY = 16 JPY.			

Table 2: Apparel expert details

Letter	Age	Gender	Occupation
A	40s	female	university professor
B	60s	male	designer / university professor
C	50s	female	university professor
D	50s	female	designer / university professor
E	40s	female	pattern maker
F	70s	female	merchandiser
G	60s	male	merchandiser

dresses and eight jackets) were purchased for evaluation from a department store in Beijing, and five Japanese jackets were purchased for evaluation from a department store in Tokyo. The specifications of these samples are shown in Table 1. Seven Japanese apparel experts (two university professors, two designers, a pattern maker, and two merchandisers) evaluated the samples. Additional details about the experts are shown in Table 2.

The experts were not informed of the clothing specifications, which included price, brand, materials, and country of manufacture. They examined the samples by observing them being worn, by putting them on a dummy, and by touching them.

First, the salability of the items in Japanese department stores was judged by the experts (possible or impossible). The experts were also instructed to make an estimate of the retail prices of the items. Then, the items were evaluated on the basis of their 1) materials, 2) colors, 3) silhouette (shape and outline), 4) design emphasis points, 5) designer ability, 6) pattern maker ability, and 7) sewing finish. Each category of evaluation was scored on a 0–2 or 0–3 point scale. Evaluators were required to provide the reason for each score they gave. Points were accumulated into a general score for each item. Finally, the reasons for each evaluation provided by the experts were summarized.

3. RESULTS AND DISCUSSION

3.1. Salability of Chinese apparel in Japanese department stores

The salability of the Chinese apparel items in the Japanese market was evaluated by the abovementioned Japanese experts (see Table 2). The experts' ratings of the salability of the Chinese apparel are shown in Table 3.

All of the Japanese apparel items were evaluated as having high salability. However, among the Chinese apparel items, only half of the samples (C1, C2, C5, C12, and C14) were evaluated as having high salability. The other samples (C4, C8, C10, C11, and C13) were judged as being impossible to sell in Japanese department stores.

The averaged general scores of the item evaluations are shown in Figure 1. The Japanese apparel item general scores were higher than those of the Chinese items for most evaluation categories except 'design emphasis points'; the scores for this category were similar for both the

Japanese and Chinese apparel items.

The main reasons given by the experts for the items being unsalable were that the required sewing quality was insufficient to meet Japanese requirements, the designs were outdated (even those samples currently being sold), and the materials were evaluated as being of low quality.

Table 3: Experts' evaluation scores regarding the salability of Chinese apparel (N=7)

Sample number	C1	C2	J3	C4	C5	J6	J7	C8	J9	C10	C11	C12	C13	C14	J15
Experts' scores: salable	5	5	7	2	4	7	6	2	7	3	1	4	1	5	6
Experts' scores: unsalable	2	2	0	5	3	0	1	5	0	4	6	3	6	2	1

However, the Chinese clothing samples C1, C2, C5, C12, and C14, which received high evaluation scores of salability in Japan, were evaluated highly in the categories of design and sewing quality. Therefore, to obtain a generally higher evaluation, Chinese apparel needs to improve in the aspects of sewing finish, quality of materials, and design to be more salable in the Japanese apparel market.

The correlation coefficients between the experts' salable evaluations and the averages of the obtained general scores for the evaluation categories are shown in Figure 2. With the exception of 'design emphasis points', all of the categories showed high correlation coefficients. This low correlation coefficient value for the design emphasis points category indicates that design was emphasized in the Chinese apparel items. However, the entire evaluation was still low compared with the Japanese apparel, in particular with respect to the category of sewing finish.

To obtain a high correlation of regression equation than single correlation, a multiple regression analysis was performed assuming the experts' salable evaluations as a response variable and the evaluation items as explanatory variables. As a result, the adjusted multiple correlation coefficient was 0.72, which was lower than some single correlation coefficient. Thus, it was no effect to make a predictive equation using multiple regressions.

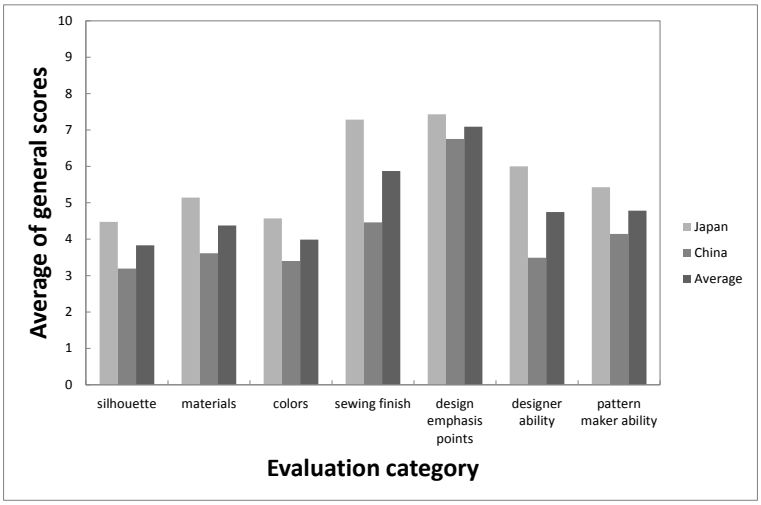

Figure 1: Averaged obtained general scores of the evaluation categories

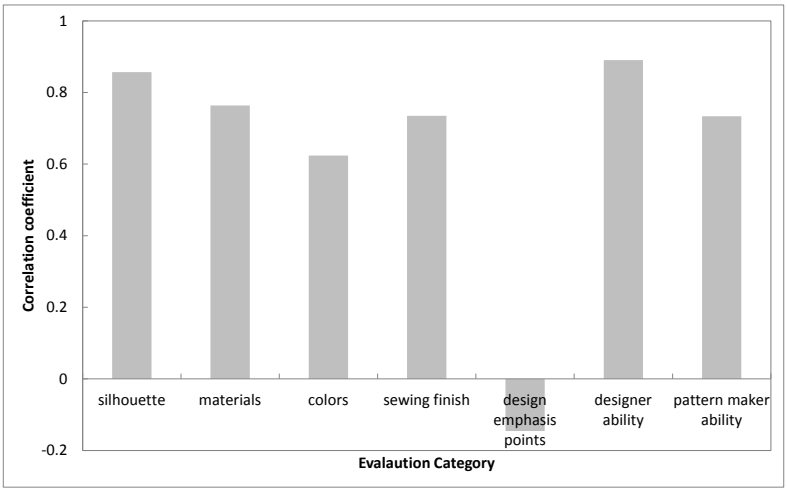

Figure 2: Correlation coefficients between experts' salability scores and the averages of the obtained general scores of the evaluation categories

The category scores for the samples with lower expert scores for salability in Japan are shown in Table 4. While those samples showed high scores in the 'design emphasis' category, the experts also commented that there are too many design elements in the items and also that the entire design was out of fashion. The samples that showed high evaluation scores are shown in Table 5. The characteristic of these samples included having a good silhouette, good materials, good colors, and/or good patterns. These samples also had good points of design emphasis and comparatively high sewing finish quality.

The results indicate that even for those samples evaluated as having design emphasis points, their salability in Japan could be improved through greater cooperation between designers, pattern makers, and sewing factories, and additionally, through improved sewing skills.

Table 4: Evaluation scores of samples with lower scores for salability in Japan (N=7)

Sample number	Experts' salability score	silhouette	materials	colors	sewing finish	design emphasis points	designer ability	pattern maker ability
C4	2.0	3.3	1.4	2.9	5.7	9.3	1.4	2.9
C8	2.0	2.4	2.4	3.3	5.0	10.0	2.9	3.6
C10	3.0	2.9	3.3	1.4	5.0	8.6	2.9	4.3
C11	1.0	1.9	2.9	3.3	0.0	7.1	2.9	1.4
C13	1.0	1.4	1.4	2.9	3.6	5.7	2.1	2.9

Table 5: Evaluation scores of samples with higher scores for salability in Japan (N=7)

Sample number	Experts' salability score	silhouette	materials	colors	sewing finish	design emphasis points	designer ability	pattern maker ability
C1	5.0	3.3	3.8	3.3	5.0	7.9	5.0	5.0
C2	5.0	3.8	5.7	5.2	5.7	7.9	4.3	4.3
C5	4.0	3.3	4.8	4.8	4.3	8.6	3.6	5.0
C12	4.0	3.3	3.8	3.3	2.1	5.7	2.9	5.0
C14	5.0	5.2	5.2	4.8	8.6	6.4	5.0	7.1

3.2. Evaluated prices

The retail prices and the experts' estimated prices of the samples are shown in Figure 3. The price of items judged as unsalable in Japanese department stores was set as zero JPY. With the exception of the scores of one expert (E1), no correlation was found between the actual purchase and the estimated prices. The estimated prices of the Japanese apparel samples were close to the actual purchase prices. As for the Chinese apparel samples, however, the prices of samples C8, C10, and C13 were estimated to be less than half of their actual purchase prices (sample C14 was the exception). Even the Chinese clothing samples with an actual retail price of over 40,000 JPY were not estimated by the experts to have such prices in Japan. These results therefore indicate that purchase prices may be decided more by the brand than the actual item characteristics.

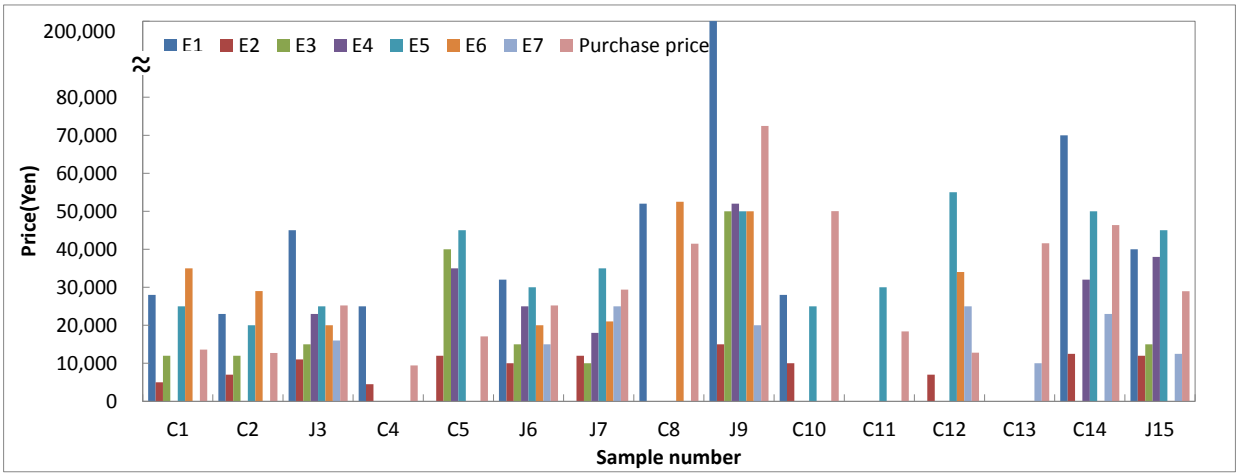

Figure 3: Estimated and actual retail purchase prices of samples

3.3. Evaluated points by comments

The Japanese experts had various career backgrounds, which likely had an influence on their evaluations. Nonetheless, some common points for consideration were identified from their comments regarding the evaluated items. Namely, they noted that to successfully sell clothing in Japanese department stores, apparel producers should focus on improving seam finishing, pressing marks, and other details such as buttons.

3.3.1. Design emphasis points and design balance

Samples with more than three design emphasis points were given low evaluations by the experts. Figure 4 shows those samples that were judged as having too many emphasis design points; C5 was evaluated as having design emphasis points on its pocket, belt, sleeve shirring, and front hem curve; C8 was also found to have design emphasis points on its tuck, patch pocket, and length difference between the front and back. In Japan, apparel with too many design emphasis points is less preferred.

Design balance was also considered to be an important evaluation point in this study. Samples of unbalanced design are shown in Figure 5; samples C4 and C10 were evaluated as having an entirely unbalanced design, while samples C11 and C13 were evaluated as having sleeve lengths that are too long for the average Japanese body shape.



(a) C5 (b) C8

Figure 4: Examples of excessive design emphasis points



(a) C4 (b) C10 (c) C11 (d) C13

Figure 5: Examples of unbalanced design

3.3.2. Seam finishing

Most of the experts looked for very high quality in the category of seam finishing. Figures 6 and 7 show examples of clothing with poor and good quality seam finishing, respectively. Interlock seam finishing was especially evaluated as being of poor quality, while piping seam finishing was considered to be high quality. However, the textile properties of each sample were also considered. Thus, even samples with piping seam finishing were evaluated poorly if they had thick textile properties, as shown in Figure 8.



(a) C2 (b) C4 (c) C10

Figure 6: Poor-quality examples of seam finishing



(a) J3 (b) J6 (c) C8

Figure 7: High-quality examples of seam finishing



Figure 8: Example of low-quality piping seam finishing (C13)

3.3.3. Pressing mark

The pressing mark of each sample was also examined. Most of the experts mentioned the pressing mark around the collar and lapel areas in their comments. Figure 9 shows some examples of the pressing marks of the samples.



(a) C5 (b) C10 (c) C12

Figure 9: Examples of pressing marks

3.3.4. Button

Buttons were another category of quality evaluated by the experts. Figure 10 shows examples that were judged as easy to unbutton. This evaluation was also related to the type of seam finish. The material of the buttons was also evaluated from the aspect of poor or high quality (see Figure 11).



(a) C4 (b) C5 (c) C12 (d) C13

Figure 10: Examples of buttons that are easy to unbutton



(a) C8 (b) J9

Figure 11: Poor-quality button (left) and high-quality button (right)

4. CONCLUSION

In this study we investigated the salability of Chinese apparel in Japanese department stores. Japanese apparel experts evaluated dresses and jackets purchased in Japanese and Chinese department stores. Half of the Chinese clothing samples were judged as unsalable in Japanese department stores, primarily because the sewing quality was incompatible with Japanese standards, the designs were judged as outdated, and the materials were of low quality. However, the other half of the Chinese clothing samples received high evaluations of salability in Japan because of their designs and sewing quality. In conclusion, to obtain generally higher evaluations, Chinese clothing needs to be improved in the aspects of sewing finish, quality of materials, and design to be salable in the Japanese apparel market. Therefore, it became clear that the difference of the salability in Japan and China. In the view point of preference, outdated design in Japan was considered as not old in China. Chinese customer accepted relatively low level of sewing and material quality. These differences of the preference may be caused by Kansei which bring up by the customers' experience and their culture on fashion. This study will help Chinese and Japanese apparel makers improve the salability of their clothing in both countries.

ACKNOWLEDGMENTS

This work was supported by JSPS (Japan Society for the Promotion of Science) fellows and JSPS KAKENHI Grant number 24220012 and 23240100.

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Textile Selection for Clothing Design by Visual Information

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Abstract: Clothing designers select textiles for clothes in the process of clothing design. The experiments are conducted to find out how far clothing designers can select textiles for clothes only by the visual information. Textiles for the experiment were selected in the condition that those are used for jackets, long pants and skirts sold in Japanese department stores. Eight chemical crape georgette textiles were selected. The images or movies to show visual information of the textiles were discussed with some experienced clothing designers and determined seven kinds of images such as a close up of cloth or gather. The images were taken in a dark room and the textiles are well-illuminated. The subjects were told the guideline of clothing design and asked to draw a clothing design picture. The subjects were asked to watch the visual images of the eight textiles on the computer screen, and to rate each textile if it is suitable to their clothing design on a scale of one to ten. After that, the textiles were handed to the subjects, and then they were asked to rate in the same manner. The method to transfer information of textile is verified to compare the rate in the case of textile images and in the case of sight and haptic of real textile. It is suggested that textiles for clothes can be selected to some extent only by visual information.

Keywords: clothing design, textile selection, visual information, online.

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1. INTRODUCTION

Recently, online shopping for various products is increasing whether as business to business or

business to consumer every year. Online trade for clothing is established to some extent. Though there is some online trade for textiles but it is hard to say that the online trade is popular compared to other products. In the existing site for online textile trade, textiles are searched by type or composition, and photos of the searched textiles are displayed on screen. It is difficult to transfer information about clothes or textiles compared to other products via the Internet, because it is not easy to transfer sense such as hand feeling via the Internet. Bergamasco et al. studied to transfer remotely hand feeling of textile [1]. It is difficult to apply this technique to online shopping, as a large apparatus was constructed for this study. There are many studies about online shopping. There are some studies to extract and evaluate factors of apparel online shopping [2-4], or to evaluate the effect of virtual try-on [5-7]. But study about textile online shopping has not been found. One of the way to transfer information about textile is to substitute other sense which can be transferred via the Internet for a sense which can't be transferred. There have been many studies to substitute visual sense for tactile sense [8-11], but for the textile information transfer another substitution has to be needed. We focused on textiles and considered what kind of information has to be transferred to understand textiles better via the Internet.

2. EXPERIMENT

2.1. Preparation of photos and movies

We got interviews with two experienced apparel designers who are experts to deal with textiles how to examine textiles when they choose textiles for their apparel designs. A designer had worked for a Japanese apparel company and designed clothes for Japanese department stores. The other designer had worked for a Japanese department store, and participated in the work of pret-a-porter in Paris. It was shown that sensory qualities and color and pattern of textiles are important for apparel designers to choose textiles. Sensory qualities of textiles are important for apparel designers if it is possible or not to form silhouette of clothes they designed with the textiles. Sensory qualities of textiles may be related to dimensions such as thickness or static or dynamic mechanical properties of textiles. Though colors or patterns must be very important factors, here those factors are not considered by conforming colors of textiles for the experiments as much as possible. Various kinds of photos and movies were proposed to transfer characteristics of textiles, and among those, eight kinds of photos and movies that are thought to be effective were adopted with advices of the experienced apparel designers.

(1) Photo of the textiles overlaid on a dummy (Kypris 9A2). The dimension of the textile is 1m by 1m, and took two photos of warp line drape and bias drape for each textile.

(2) Photo of magnified surface of the textiles. The dimension of the textile is 20cm by 1m, and the textiles are overlaid over a cylindrical object to cause curvature in the surface of the textiles.

(3) Photo of the textiles overlaid on a an human arm. The dimension of the textile is 20cm by 1m.

(4) Photos of gathers. The gather is applied to the neckline of the dummy. The dimension of the textile is 70cm by 70cm. Two directions of warp and bias of gathering are made. The photo of the gather with entire torso of the dummy and the photo of the magnified image of the gather are taken.

(5) Photos illuminated form backside of textiles. The dimension of the textile is 1m by 1m. The directions of the light are from upside, level, and downside.

(6) Movie of textile movements while it is hanging and fanned from the bottom. The dimension of

the textile is 70cm by 70cm. A commercially available dryer is used to fan.

(7) Movie of textile movements while it is wrapped around a mannequin and the mannequin is shaken. The dimension of the textile is 1m by 1m. The magnitude of the fluctuation was about 30 cm and the frequency was about 1 Hz.

(8) Movie of textile movement when it is balled up by hand and then expands. The dimension of the textile is 20cm by 20cm

Fig. 1 shows examples of textile images.



Figure 1: Examples of textile images

2.2. Experimental procedure

The experiment was conducted under the condition that the subjects designed clothing and choose textiles for the designed clothes. The textiles that may be able to utilize for the designed clothes were collected and photos and movies described above were made from the textiles. The photos and movies of each textile are shown to the subjects, and then the subjects rate the degree of fitness of each textile to make designed clothing. Then, subjects watch and touch each real textile, and then the subjects rate the degree of fitness of each textile to make designed clothing same as the case of photos and movies. The degree of coincidence of the rating in both cases is examined.

2.3. First experiment

To see the possibility to select a textile by watching photos and movies for clothing, the experiments were conducted with two experienced apparel designers and an active apparel designer. The clothing designed for the experiment is set to the dress with thin textile with drapes. According to the setting of the dress, apparel designers were asked to design clothing. An example of the designs is shown in Fig. 2.

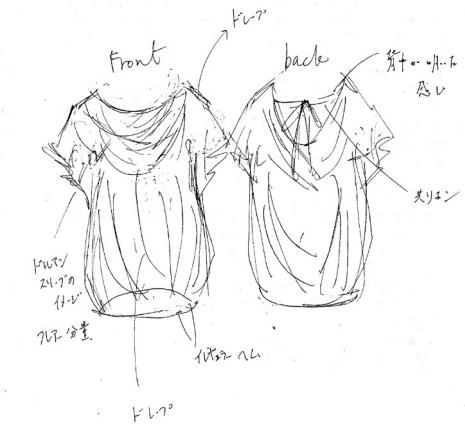

Figure 2: Design example

Through this process, three apparel designers have an idea of clothing in their mind. We gave information about the clothing designed for the experiment to a textile dealer and asked the dealer to select the textiles for the experiment. Fourteen kinds of textiles are selected for the experiment. In this experiments, to exclude the factor of color, colors of the textiles are conformed to beige. In the first stage, the subjects watched the photos and movies of 14 textiles. The order to watch the textiles was determined by random numbers, and the order was the same for three subjects. To show the photos and movies of the textiles, HP Pavilion dv6-6c0 computer, Nanao FlexScan S2410W display and Microsoft Office 2013 PowerPoint were utilized. There was no time limit to watch and it was allowed to go back and forth to watch the photos and movies of the textiles. The subjects rated on a scale of one to ten the degree of fitness of each textile to make designed clothing. After that, the subjects watched and touched each real textile. The order to watch the textiles was determined by random numbers, but the order is different from the order to watch the images. The dimension of the textiles to watch and touch was 20cm by 20cm, and the experiments were conducted in the ordinal environment of a room. The subjects evaluated the textiles in the defined order. As in the case of images, the subjects rated on a scale of one to ten, and the subjects could go back and forth to watch and touch the real textiles.

2.4. Second experiment

The next experiments are conducted in more practical conditions. The designed items are set to the full items (suit, skirt and ants for ladies) made with georgette of middle thickness for sales in Japanese department stores. The subjects of the experiments are 14 university students in design and dressmaking course. The students have been studied how to design and make clothing. We asked the subjects to draw apparel design under the condition of the experiments. The textiles utilized for the experiments were selected by a experienced apparel designer form crape georgette swatches of intermediate thickness in a textile company. Eleven textiles were selected for the experiments. The textiles consist of triacetate, polyester and polyurethane. Name and composition of the textiles are shown in table 1.

Table 1: Name and composition of the textiles for second experiment

No.	Name	Composition
01	Soir pearl soft georgette	TA60% + PE40%
02	CELINE DCM	TA70% + PE30%
03	DIAME MDG	TA71% + PE29%
04	Lionel 2WAY	TA88% + PU12%
05	Soir pearl double cross SNR	TA60% + PE40%
06	Princess tiara	PE100%
07	Soir pearl back satin	TA80% + PE20%
08	High twist GGT	TA88% + PE9% + PU3%
09	TIS crape satin	TA79% + PE21%
10	Soir pearl double WEET	TA60% + PE40%
11	NOG honey	TA70% + PE30%

TA : triacetate, PE : polyester, PU : polyurethane

In this experiments, colors of the textiles are also conformed to beige to exclude the factor of color. Computer hardware and software for the experiments and the way to watch the images or textiles are the same as before. The way to evaluate the textiles is also the same as before.

3. RESULT AND DISCUSSION

3.1. Results of the first experiment

The result of the experiments is shown in Fig. 3. The three graphs are the results of three subjects. The vertical axis means rating and the horizontal axis means textile no. The red bars show the rating by images and blue bars show the rating by real textiles. Most of the differences of the rating for the images and the real textiles are about 1, and the average is 1.3. Few of them are more than two and one is more than four. From the results, it is more or less possible to evaluate textiles by images. In the experiments, rating differences of thick textiles are rather big and that of thin and shiny textiles are small. Some differences were observed for thin and dull textiles. The biggest difference was observed in a sick textile. The subjects may misunderstand to see the movie in which the textile is wind-whipped like other textiles. Though there are some cases that the textile information was not properly transmitted, it was suggested that textile information can be transmitted to some extent.

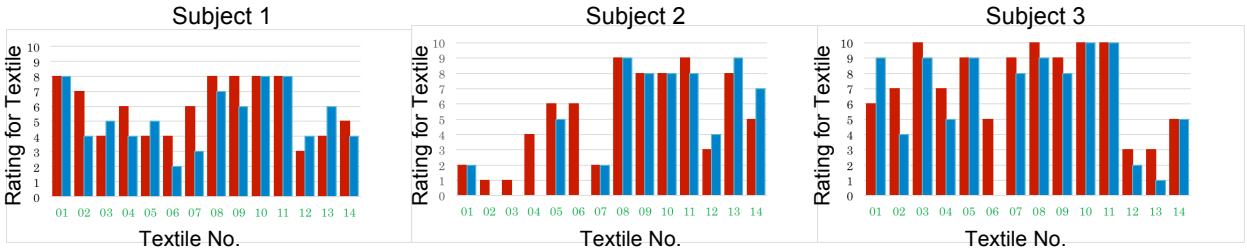

Figure 3: Results of the first experiment for three subjects. Red bars show rating by textile image and blue bars show rating by real textile.

3.2. Results of the second experiment

The average difference of the rating for the images and the real textiles is 1.5. This value is almost the same as before. The colors of the sample textiles are conformed to beige in the former experiment, but the sample textiles were selected from broad range of textiles. For this experiment, sample textiles were selected from narrower range of textiles than the former experiment. The situation of this experiment is harder than the former experiment because the subjects of this experiment are students but designers. After the experiment, the subjects were interviewed and they remarked that it is hard to detect the thickness of the textiles. There is room for improvement of the way of presentation of textile properties by images, and it is expected to decrease the error.

4. CONCLUSION

In this study, it is suggested that textile information can be transmitted to some extent in the situation of textile selection for apparel design. But there are many challenges. It is very difficult to show color of textile accurately on screen and we have many problems such as illumination, display calibration and so on. As various information is attached to textile, it is necessary to confirm how much designers perceive textiles with the information. Much more research is necessary to decide what kind of photos and movies are needed and what kind of images are not needed to transmit textile information.

ACKNOWLEDGMENTS

This work was partly supported by Grants-in-Aid for Scientific Research (No. 23240100, 24220012) from the Ministry of Education, Science, Sports and Culture of Japan.

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Objective Evaluation of Baby's Underwear Materials for Comfort Clothing Life

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Abstract: This study aims to estimate the properties of baby's clothes materials and consider the applicability to Baby's underwear. Observing styles appeared in our daily clothing lives, the underwear which should be put on inside is important to form comfort clothing macroclimate under layers of clothing from the inside to the outside. Under wear materials are required to play roles as materials worn next to skin. The underwear requires the movable design, materials with tender touch feeling and good moisture transport from the previous study. Especially for baby's underwear materials, the fabrics must be selected carefully since the heat capacity of their body is small and the skin epidermis is thin. In this study typical materials worn next to skin are collected among cover-all wears on the market. Twenty kinds of samples are selected. Cotton and cotton blend fabrics are mainly used for the baby and lady's underwear. Samples are measured for their physical properties and the transfer properties of air, heat and water. From the results of low specific density value and compression property, underwear of pile fabrics is suitable in winter. Underwear of 1x1 interlock knitted fabrics can be napped easily and produced various fabrics adopted widely use. They are suitable in all seasons from the thermal and air permeation property, and shows smoothest and softest touch feeling among sample groups in this study.

Keywords: baby's underwear, comfort, physical property, air/water transport

1. INTRODUCTION

Baby clothes market is brisk in Asian countries regardless of a declining birthrate and aging population in the society. It is said that the age of baby-wears comes to a close in baby clothes business. Objective evaluation of baby clothes shall be demanded and the development of properties expected. In baby clothes, under-wears play the important roles, such as showing a pretty appearance and keeping appropriate environment around babies. In previous papers [3,5,6],

studies on the objective evaluation of baby coverall wears has been carried out and reported that the flexibility of baby coverall wears can be described using tensile mechanical properties. In this study, considering the limber baby's body, the tensile, compression property and surface frictional is important to examine. And the objective evaluation of soft feeling is seriously expected to stand. After market research, we conduct a questionnaire on the recognition of baby clothes to consumers who shall be parents in future. The impression and expectations of baby's wears are asked. And then typical kinds of baby under-wear clothes are collected. Materials of them have be brought to the touch feeling sensory test. On the other hand, the experiment of the tensile, compression property and surface friction are carried out for the quantitative estimation. It is essential to progress the objective evaluation from different angles such as the questionnaire survey, the sensory test and the experiment.

2. QUESTIONNAIRE INVESTIGATION

In order to get the knowledge and requirements of consumers, questionnaire investigation was carried out as follows:

Term: October to December 2013

Subjects: 210 universities students, 20-22 years old

Investigation method: Using a questionnaire, Subjects fill out evaluation forms which include

Five items on motive for purchase, size, materials, value of self garment choice and general preference of baby clothes.

After collected questionnaire sheets, answers on items were amounted and discussed.

3. EXPERIMENTAL

3.1. Samples

After researching the baby clothes figures and materials, 22 typical baby's wears were prepared. Basic properties of samples for this study are shown in Table 1.

Group, no.		Structure	Fiber content	Weight	Thickness	Bulk density	stitch density	
				mg/cm²	mm	g/cm³	Wales/inch	Course/inch
s	1	1x1 interlock	cotton100%	14.49	1.012	0.143	32	45.5
	2	1x1 interlock	cotton100%	19.57	1.334	0.147	39.5	42
	3	1x1 interlock	cotton70/acrylic30%	19.25	1.753	0.110	387	28.5
	4	1x1 interlock	cotton100%	21.80	1.361	0.160	40.5	42.5
	5	1x1 interlock	cotton100%	15.18	1.080	0.141	31.5	50.5
	6	1x1 interlock	nylon100%	7.57	0.266	0.284	52	32
	7	1x1 interlock with napped	acrylic90/cotton10%	18.69	2.887	0.065	23.5	25.5
	8	quilt	cotton100% PE inside	19.56	2.095	0.093	33.5	37.5
	9	1x1 interlock with napped	cotton95/polyurethane5%	24.23	1.989	0.122	35	47
w	10	1x1 interlock	wool100%	24.04	1.118	0.215	39.5	36
f	1	1x1 rib	wool100%	26.49	1.495	0.177	52	43.5
g	1	woven double gauze	cotton100%	10.82	1.015	0.107	52	46.5
	2		cotton100%	12.16	0.861	0.141	61.5	48
p	1	plain knitted with pile	cotton100%	21.36	1.822	0.117	31	32
	2		cotton60/polyester40%	19.80	1.950	0.102	27	38.5
	3		cotton80/polyester20%	18.78	1.607	0.117	28.5	33.5
m	1	mesh knitted net	cotton100%	9.89	1.011	0.098	29	31.5
t	1	plain knitted	cotton100%	11.56	0.793	0.146	36	43
	2		cotton100%	11.68	0.707	0.165	38.5	43
	3		cotton100%	16.26	0.960	0.169	29.5	38.5
	4		cotton100%	15.36	1.041	0.148	38.5	48.5
	5		cotton100%	20.91	1.460	0.143	35.5	50.5

The samples were divided into six groups from knotting/weaving structures. The letter of group column shows the structure types (s;1x1 interlock and w from wool fibers belong to this group, f;1x1 rib, g; double gauze, p; plain knitted with piles, m; Knitted like mesh, t; plain knitted).

3.2. Measurement of structural properties and mechanical properties

Compression and surface properties were measured by KES-FB3 and FB4 testing apparatuses respectively. Thickness at the compression stress of 0,5gf/cm^2 was derived from the compression stress-thickness curve measured under the condition at the maximum compression stress of 50gf/cm^2. Mean coefficient of kinetic friction, MIU, and MMD, which indicates the deviation value of MIU are detected from the recorded wave of the frictional force- distant of samples surface. SMD shows the surface roughness that is the deviation of thickness.

3.3. Measurement of air resistance and water absorption

Air resistance was measured by KES-AP1 apparatus under one cycle process of the charge-discharge of constant air flow amount through sample sides.

Those experimental measurement were carried out in the laboratory controlled at the standard condition of 20± 2 and 65±5%R.H.

For water absorption, rectangle of specimen were taken from samples of each group and conditioned in the high temperature box until no-water level of specimen, weighed as w_0. And then the specimen were put in high humid chamber and weighed as w_x at regular intervals for more than 160hours. The changes of water absorption (=(w_x-w_0)/w_0 x100, %) were recorded.

4. SENSORY TEST BY TOUCH AND VISION

Using selected words list which include the seven most important words to express baby's wear material properties, the sensory test was carried out for seven characteristic samples. The "feel "of the baby's wear – both positive and negative adjectives were elicited. The seven pairs of bipolar words were prepared and arranged into a grid where each trait was put on the between the extreme values of its poles and could be estimated on a five point scale. The seven pairs were thick/thin, soft/hard, warm/cold, stretching/non-stretching, smooth/rough, humid/dry and preferable/not preferable.

Samples were rated with consumer judges by handle and vision. The results were examined in relation to the samples properties experimentally.

5. RESULTS AND DISCUSSION

5.1. Requirements of consumers

From results of questionnaire investigation carried out before the experiment, the three major motives for the purchase of baby clothes are "good material" "mobility" and "size. Since good materials were regarded as most important, we asked about which materials are required by consumers. For constituting fiber sorts, answers are summarized in Figures 1(a), 1(b) and 1(c), for natural fiber sorts from cotton or wool, for cotton or cotton blend and for normal or organic cotton, respectively. Percentage shows the backing rate of total answers.

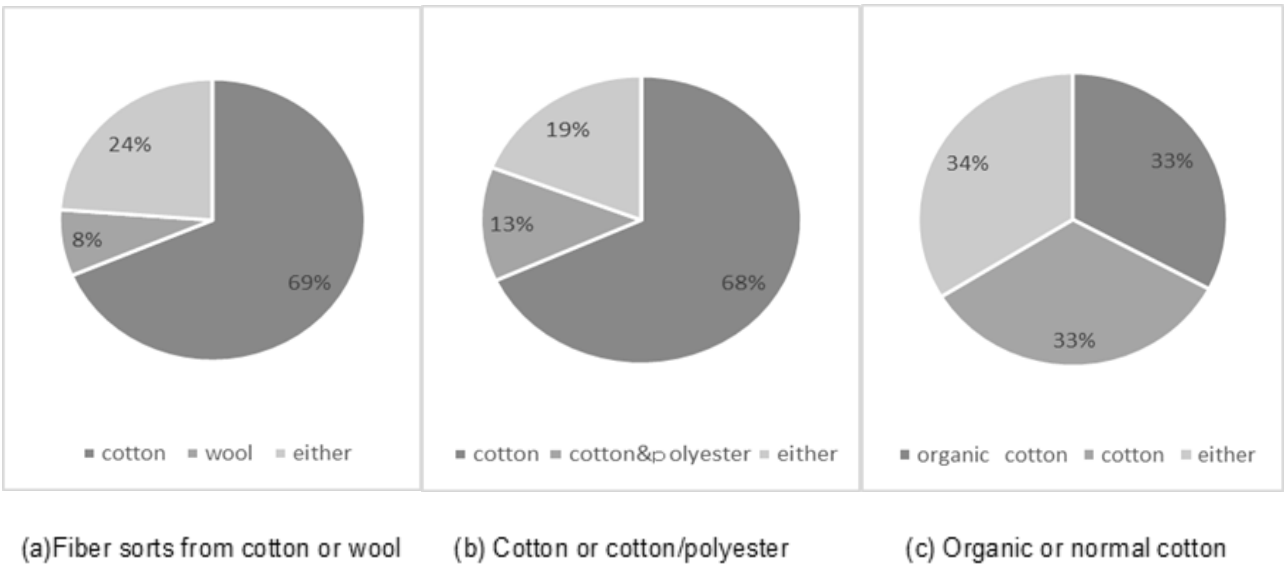

Figure 1: Results of questionnaire investigation on desirable materials of baby clothes

5.2. Properties of fabrics applied to baby clothes

Figure 2 shows the compression properties of all the sample groups. LC is linearity of compression power-thickness relation curve. WC is the compression energy when a sample is compressed and RC is Resilience.

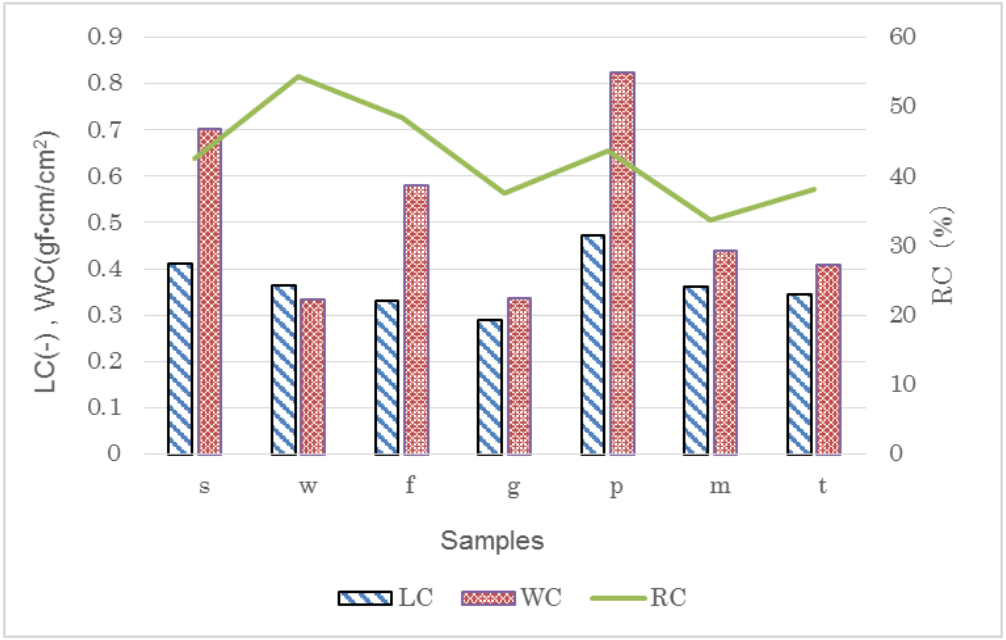

Figure 2: Compression properties measured

Comparing sample G of double gauze to other knitted samples, LC and WC are smallest among all the sample groups. Oppositely sample P that is the knitted fabrics with piles shows largest LC and WC, comparing with other groups. From the measured results of compression resilience RC, wool 1x1 interlock fabrics has the highest RC, then it has high recovery nature after deformed. Plain knitted, mesh, gauze groups show the small RC, then these group fabrics have less recovering ability after once deformed.

5.3. Air resistance and water absorption

Air resistance is smallest for G and M groups and largest for 1x1 interlock group as shown in Figure 3.

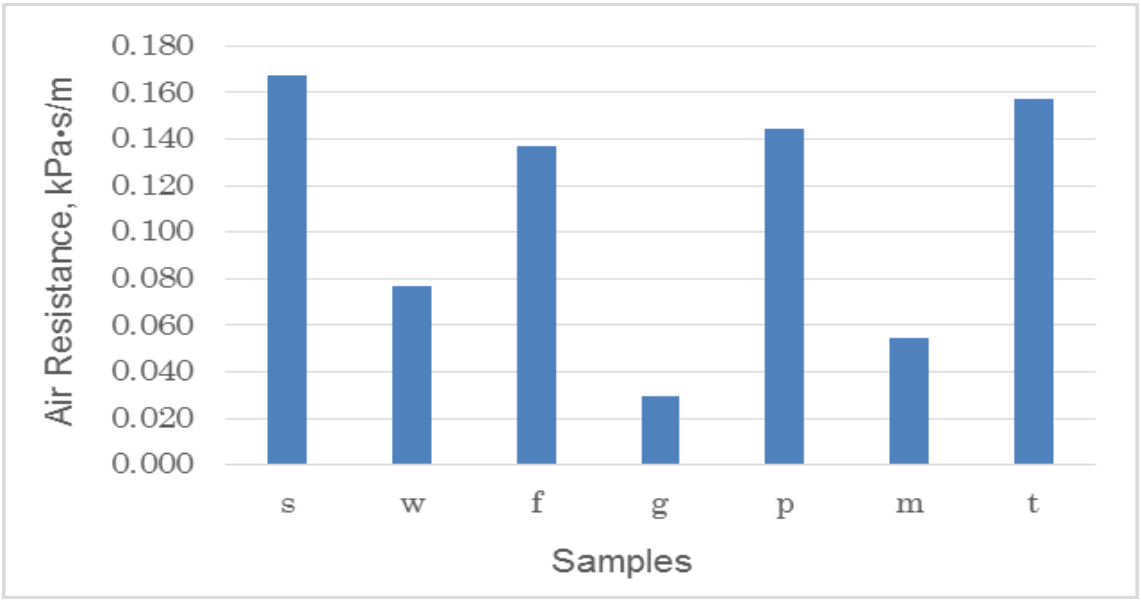

Figure 3: Air resistance

The changes of moisture absorption measured at regular intervals are plotted for four samples of groups, and mesh, and Gauze samples in Figure 5. Samples s7, s8 and w are sold for winter use and the sample s1 and mesh sample m is for summer use.

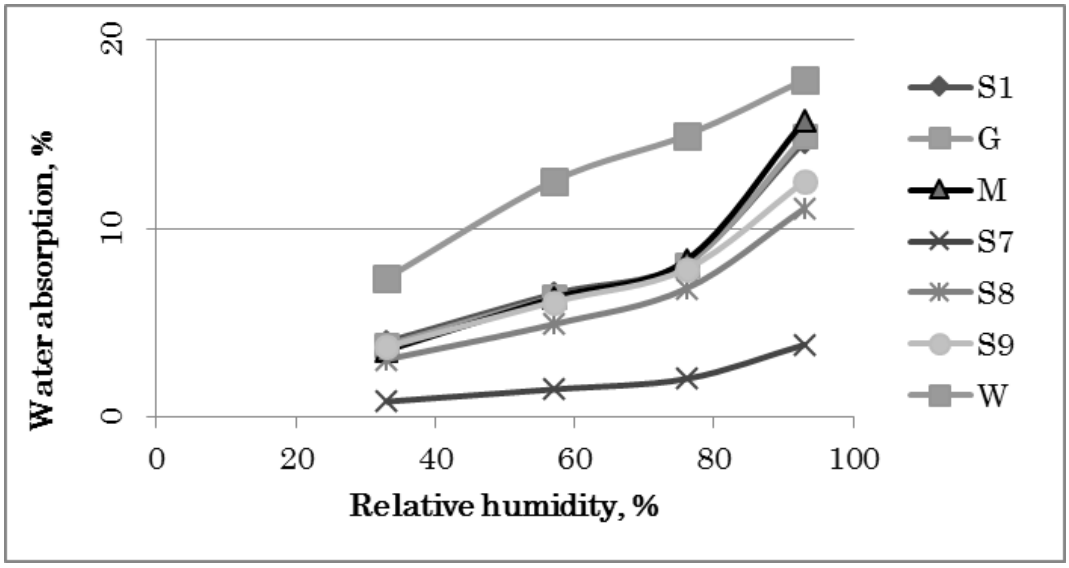

Figure 4: The changes of water absorption

The sample w, which is made from wool 1x1 interlock structure, has the highest water ability to absorb. Wool fiber nature affected this result. The sample s7 shows the lowest ability to absorb moisture. Both mesh and gauze samples indicated the rapid increase of water absorption at more than 80% relative humidity. On the whole, relative thick materials like s7 and s8 is suitable for winter wear and thinner materials m and gauze fabrics is good for summer clothes in Japan. Wool knitted fabrics has a wide range application to every season.

5.4. Sensory test profile

Scores for impression of samples rated by judges in the sensory test are shown for each sample in Figure 5. The seven pairs were thick/thin, soft/hard, warm/cold, stretching/non-stretching, smooth/rough, humid/dry and preferable/not preferable. They are plotted in each figure from sample to sample. Respondents felt that thicker(thinner) fabrics were warner(colder). Samples s7, s8 and s9 were rated as to be very thick and slightly humid. Oppositely, sample m and gauze were estimated as very /slightly thin and slightly dry. For surface touch feeling, samples s1 of cotton fibers provides smooth feeling to respondents.

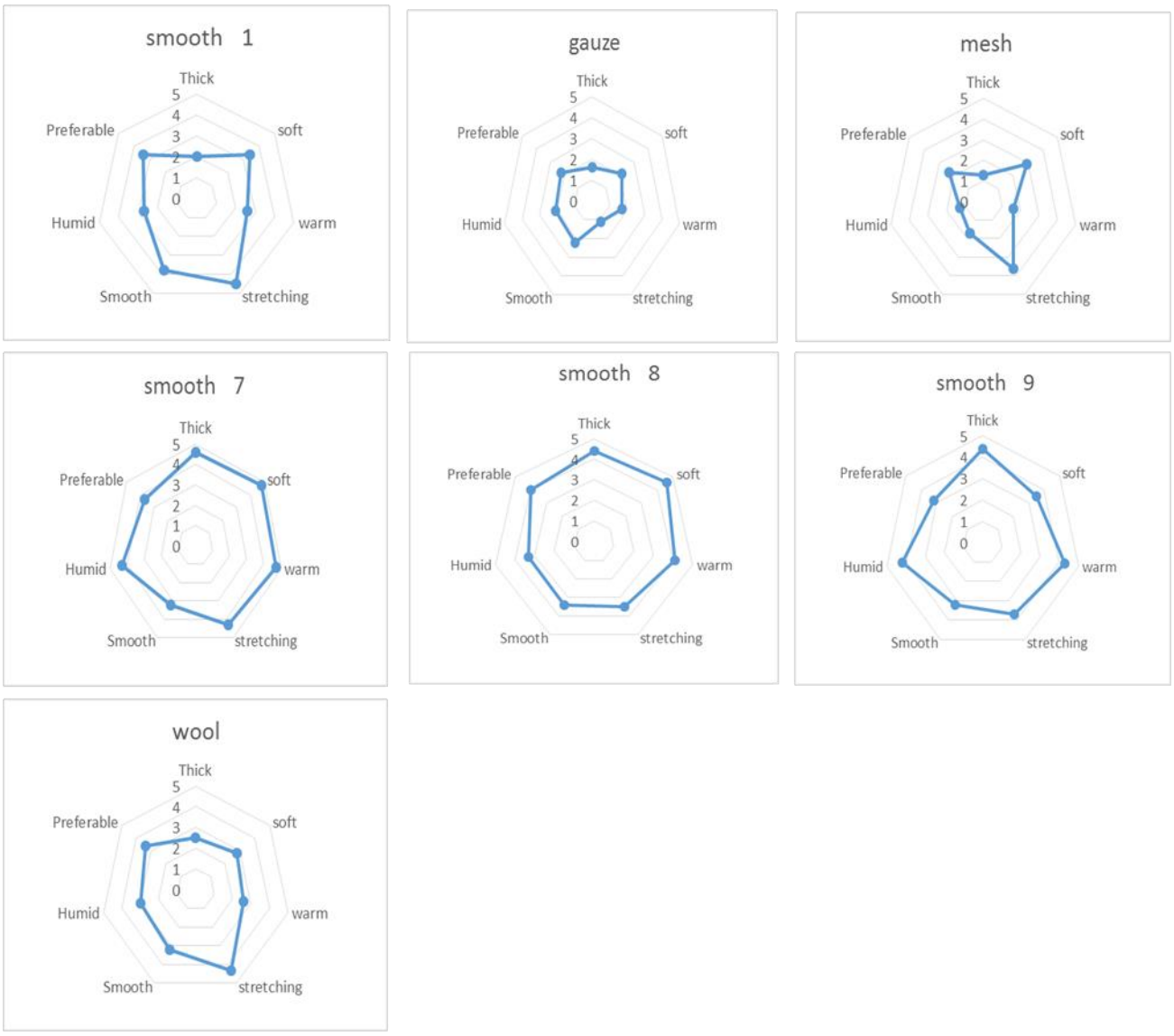

Figure 5: Sensory test profiles

From the result of a survey questionnaire, it is obvious that the require the functions of self wears to be good designed, price and sizes, with wishing baby clothes to be from good materials, comfort and good to act. Good price is required both wears. For consistent fiber sorts, cotton is judged to be suitable in baby's wear. Then we selected typical baby clothes of different structure and consistent fibers. In the experiment, tor those samples, structural property, mechanical property, air and water permeation properties were measured. Results of the experiment were analyzed in relation to that of sensory test. The strong relations were explained in Figure 6.

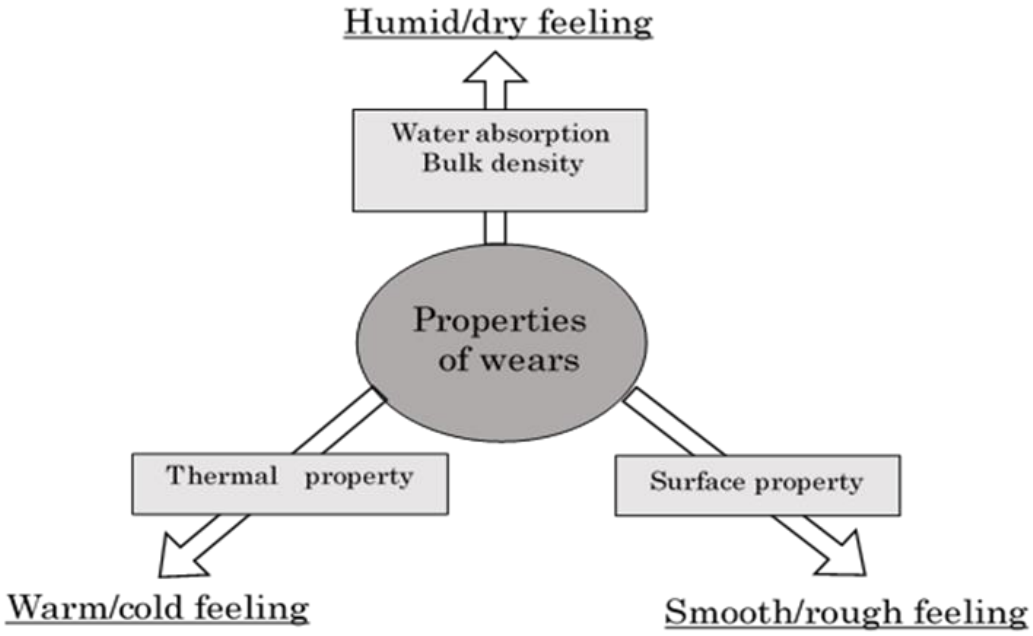

Figure 6: Relation of sensorial feeling and properties of samples measured in the experiment

Correlation coefficient of humid/dry score and water absorption at 93%RH is -0,716; smooth/rough and SMD is -0.588; warm/cold and thickness is 0,936.

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BIOGRAPHY

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Dr. Yoshimi Okamura graduated from the master course of Nara Women's University in 1977. She belonged to several junior colleges in 1977-1999. She has been a professor of Miyazaki University since 2000. Her researches are on i) the drawing and heat treatment on surface free energies of polyethylene terephthalate fibers, ii) Capillary wetting rate in nylon fibrous assemblies and iii) dyeing mechanism of cellulose fibers.

3C - Measurement 1

Establishing Metrics for Kansei Responses: An Approach Using the Rasch Model

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Abstract: Although qualitative comparisons are necessarily part of the process to elicit users' kansei responses to products, they are insufficient to provide a more fine-grained interpretation of users' interaction, which can require a measurement system. However, kansei variables cannot be measured directly. Data obtained from kansei responses need to be transformed by statistical methods and meet measurement assumptions. An approach to validate the quantitative structure of kansei scales is the application of Rasch measurement theory. The Rasch model, which is referred to as a family of probabilistic models, provides mechanisms to test the hypothesis that the observations meet the assumptions for establishing a quantitative structure. In this paper a number of procedures in Rasch modelling are outlined. Different examples from empirical applications using some techniques of kansei engineering show that the establishment of measures for comparisons between individuals and between stimulus objects is not a trivial matter.

Keywords: Kansei Engineering, Kansei Measurement, Rasch Model, Validation

1. INTRODUCTION

In his annual letter for the Gates Foundation on how important measurement is to improving the human condition (2013), Bill Gates used the words from Willian Rosen about steam power (Rosen, 2010). To establish steam power as a powerful invention, innovative ways to measure energy consumed by engines were necessary. Measurement, therefore, allowed inventors and engineers to compare incremental changes, which were expected to lead to improvements in engines. To Gates, there is an important lesson to be learnt from Rosen's observation: "*Without feedback from precise measurement, Mr. Rosen writes, invention is doomed to be rare and erratic* (Gates, 2013)." Gates' understanding on the measurement issue can clearly be identified in current research in a diversity of domains. Precise measurement has therefore extrapolated the domains of natural sciences, such as comparisons between students' performance in education, responses to

treatments for depression in clinical assessments and consumers' satisfaction with regard to products, to mention but a few. Kansei engineering (KE) is not an exception. Applications abound about the notion that more or less of an element affects in different degrees the users' impression with regard to a kansei attribute of the product.

In the process, however, formal measurement cannot be established if too little information is available, usually at the beginning of the development of a new product. In that case, measurement using qualitative tools might take place. This includes pilot studies for identifying unwanted interactions between variables and the relevant construct and qualitative dimensions using statistical tools such as principal component analysis (Barnes and Lillford, 2009). Furthermore, measurement theory characterises that not every property of an observed event can be numerically represented. Under this perspective, kansei responses cannot be established as objective measures if they do not meet measurement assumptions. On the other hand, quantitative properties can be achieved if a relevant scale presents additivity, constant unit and invariant comparisons, which are subjected to theoretical foundation and empirical validation (Andrich, 1988). In other words, scales for kansei words are typically established by convention (e.g., -3 to +3, 0 to 7 or strongly disagree to strongly agree) while the quantitative characteristics are determined by the mathematical model used to their construction.

The purpose of measurement interpreted in this paper is to provide a consistent way to establish a shortened account of responses that people make to express their attitude and feelings with regard to a kansei attribute. The aim of the paper is to outline a novel approach to construct measurement scales for kansei responses underpinned by Rasch measurement theory (Camargo and Henson, 2011), which is commonly referred to as the Rasch model (RM), after the Danish mathematician Georg Rasch who developed it in the 1950s (Rasch, 1960, 1980). The RM is the denotation of a family of probabilistic models associated with latent trait theory in more recent psychometric approaches. Measurement is obtained from a combination between persons' responses and independent variables, called items. The RM's property of separability of the parameters for persons and items allows the design of a range of kansei words or statements that are used as a yardstick in a scale. Furthermore, the separability of parameters allows the comparison between any pair of individuals of a sample independently of the items and the comparison between any pair of items independently of the persons used to establish the scale.

In contrast with more typical data modelling that tries to fit a model to data, the RM's procedures test the data against measurement assumptions. Thus, if kansei data fit the model, it is possible to establish a scale with quantitative properties, referred to as a metric. However, in kansei practice it is very unlikely to find data that perfectly fit the RM. For this reason, most of the procedures in Rasch analysis test the data for anomalies, identifying sources of misfit and to what extent they corrupt measurement.

2. MEASUREMENT ASSUMPTIONS

The assumptions for making measurement possible go side by side with what one wants to make with the values obtained from measuring an object. There is frequently a formal difference between the kind of assignment of numbers originating from different procedures of measurement. For example, one could be interested in the classification of athletes at the finish line of a marathon. This would be possible taking note of the order of each athlete when crossing the line. The assumption here is that the first athlete crossing the finish line is the fastest. However, one could not be able to compare time performances between athletes without a calibrated chronometer. The

assumption for this case would be the fastest athlete spends less time to cover a certain distance. Performance between athletes could therefore be compared by objective measures. In terms of kansei attributes, the measurement assumptions depend on the empirical, qualitative hypothesis that supports the association of the relevant kansei variables with physical properties of a product.

Measurement is fostered in this paper as a way of making meaningful inferences on kansei variables based on the numbers obtained from observed events. The main assumption is that the numbers represent a property of the relevant attribute. That is, a metric must show valid evidence for a one-to-one relationship between the structure of mathematical operations on real numbers and the properties of the attribute that is measured (Krants et al., 1971; Luce and Tukey, 1964).

Another assumption is that a relevant kansei process can adequately be modeled as a systematic element, which is established by the mathematical model over operating conditions, and a random component, which is established by the measurement error associated with the estimation of parameters. This distinguishes the model from more typical approaches in the domain, which fail when conveying information about different source of errors (i.e., systematic and random), providing just one estimate of standard error for all respondents.

3. ESTIMATION OF PARAMETERS

In Rasch modelling the calibration of measures for items and persons is based on estimation of parameters (Wright and Master, 1982). Most of the estimation procedures are based on the method of maximum likelihood (Fisher, 1922). The estimates obtained from this method point to the values of parameters which maximize the likelihood that the observed data would have generated. A benefit of this method is to calculate the standard error for each estimate through a second derivative of a likelihood function (Linacre, 1999).

Estimates of the person locations and item locations are preliminarily made according to the rating scale model (Andrich, 1978) or the partial credit model (Masters, 1982) and then compared with the observations. Estimates are then revised and new estimates are computed. This process of iteration is carried out until the changes of the estimates are smaller than a stopping rule controlled by a convergence criterion. However, the iterative process is laborious, requiring a computer-intensive solution for practical purposes (Camargo and Henson, 2012a). The framework of an analysis can therefore have slight differences according to the software package used. Nevertheless, in general terms, after the estimates have been made, Rasch analysis is carried out to evaluate the extent to which the data fit the model.

4. ANOMALIES IN A DATA SET

Data from kansei responses to product features can present many symptoms of anomaly to fit the model. In KE it is very likely that persons do not give ratings of their entire interaction with products objectively. There will be items preliminary established in a structure that clearly do not fit the model. Redundancy, misrepresentation, misinterpretation, bias and ambiguity are some sources of misfit in items. There will also be cases in which the whole data set presents poor fit because, under the RM perspective, this is an indicative of a structure that is not quantitative. In this case, inferences made from the statistical results cannot be generalised beyond the sample studied and the scores cannot be considered as an element of a measurement structure.

However, there are different degrees of misfit in terms of a measurement structure which is originated from physical interactions with products. These different degrees of misfit ought carefully

to be analysed for items and for persons. For example, if one item is removed from a set because some degree of misfit is identified, the fit statistics will change for all other items. Furthermore, theoretical cut-offs are useful benchmarks although they ought not to be taken as a sole basis to make a decision. In general, such as in physics, misfit ought to be considered an anomaly in the data and substantively investigated.

5. EXAMPLES OF DISCREPANCIES TO THE MODEL BASED ON TWO EMPIRICAL STUDIES

5.1. Validity of the category scoring system

An important source of misfit is associated with the respondents' inconsistent use of the response categories when the scale has more than two response options. The transitions between categories can be interpreted as though there was an independent response for each of the thresholds. This allows the identification of potential problems with the empirical order of categories. If the response patterns are consistent, each response category has a point along the ability continuum where the most probable response is identified.

An example of inconsistent transitions between categories is the item "it is easy to know how much of the product is left in the packaging" taken from a study on containers of some products (Camargo and Henson, 2012b). In the study, 120 participants gave their ratings for five squeezable, everyday products. The scope of the study was to measure the relative importance of the packaging material for obtaining an intuitive impression of a moisturizer cream as a product feature when squeezing its container. Respondents, without seeing the products, used a self-report questionnaire that contained 16 statements based on the understanding of the product context to assess the required kansei attribute for each confectionery. The scale was designed as five-point Likert-style response options, i.e., strongly disagree, disagree, neutral, agree, and strongly agree with associated scores of 0, 1, 2, 3 and 4, respectively. Figure 1 shows that respondents did not use the category system for the item as it was designed by the analyst. The transitions do not discriminate between adjacent categories.

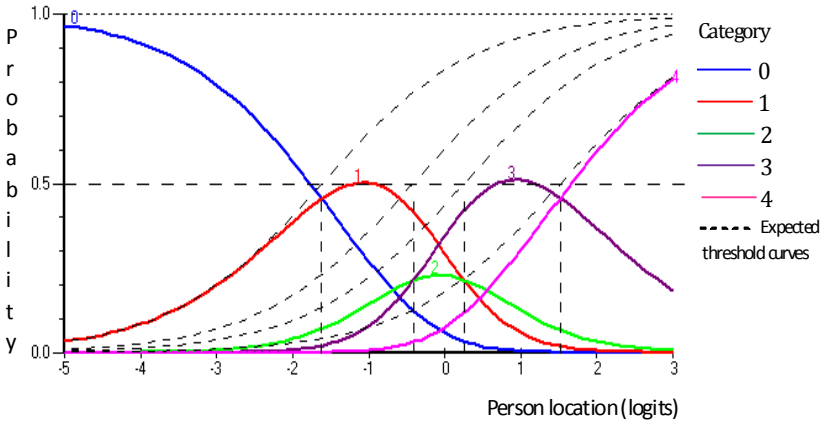


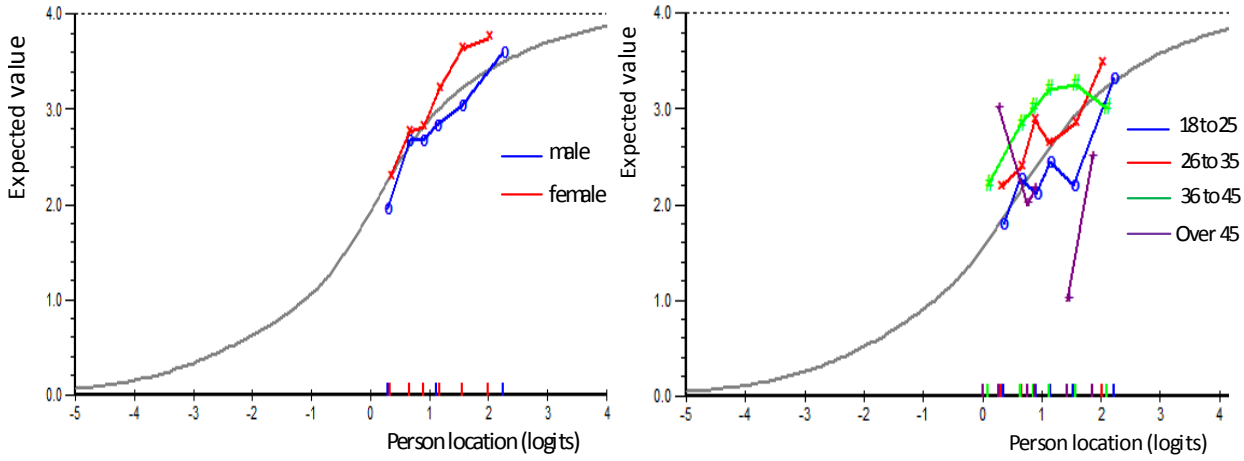
Figure 1: Disordered thresholds of an item from the study on packaging.

5.2. Differential item functioning

Another source of misfit in the data with regard to the model is denoted differential item functioning (DIF) or item bias (Broderson et al., 2007). DIF is presented when a group demonstrates consistently greater inclination to endorse an item than another group. This could be found in male and female groups, social classes, different professional groups, leisure activities groups, different age groups, cross-cultural investigations and cross-national studies.

DIF was, for example, identified in a study on the specialness of confectionery (Camargo and Henson, 2011). In the study, 306 participants gave their ratings for four pieces of wrapped confectionery. Respondents used a self-report questionnaire that contained 24 statements based on the understanding of the product context to assess the required latent attribute for each confectionery. DIF was detected through a two-way analysis of variance, indicating differences of responses between sexes as well as age groups.

Figure 2a shows that female respondents were more inclined to endorse the item “this chocolate is like a little present for me” than male respondents. Figure 2b indicates that the item “this chocolate would be nice during a break from housework” was more difficult to endorse by respondents in the age range from 18 to 25.



(a) (b)

Figure 2: DIF identified in the study on specialness of confectionery for (a) sex and (b) age groups.

5.3. Response dependence

Response dependence is identified when a person’s response to an item in a scale interferes with his or her response to another item within the same scale. Tests for local dependence identify anomalies that do not allow a scale to perform independently. Response dependence can, for example, be found in satisfaction questionnaires where a positive rating of a respondent depends on the responses to the preceding items and where that rating will interfere in the way that the responses on the following items are rated (Wilson et al., 1997).

One technique for assessing those violations is to identify patterns of high correlations among the standardised item residuals. The definition of high correlation can vary according to the context of use of the scale. One of the approaches is firstly to examine items with a coefficient of correlation higher than 0.30 between their standardised residuals (Tennant and Conaghan, 2007).

In the study on packaging mentioned in Section 5.1, for example, the preliminary analysis indicated dependence between the item “the product inside the container would spread easily” and the item “the product in this packaging is likely to flow easily” for one of the stimuli. Although the items were designed to measure two different impressions, the dependence suggests that they are redundant under the respondents’ point of view. Redundant items can mislead inferences or decisions made on account of means and standard deviations. Redundancy has also the effect of inflating reliability indices and item discrimination estimates (Marais and Andrich, 2008).

Another example from the study on packaging is the dependence indicated by a high correlation between the residuals of the item “the container feels only half filled when squeezing it” and the item “I might get a bit watery product in this container”. Apparently, those items are not redundant.

However, both of them presented misfit to the model. This could be a consequence of the absence of independent or relevant information in the context of the study.

5.4. Dimensionality

In Rasch modelling, trait dependence represents the violation of the assumption of unidimensionality in the measurement structure. The violation is identified in scales containing items developed for measuring a single attribute although there are sub-sets of items measuring somewhat different aspects of the attribute. In KE studies, items out of the considered context could stimulate different aspects of the users' experience other than the relevant attribute which an analyst wants to know about. A questionnaire for chocolate could, for example, contain items associated with peoples' affective responses to sharing among friends although the analyst is exclusively interested in the persons' feelings related to specialness.

Another point to be emphasised is that the concept of unidimensionality in the RM refers to independent variables that work well all together in a metric. It is noteworthy that in KE not only the variables ought to work well all together but also concurrently for every relevant stimulus object. An instance of violation of the assumption would be a pool of items that work well for two stimuli although in a different way for each stimulus. This situation can take place if the metric is calibrated individually. The reason is that differences in responses pattern can provoke different score systems across stimuli.

An example of violation of unidimensionality of this type is taken from the study on the specialness of confectionery (see Section 5.2). In that study a pool of 12 items was carefully calibrated for each confectionery separately. The system constituted a sound basis of measurement for each individual confectionery (Camargo and Henson, 2011). However, despite a common set of calibrated items, the stimuli cannot be directly compared through those scales. If the four 12-item scales had worked similarly, the locations of the items on the continuum for the different stimuli would be similar as well, taking into account their measurement errors. Figure 3 shows the results from t-tests between locations of items that belong to scales obtained from independent calibrations for two pieces of confectionery with higher endorsement for specialness. The high number of t-tests that fell out of 95% of the confidence interval indicates that the items drifted into different locations when participants considered the stimuli. That is, the statements in the scales had different interpretations according to the stimulus. One solution to overcome this problem is to use the stimulus objects as an independent parameter using the faceted RM.

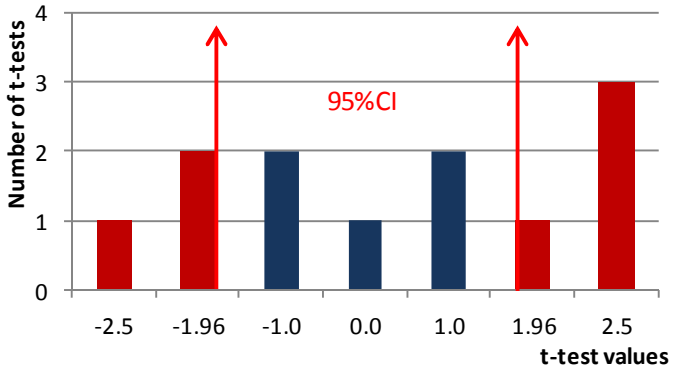


Figure 3: T-tests results from the comparison between two scales for the specialness of confectionery.

6. FUNCTIONING OF A RASCH-CALIBRATED METRIC FOR KANSEI RESPONSES

A derivation of the RM, namely the many-facet Rasch model (MFRM) developed by Linacre (1989), has been adapted by Camargo and Henson (2012b) for applications in KE. A facet is defined as a component or variable of the measurement condition that is assumed to affect the scores in a systematic fashion. There are at least three facets in the particular case of kansei metrics: persons, items and stimulus objects. The facets of the metric are represented by independent parameters sharing the same linear continuum. When such parameters are combined, it is possible to obtain the probability of a person's endorsement to any item for any stimulus.

A metric attains interpretation when the difference between persons as well as between items is established by the distance between different locations. Those differences are interpreted through the adapted MFRM, such that the probability of a response X is obtained by a function f of the locations (Camargo and Henson, 2012b) given by

$$\Pr(X) = f(\beta - \delta + \zeta) \tag{1}$$

where β represents the person parameter, δ is the item parameter and ζ represents the stimulus object. Thus,

1. The person parameter indicates the inclination of endorsement to any item and any stimulus object. That is, the more the readiness, the higher the probability of affirming an item.
2. The item parameter indicates the difficulty of endorsement. An easier item is endorsed by relatively more respondents than a more difficult item. That is, the easier the item, the more likely it will be affirmed.
3. The stimulus parameter indicates the kansei fulfilment. The more the attribute is fulfilled by the stimulus, the more likely it will be endorsed.

Figure 4 displays the generic representation of a metric for kansei responses using the RM. Column Facet 1 represents the persons' inclination of endorsement. Column Facet 2 indicates the difficulty of kansei words or kansei statements and Column 3 represents the fulfilment value or degree of the kansei attribute. It is noteworthy that all facets are on the same linear continuum.

The interpretation of probability of a response is established by the distance amongst a person, an item and a stimulus object. Zero distance amongst them indicates a probability of 50% of agreement. This is the case for Paul at location 0 with regard to Item 1 and Stimulus 4. Taking the same item and stimuli, Mary, David and Juan will have higher probability of endorsement, and Lucy a lower probability if they are compared with Paul.

One important characteristic of a Rasch-calibrated metric is the interpretation based on invariant comparisons. Note that the comparison between Mary and David or Mary and Lucy does not depend on any item in the metric and any stimulus object either. This allows the interpretation that David and Juan share the same degree of agreement with regard to the kansei attribute. Using a symmetric argument the comparison of difficulty between any pair of items and the fulfilment value of the kansei attribute between any pair of stimulus objects can also be made.

The unit in Rasch modeling is the log-odds unit, usually called logit. The logit is the distance on the continuum that indicates changes of the odds of observing the relevant event computed through Napierian logarithm (Linacre and Wright, 1989). The unit in logit denotes the same interval with regard to changes on the continuum.

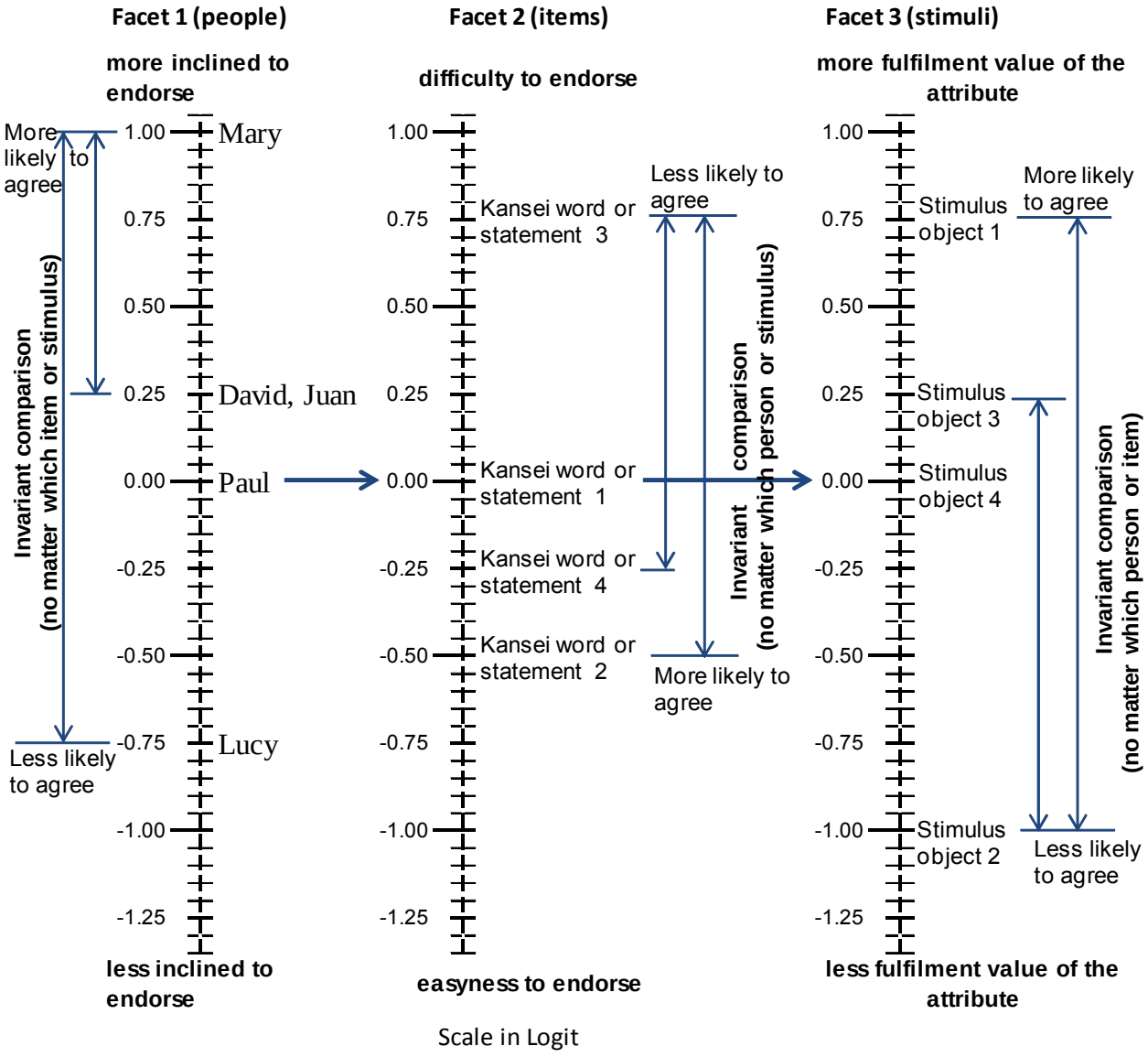


Figure 4: Generic representation of a metric for kansei responses using the faceted RM.

7. IMPLICATIONS

The feasibility of applying a measurement model in KE depends on the aims of an investigation. In the case of simple observations, the assumption could be whether the kansei attribute in a product was absent or present under certain conditions or whether it was manifested to some extent or to a greater extent. In this case, the investigatory observations are qualitative. As a result, the identification and classification interpreted from the data are nominal. On the other hand, if the assumption is that an observed event is better than another, then it is necessary to assign numerical values to those events. The numerical values, in that situation, follow an order for identifying which event will hold more or less of a kansei attribute. Furthermore, if algebraic operations on the numerical values are required, the measurement assumptions, which were briefly mentioned in Section 2, have to be met.

The RM provides theory and procedures to examine how well the kansei data fit together and cooperate to define the attribute being measured. The RM properties are important in KE studies when the consistency or stability of the scores are necessary for testing and comparing other similar

objects using different sample of respondents. Those properties are also important to validate the inferences or interpretations that one makes from the test scores.

Given evidence from studies in different domains of knowledge using the RM, it is possible to envisage that a well-defined scale of measurement has potential applications in many KE settings. Defining subpopulations according to their differences is a far more advantageous approach to manage kansei attributes of a product than an entire population. Nevertheless, users' experience with regard to a kansei attribute is frequently idiosyncratic. Therefore, research taking into account different sub-groups of people, such as cross-cultural and cross-national studies, is strongly recommended for generalising the findings to more worldwide products.

One of the benefits from the application of the RM in KE is to avoid a number of pilot studies using individual variables in test groups. After calibration, smaller samples are necessary to validate results when comparing with typical approaches in the domain. Furthermore, calibrated metrics can measure oscillations in kansei responses to a product as a consequence of contextual conditions throughout the life-cycle of a product.

8. CONCLUSION

In this paper a number of the procedures in Rasch modelling to test a data set for a quantitative structure were outlined. Different examples from empirical applications using some techniques of kansei engineering show that the establishment of measures for comparisons between individuals and between stimulus objects is not trivial. A novel approach to measure kansei responses is the application of the RM. The purpose is to establish a consistent way to interpret and compare a shortened account of responses that people make to express their attitude with regard to a kansei attribute.

One outcome from the application of the RM in KE is the establishment of calibrated metrics. Those metrics have allowed the comparison between any two persons independently of the kansei variables used in a study and the comparison of the any pair of variables independently of the persons used to calibrate the scale. This property is relevant to validate the inferences or interpretations that one makes from test scores.

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Applying the Rasch Model to Measure Kansei Responses to Fabric Seats

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Abstract: This paper is concerned with the empirical development of a scale to measure tactile interaction based on users' experience with fabric seats. Volunteers slid their fingertips over samples of fabric, giving their ratings against kansei statements. Physical interaction was established by the friction coefficient of the contact measured through two different devices. Firstly, a commercially available metallic probe was used. The mechanism is designed to collect data within the frequency range that can be perceived by humans. Secondly, a tactile tribometer using a multiple layer model to mimic human characteristics was used. Scales of measurement were established through the Rasch model. As a result, a linear metric was obtained for samples of fabric, which allowed the alignment of the responses with the physical properties associated with the materials' roughness and coefficient of friction.

Keywords: Kansei Measurement, Evaluation, Rasch Model, Fabric Seats, Friction.

1. INTRODUCTION

The development of new tactile features for fabric of car seats requires better understanding of the kansei attributes associated with the users' experience. However, these underlying attributes solely exist as an element of a premise or a concept, called latent trait or construct, such as attractiveness or pleasantness. Those attributes cannot directly be measured and inferences based on their assessment are error-prone. One solution to overcome the difficulties for a more reliable interpretation of numerical outcomes is to establish theory-driven scales of measurement.

This paper is concerned with an empirical study to develop a scale for users' impressions when they touch samples of fabric using Rasch measurement theory. The construct being measured is the users' distinctiveness of different textures and materials of fabric based on kansei attributes. The aim is to demonstrate that a quantitative correspondence between a scale for kansei responses and a scale for physical characteristics related to the surfaces' roughness can be established.

Physical interaction with the pieces of fabric was conceptualized in the study by the friction coefficient obtained through two mechanical devices designed for simulating the human fingertip friction. One of the mechanisms was a commercially available metallic probe designed to collect data within the frequency range that can be perceived by humans. The other mechanism was a tactile tribometer designed to mimic human characteristics. We adopted this approach to obtain frictional forces instead of touch-feel data from real people because a mechanical device could serve the purpose of a useful benchmark (Shao et al., 2009). It is noteworthy that the devices were used as two different alternatives to collect physical data. Nevertheless, the comparison of performance between the two devices was not part of the study's scope.

In the investigation we used techniques based on kansei engineering to establish stimulus statements (Nagamachi, 2008). Kansei responses were subsequently transformed into objective measures using a rationale based on the Rasch model (RM) (Andrich, 1988). Objective measures are obtained when the comparison between a pair of variables is independent of the particular sample of persons taken as instrumental and the relative difference between any two persons is independent of the relevant variables taken as elements of comparison (Andrich, 1988). The RM refers to a family of probabilistic models that provide mechanisms to test the hypothesis that the observations meet the necessary assumptions for objective measurement.

The results have suggested that objective measures can be established for fabric seats after calibration of the scales. Furthermore, the calibrations developed in the research allowed the association of the coefficient of friction (COF) and characteristics of roughness of the materials with the kansei responses based on users' experience.

2. KANSEI RESPONSES

Different aspects of the materials used in fabric of car seats ought to be considered when developing new features. One of them is the contribution of sensory information from the physical contact along with the users' impressions of an underlying attribute of the product, called kansei responses in this study.

The most common framework for eliciting kansei responses to design elements is to identify adjectives that people use to describe the product and embody them into self-report questionnaires. A number of consumers are asked to give a rating of the degree to which each word describes a range of products. The responses to the questionnaires are turned into a measure of kansei responses using statistical techniques such as principal component analysis (PCA).

However, such procedures aggregate a considerable amount of inaccuracies in the measurement process. Inaccuracies can in many cases be associated with biased scales influenced by differences of sex, age groups and cross-cultural preferences, difficulty in establishing equal interval in scales, and qualitative dimensions identified in a study, which are subject to circumstances of sampling (Camargo and Henson, 2012). Consequently, it is difficult to interpret the results beyond the considered sample, limiting the understanding of a more general human–product interaction.

2.1. Measurement of kansei responses using the Rasch model

Although less familiar than the classical statistical approaches, Camargo and Henson (2011) have demonstrated that the RM can succeed in dealing with some shortcomings associated with the inaccuracies in the kansei measurement process. Following the Rasch modelling approach, persons' responses are turned into objective measures by calibrating a scale with targeted kansei words or statements established as a yardstick.

The RM is a probabilistic approach that yields interval measures and examines the alignment of those measures against scientific measurement principles based on additivity, a constant unit and invariant comparisons. The RM predicts response probabilities from two independent parameters, one for estimation of ***items***, referred to as kansei words or statements henceforth, and another one for estimation of persons on the same scale.

The model embodies two key assumptions. The first assumption is that the response of a person to an item must not interfere with his or her response to another item within the same scale. The second assumption is that the scale ought to be unidimensional.

A number of RMs have been used in different applications. Camargo and Henson (2012) have adapted for applications in KE the many-facet Rasch model developed by Linacre (1989). Thus, assuming that the data fit the model, it is possible to transform a categorical scale into an interval level with the logit as unit of measurement.

3. METHOD

A two-stage experiment was designed to demonstrate the quantitative correspondence between users' kansei responses and physical characteristics of some pieces of fabric. The first stage was used for calibrating a kansei metric and the second stage for collecting physical data.

We firstly established a preliminary pool of words to express the users' experience associated with touch. Based on the understanding of the product context, 98 kansei words were obtained from catalogues of manufacturers, online consumers' reviews, advertisement and scientific literature. Subsequently, we selected a pool of 15 statements as relevant to the application (Table 1).

Table 1: Preliminary pool of kansei statements.

Code	Kansei statements (items)	
1	This is a smooth fabric	滑らかである
2	This fabric feels elastic	弾力性がある
3	This fabric is soft	やわらかい
4	This fabric feels warm	暖かみがある
5	This fabric feels wet	湿り気がある
6	This fabric feels relaxing	落ち着いた感じがする
7	I think this fabric is functional	機能的だと思う
8	This is a high quality fabric	高品質である
9	This fabric might be cheap	安っぽく感じる
10	I think this fabric is artificial	人工的だと思う
11	This is a simple fabric	シンプルである
12	This fabric is modern	モダンである
13	I think this fabric is unique	特徴的である
14	I think this fabric is familiar	馴染みやすい
15	This is a pleasant fabric	快適である

We selected five samples of fabric with the dimensions of 150mm x 150mm according to the material and characteristics of the surface (Table 2). A barrier was used to prevent visual contact of respondents with the samples. We asked participants to dry their fingers. They were also instructed through a demonstration to slide their index fingertip applying just sufficient force and slow speed (~10 mms^{-1}) to feel the sample (Figure 1).

We collected data from 96 participants, 94.8% males, 50% in the age range from 18 to 35 and 50% over 35. The size of the sample was established according to the stability of the metric assuming a measurement error of 0.5 logit at 95% level of the confidence interval (CI). The participants gave ratings of their endorsement based on a five-point scale (i.e., strongly disagree, disagree, neutral, agree, and strongly agree) using computer-based self-report questionnaires (translated to Japanese language).

Table 2: Selected fabric samples

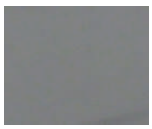
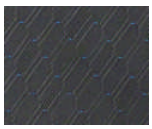
Code	Fabric 1	Fabric 2	Fabric 3	Fabric 4	Fabric 5
Fabric					
Material	Artificial leather	Woven (warp knit)	Non-woven	Woven (Knit added emboss decoration)	Woven (plane weave)
Thickness (mm)	0.37	1.60	1.23	0.81	1.10
Roughness (μm)	1.51	1.89	1.81	4.57	4.10



Figure 1: Test lay-out.

3.1. Coefficient of friction and roughness for the samples using a metallic probe

Measurement of friction force using a metallic probe (Kato tech Co. Ltd., model KES-SE®) was carried out through a mechanical unit, an amplifier and a computer program. A ring type load cell with differential transformer was used to collect data through a friction sensor with loading area of 100mm^2 (Piano Wire-STD) (Figure 2). The measurement speed of 0.5mms^{-1} was established for the test. A base of polyurethane foam with thickness of 3mm was used beneath each sample of fabric with dimensions of 150mm x 150mm.

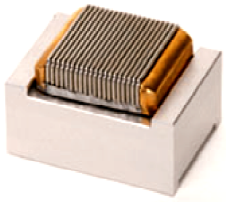


Figure 2: Sensor used with the Friction Tester KES® (Kato tech Co. Ltd.)

The materials' roughness was obtained using the KES® system. The readings were used for the graphical correspondence with kansei responses and COF for both systems, the friction tester KES® and the artificial fingertip.

3.2. Coefficient of friction for the samples of fabric using an artificial fingertip

A multiple layer model was used to mimic the human's fingertip sensitivity. The outer layer is an encapsulated silicone with a thin polyurethane layer to represent skin. The inner layer is a combination of silicone gel base and elastomer to represent soft tissue. To support the fingertip and simulate the bone, there is a hard core at the back of the artificial fingertip (Shao et al., 2010). The testing system to measure the friction force between the fingertip consisted of a two-axis load cell, an X–Z motion table, an artificial fingertip, a controller and a software program using a National Instruments LabVIEW® system (Figure 3). The artificial fingertip was fixed to the motion table and was slid over the samples of fabric using speed of $10mms^{-1}$. The average of four readings for each piece of fabric was computed along with their standard error.

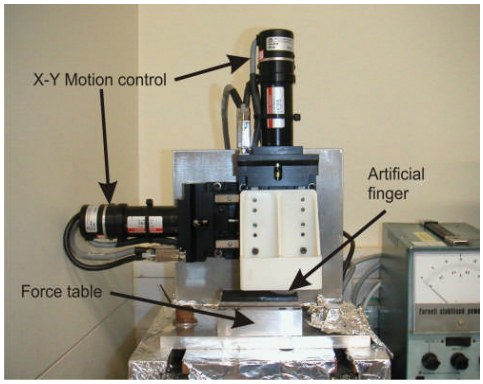


Figure 3: Finger friction tribometer (Shao et al., 2010).

3.3. Rasch analysis of kansei responses

Calibration of the measurement scale for kansei responses was carried out through the faceted Rasch model using the software package RUMM2030®. Throughout the analysis we investigated sources of misfit to the model, such as respondents' inconsistent use of the response categories and differential item functioning for age groups (whether a person subgroup demonstrated consistently greater ability to endorse an item than another subgroup). Furthermore, we tested the assumption of response independency through of the degree of correlation in which the response to an item determined the response to another item.

Different indices were used as quality control for calibration of the measurement scale. One of them was obtained through the item-construct interaction using chi-square statistic, which indicated the degree of invariance across the construct (Andrich, 1988). The statistic was taken from the differences between the observed scores of all persons at 95% of the CI and their theoretical values based on the model. Non-significant variance across the construct was given by $p \geq 0.05$. Another

quality control was the analysis of fit statistics for the person and item interaction with the model. Those statistics represented the residuals between the expected values by the model and the observed values obtained for each person computed over all items and for each item computed over all persons. The residuals were firstly transformed into a z-distribution. The perfect fit would be indicated by a mean of the residuals equal to zero with standard deviation (σ) of one. In practice, however, we can only obtain an approximation from a perfect fit. Thus, an item-person interaction with fit residual statistic indicating $\sigma \leq 1.40$ was deemed acceptable in this study. Individual person and item deviations from the model were indicated as chi-square statistics. Residuals $\geq \pm 2.5$ indicated misfit to the model, representing around 99% of the CI (Pallant and Tennant, 2007).

Test for multi-dimensionality indicated whether the variables were measuring different underlying kansei constructs. We formally tested the dimensionality of the construct through PCA of the residuals, determining two subsets according to the pattern of first factor loadings. Using paired t-tests we examined the difference between person estimates for the two subsets. We deemed the construct as unidimensional when a proportion of the t-tests ≤ 0.05 fell outside of the t-range of ±1.96 for the CI (Tennant and Conaghan, 2007).

4. RESULTS

4.1. Calibration of the metric

Data from the preliminary pool of items were initially tested, indicating inconsistent response patterns and, therefore, the system was re-scored into four categories. The response categories of Item 9 were additionally recoded by applying reversed order. That is, the statement "*This fabric might be cheap*" held an opposite vector when comparing with the other items in the pool, according to the preliminary analysis of the data.

Decision criterion to remove five items from the analysis was based on individual item-fit and high positive correlations of item-person residuals. The procedures for deletion of items can be traced throughout the sequence of calibrations (Table 3).

Table 3: Summary of the calibration steps and fit statistics

Calibration	Source of misfit	Action	Person-item interaction				Item-construct interaction			n	Unidimensionality
			Item-fit residual		Person-fit residual		χ^2	df	*p*		Proportion of t-tests ≤ 95% CI
			Mean	σ	Mean	σ					
1	Item misfit (residual ≥ ±2.5)	Remove 9 (cheap)	0.33	0.86	-0.21	1.26	85.81	28	<0.05	96	>0.05
2	High correlation (unique on artificial and smooth)	Remove 13 (unique)	0.35	1.11	-0.19	1.21	89.75	26	<0.05	96	>0.05
3	Item misfit (residual ≥ ±2.5)	Remove 10 (artificial)	0.35	1.00	-0.17	1.14	46.27	24	<0.05	96	>0.05
4	Low chi-square probability (high variance)	Remove 5 (wet)	0.32	0.94	-0.20	1.12	31.11	22	0.094	96	>0.05
5	Low chi-square probability (high variance)	Remove 12 (modern)	0.32	0.83	-0.21	1.09	19.15	20	0.512	96	>0.05
6	Person locations t-tests < 95%CI	Remove 5 persons	0.33	0.82	-0.21	1.09	20.01	20	0.460	91	0.04

The metric is the representation of the relative locations of all facets on the same logit scale (Figure 4). In the metric, person locations are indicated in the first column. The relative locations indicate ordered levels of endorsement to the samples of fabric. The second column of the metric indicates the levels of difficulty of endorsement for items. Column Fabric presents the relative location of the samples of fabric on the continuum. Locations, standard errors of measurement and fit residuals are indicates in Table 4.

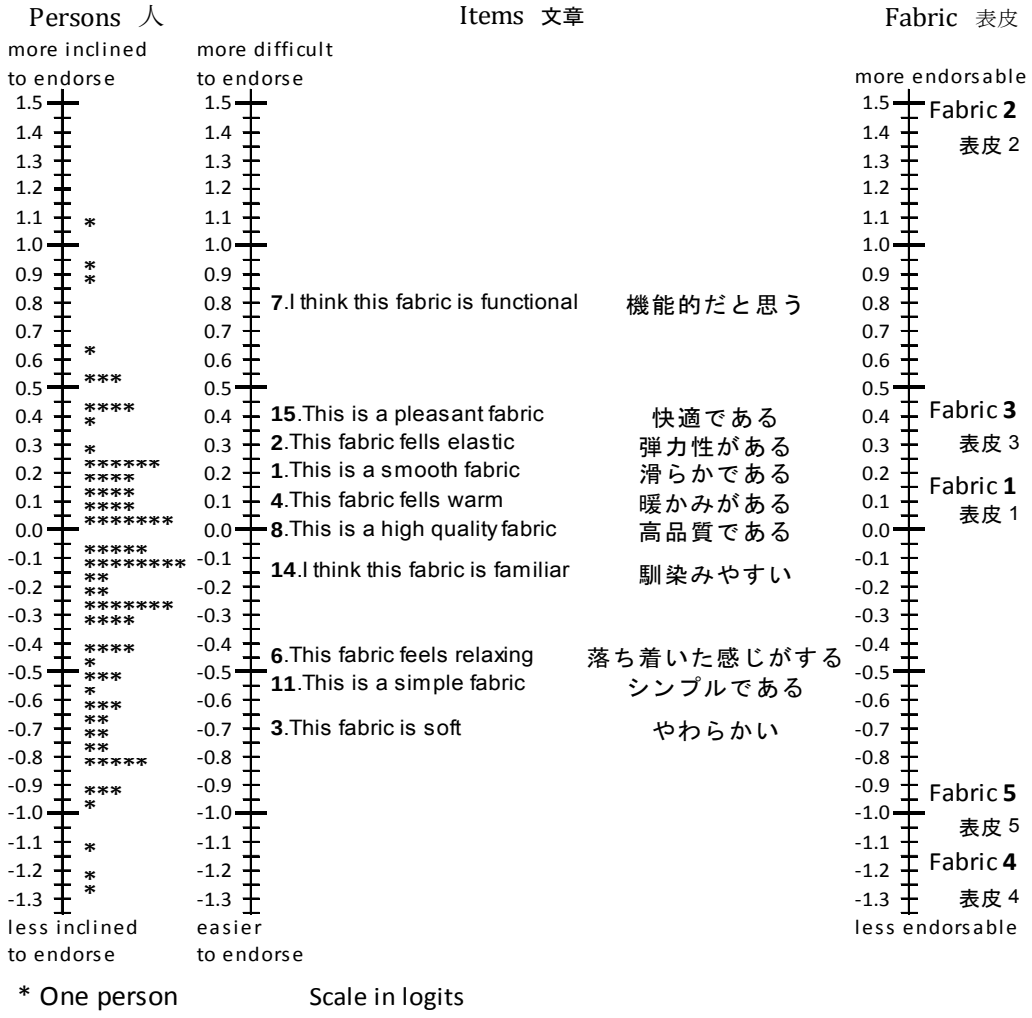


Figure 4: Metric with 10 calibrated items for the five samples of fabric

4.2. Relationship between kansei responses and friction

The metric for persons' kansei responses and the coefficient of friction for the samples of fabric were, in this study, designed to share the physical characteristic obtained from the texture of surfaces (roughness). The correspondences were established according to the method adopted for computing the coefficient of friction.

4.2.1. Correspondence using KES® system

Figure 5 is a graphical representation of the correspondence between the metric for kansei responses and the KES® system used to obtain the measurement of the forces f_x and f_y , such that $\mu = f_x / f_y$ represents the coefficient of friction. The linear metric for kansei responses, represented by the vertical axis at the upper part of the graph, was obtained from Table 4. The

Table 4: Locations in logits of items and fabric and their measurement errors

Items	Location	SE	Fit residual	Fabric	Location	SE
3	-0.71	0.16	0.01	2	1.50	0.18
11	-0.56	0.17	0.35	3	0.43	0.17
6	-0.45	0.18	0.03	1	0.16	0.18
14	-0.16	0.18	0.17	5	-0.92	0.17
8	0.05	0.17	0.40	4	-1.16	0.18
4	0.18	0.18	0.06			
1	0.28	0.16	-0.06			
2	0.28	0.18	0.27			
15	0.30	0.19	0.07			
7	0.79	0.19	0.05			

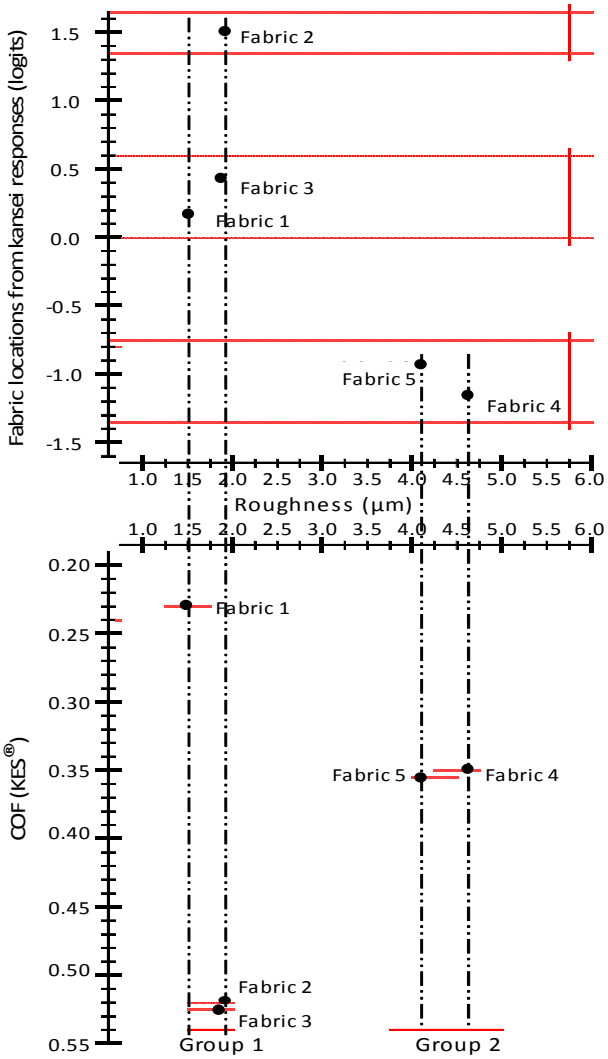


Figure 5: Representation of the overlapping metrics for kansei responses to samples of fabric and the COF obtained through the KES® system, both the metrics sharing the physical element roughness.

dashed, red lines indicate the location of a sample plus the standard error (SE). Samples were grouped when their SE overlapped. Three groups under this condition were established as follows: Sample 2, group formed by Samples 1 and 3 and group formed by Samples 4 and 5.

The roughness levels (R_a) are indicated by the horizontal axis. The vertical dashed, black lines indicate the bounds of roughness for samples based on the kansei responses. However, only one reading of roughness was obtained for each fabric and, therefore, the measurement error was not computed in the study. Two groups were formed: the group formed by Samples 1, 2 and 3, and the group established by Samples 4 and 5.

The lower part of Figure 5 represents the correspondence between the coefficients of friction and the locations of samples on the kansei continuum. However, only one reading of friction force was obtained for each fabric and, therefore, the measurement error was not computed in the study. Two groups of kansei responses associated with the roughness can be established: Group 1 formed by Fabric 1, 2 and 3 with roughness between 1.51µm and 1.89µm, and Group 2 formed by Fabric 4 and 5 with roughness between 4.10µm and 4.57µm. However, a range of COF was not identified within the discrimination of kansei responses.

4.2.2. Correspondence using the artificial fingertip

Similarly, a graphical representation of the correspondence between the metric for kansei responses and the artificial fingertip system was established (Figure 6). At the upper part of Figure 6 the horizontal dashed, red lines indicate the lower and upper bound of kansei responses that can be associated with the interval of COF indicated at the lower part of the graph by the dashed, red lines. The red lines indicate the location of a sample plus the standard error (SE). Samples were grouped when their SE overlapped.

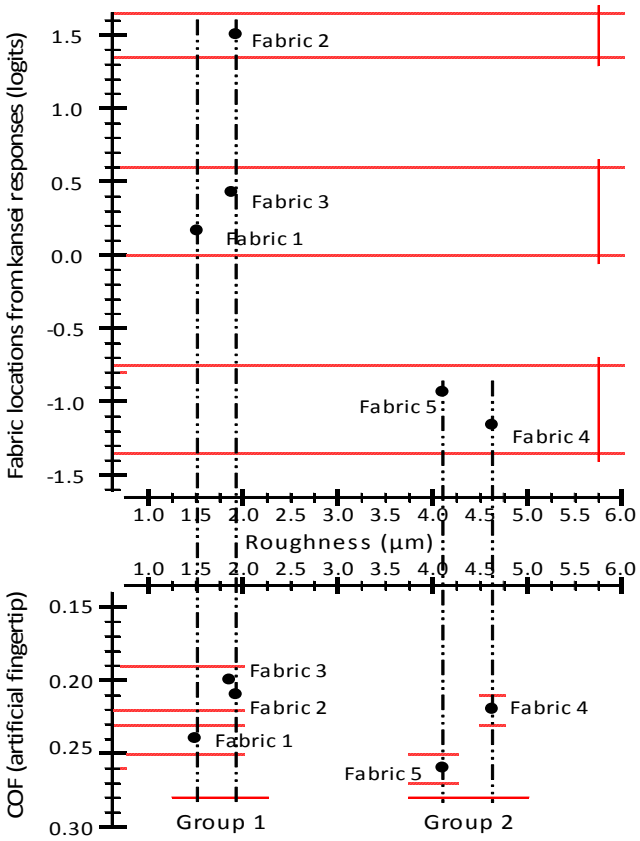


Figure 6: Representation of the overlapping metrics for kansei responses to samples of fabric and COF obtained through the artificial fingertip, sharing the physical element roughness.

Two groups of kansei responses associated with the roughness can be established: Group 1 formed by Fabric 1, 2 and 3 with COF from 0.20 to 0.23 using the artificial fingertip and with roughness between 1.51μm and 1.89μm, and Group 2 formed by Fabric 4 and 5 indicating COF from 0.22 to 0.26 using the artificial fingertip and with roughness between 4.10μm and 4.57μm.

5. DISCUSSION

The relationship between the kansei responses, the characteristic of roughness of each sample of fabric and its coefficient of friction has been made possible by overlapping the metrics. The metrics are assumed to be linear because all elements can be represented as fixed positions along one straight line. For the kansei responses, the linearity of the scale is a property of the RM. We used the procedures from Rasch analysis, called calibration, to verify empirically whether the data were conformed to the model, which allowed the control of variance and traceability in the study.

The sequence of calibrations using the RM produced a scale for some samples of fabric with a quantitative property. This property was achieved after fitting data to the model. In more typical statistical approaches in the domain, which fit a model to the data at hand, the assumption that data hold at least interval properties ought to be tested and not just assumed. The theoretical foundations of the RM, in contrast, provided mechanisms to examine whether the data fitted together and cooperated to define the kansei differences among the samples of fabric. Two of the main sources of misfit in the data set were the response dependence (i.e., when an item interfered with the response to another item) and the construct dependence (when the kansei statements represented more than one construct). After resolving for the misfits, an interval scale in logit was produced.

The log-odds unit, typically called logit, was the unit of measurement used by the model. Scores, which were transformed into locations in logit on the continuum, attain meaning when comparing a pair of persons, items or stimuli through the distance between locations. Ben Wright (1993) once stated the logit for latent variables is not more difficult to understand than the unit ampere for electric current. They not only measure an invisible, underlying variable but also they present the property of invariant comparisons. As a result from this property, particular differences between any pair of persons and any pair of samples of fabric have the same interpretation across the scale. Furthermore, if the calibrated items are fixed at their locations, estimates for a new reasonably targeted sample of persons can be obtained and valid comparisons can be established. Similar reasoning can be elaborated with regard to the samples of fabric.

6. CONCLUSION

In this research we investigated the users' impression with regard to different textures and materials of fabric for car seats. The purpose was to demonstrate that distinct impressions could be measured by a scale based on kansei attributes.

We collected kansei responses from a number of persons who slid their fingertips over some samples of fabric. Ten kansei statements fitted the Rasch model, establishing a calibrated scale for persons' responses. Subsequently, kansei responses were associated with the roughness of the fabric's surface and its coefficient of friction. We obtained the coefficients of friction using the KES® system and an artificial fingertip, simulating the contact between the human fingertip and the surfaces. Nevertheless, the comparison between the devices' performance was not part of the study's scope. Using a graphical correspondence, two ranges of roughness that could be associated with the

kansei responses were identified. Furthermore, through overlapping metrics we distinguished two ranges of coefficients of friction related to the responses when using the artificial fingertip. However, no coefficient of friction brackets for the groups of kansei responses were found when using the KES® system.

The calibration procedures gave evidence that part of the data fitted the Rasch model, producing a linear scale for the kansei responses and achieving the model's property of invariant comparisons. That is, particular differences between any pair of persons and any pair of stimulus objects have the same interpretation across the scale. Users' distinction of different textures and materials of fabric can, therefore, quantitatively be made independently of any particular kansei attribute.

The model's properties of invariant comparisons, same interval for the linear continuum and a constant unit in logit were achieved for the scale of fabric based on kansei attributes. As a consequence, we demonstrated the construction of the quantitative correspondence between the scale for kansei responses and the scale for physical characteristics related to the surfaces' roughness and coefficients of friction.

ACKNOWLEDGMENTS

This research was supported by an agreement between Toyota Boshoku Corporation through the Internship Program and the University of Leeds. The authors gratefully acknowledge use of the facilities of the Division of Evaluation and Engineering in Japan.

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OCC model: application and comparison to the dimensional model of emotion

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Abstract: This paper presents a review and comparison between the model of cognitive structure of emotions (also known as OCC) and the dimensional circumplex of core affect for consumer products. The numbers of emotion types in each emotion group of OCC is compared and associated to those of circumplex of product emotion. Prospect-based group represents the highest number of emotions in the circumplex followed by well-being, Fortune-of-others, and well-being/attribution-compound group. Considering that the addressed circumplex originally targeted emotions generated by products' appearances and the prominent presence of prospect-based and well-being emotions on the circumplex, it is concluded that people judge the personal benefits of using products (consequences of events for self, in OCC terms) by their appearance. That is also confirmed by the eminent representation of attraction emotions on the circumplex, demonstrating the effect of visual aesthetics (as a product aspect) on attraction. Some of the differences between the two models were also established. It is asserted that OCC model uncovers the antecedents of emotions subscribing to the adapting function of emotions as a coping mechanism with the world while dimensional model is concerned with describing the nature of emotions and their dimensions. The significance of each model for the design practice is therefore determined by the design purpose in addressing emotions and the context of use.

Keywords: Emotion, OCC model, Circumplex of core affect, dimensional model.

1. INTRODUCTION

A major part of our everyday experiences in interaction with people, objects or situations is emotions. Emotions are considered to signal a person about their surrounding and motivate appropriate responses to situations (Frijda, 1986). Therefore they are necessary informants for our wellbeing, our everyday experiences and even cognitive processes (Schwarz and Clore, 1983; Ortony, Clore and Collins, 1988). Our enjoyment in using products or services is often attributed to the pleasant emotions that they generate and vice versa, our negative reactions entail negative emotions. Consequently it comes as no surprise that a lot of research in the field of product and interaction design is dedicated to the study of emotions and feelings (Desmet, 2008; Demir et al., 2009; Thüring and Mahlke, 2007, to name a few), measuring them (Desmet, 2005) and investigating their association with positive and pleasurable experiences (Jordan, 1998; Desmet, 2012). Recently, Desmet (2012) investigated 25 product-evoked positive emotions (e.g., confidence, desire,

fascination, etc.) and their six sources including object-focus, activity focus, meaning focus, etc. With regard to interactive systems, Agarwal and Meyer (2009) argued that emotional responses are central to user's overall judgment of the experience and perceived usability. Mahlke and Lindgaard (2007) similarly linked the perception of instrumental qualities of interactive products (e.g. usability) to emotional reactions.

One of the main concerns in emotion studies is its evaluation. In order to design products and interfaces which generate positive emotional responses, one must be able to understand the nature of these responses. In order to improve those designs, one must be able to evaluate those responses as well (Sacharin et al., 2012). Here we are faced with two issues, first to describe the process underlying emotions and second, to evaluate them.

A number of emotion theories were advanced in the past leading to development of a number of evaluation techniques for measuring emotions. This paper does not intend to provide a comprehensive review of all available emotion theories. Instead, it offers an overview and comparison of two theories that are selectively recognized as useful in the field of design and product development. The first is the model of *cognitive structure of emotions* by Ortony, Clore and Collins (1988) (the model is simply regarded as OCC model in this document) which was further adopted by Desmet and Hekkert (2002) for product emotions. The second is the dimensional model of emotions namely *Circumplex of affect for consumer products* developed by Desmet (2008) as a basis for designing PrEmo (Desmet, 2005), a tool for evaluating product emotions. The aim was to compare the above and determine their similarities and differences.

1.1. Emotions

Before starting a discussion on emotion theories and evaluation techniques, it is important to first establish a definition for emotions. Ortony, Clore, and Foss (1987) provided an operational definition which described emotions as internal, mental states which are elicited when people react to an ongoing situation that is perceived good or bad for their concern. Clore, Schwarz and Conway (1994) mentioned that this characterization is not sufficient because it does not distinguish emotions from other affective states such as moods. They performed an overview of a number of related definitions and concluded that emotions also need to be focused on something (for instance an object, e.g., proud *of* someone, distress *about* something, etc.), deal with present time (rather than future or past) hence short term reactions and that cognitive processes (also known as appraisal) are integral parts of emotions. Later Ortony, Clore, and Collins (1988) defined emotions as valenced reactions (i.e., an affective reaction based on the perceived goodness or badness of things) and asserted that an emotion is determined by how the eliciting situation is understood by a person. This definition and the OCC model that followed categorizes emotions based on their focus (i.e., what emotions are about) and their exclusive appraisal patterns.

A number of researchers emphasized that emotions involve a level of physiological arousal (Russell, 1980, 2003; Ortony, Clore, and Collins, 1988; Yik, Russell, and Steiger 2011). Scherer (2005) have considered emotions as a multi-component phenomenon involving cognitive component, physiological reactions, motivational changes, motor behaviors, and subjective feelings, all of which take part in forming an emotional experience. Sacharin et al. (2012) regarded the feeling component as the central component of emotions which is inherently subjective and accessible through self-reports.

It seems that most researchers agree on some underlying factors of emotion which could be summarized as follows; first, emotions are elicited in reactions to our surrounding environment meaning they have a particular focus, second, they involve subjective feelings that are available to a us on a conscious level, third, they involve an appraisal process, i.e., an assessment of the benefits or harms of the situation for our personal concerns, forth, they involve physiological reactions (e.g. arousal). The OCC model and dimensional theory of emotions each rely on some of these factors in describing emotions and so an overview of these two models is necessary.

1.2. OCC model

OCC model, similar to most cognitive views (e.g. Arnold, 1960; Lazarus, 1966; Scherer, 1984), considers emotions to arise from affective or valenced reactions (i.e., subjective feelings) subsequent

to the appraisal of a stimulus as being beneficial or harmful to one's concern (Ortony, Clore, and Collins, 1988). The model differentiates and categorizes emotions based on their underlying appraisal patterns, i.e., the cognitive structural logics a person employs for evaluating the situation. Those patterns involve the person's focus at the time, their concern, and their appraisal preceding an affective reaction. The main building blocks of OCC model are summarized in Figure 1.

As shown in the model, a person could alternatively have three types of focus which are consequence of events, actions of agents, and aspects of objects. Once one evaluates the significance of those for their personal concern, an affective reaction is elicited resulting in an emotion. Various combinations of these elements create specific patterns demonstrating six main groups of emotions, each comprising several emotions types. All emotion types in a group share the same unique cognitive pattern.

Emotion groups are *fortune-of-others, prospect-based, well-being, attribution, well-being/attribution-compound,* and *attraction*. In total, the model introduces 22 emotion types accounting for all ranges of human emotions. These emotions are introduced each as a representative of a family of similar emotions with various intensities. The reason is that Ortony and colleagues speculated that relying on a list of discrete emotions that is understood by everyone equally is impossible due to language barriers and people's different interpretations of a word. As an example, emotion *happy* may be referred to by other emotion terms for instance cheerful, glad, delighted or other similar terms but they all share the same eliciting conditions. Thus the emotion types used in the model (e.g. resentment, joy, pity, etc.) are meant to represent an emotional experience rather than a lexical or folk taxonomy. The emotion groups are discussed in more details below.

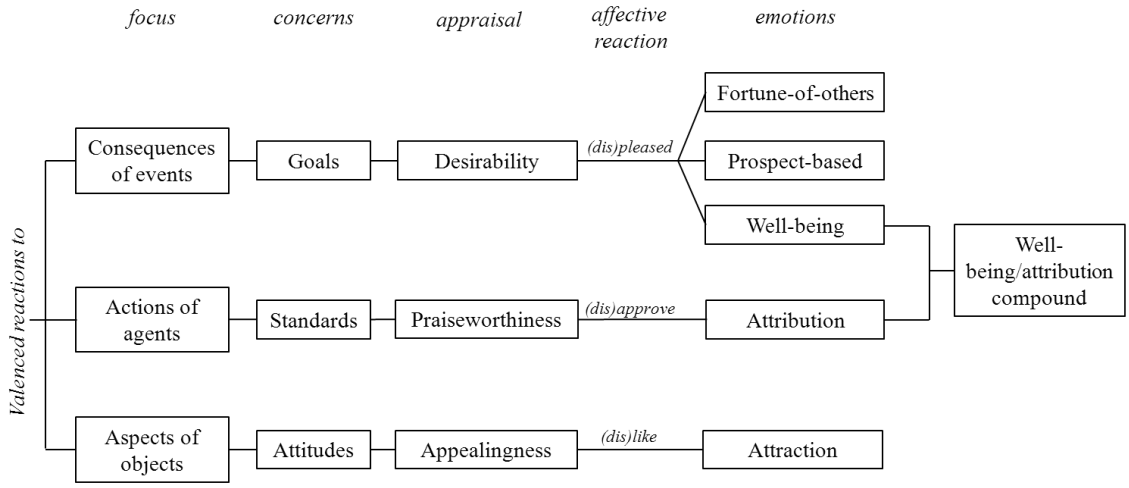

Figure 1. A simple visualization of OCC model (adapted from Ortony, Clore and Collins, 1988)

The appraisal criterion for consequences of event's is their desirability for achieving one's goals. This generates the affective reaction of being pleased (if consequences are beneficial to one's goals) or displeased (if consequences are harmful to one's goals). The resulting emotion groups are, as named and classified by Ortony and colleagues, fortune-of-others (e.g., gloating, pity), prospect-based (e.g., satisfaction, relief), and well-being (e.g., joy, distress). For instance, one's goal (concern) might be to get recognized by his boss upon delivering a 3D render of a model using certain software. The consequence of using that particular software might not turn desirable (an appraisal) as it does not encompass certain shades intended for the final rendering. The person feels displeased (an affective reaction) and the emotion dissatisfaction (in prospect-based group) is generated as his hopes are not confirmed.

Appraising the praiseworthiness of the actions of an agent, evaluated against one's personal standards, results in affective reaction of approving (if actions meet one's standards) or disapproving (if actions do not meet one's standards) and subsequently evokes emotions in attribution group(e.g., pride, shame). The agent here is not always necessarily a human agent and is also understood as

objects in terms of their instrumentality. For instance, a person might disapprove of the actions of a computer software (here, the agent) which does not follow his commands whereas his standards for that type of software is to be responsive and quick. As the result, an emotion of reproach (in attribution group) may be elicited.

OCC model also accounts for the situation where one evaluates the actions of an agent in terms of their consequences, suggesting well-being/ attribution compound (e.g., anger, gratitude) emotion group. This is the case of the simultaneous occurrence of the eliciting conditions for well-being and attribution emotion group. These emotions are not mere compounds of emotions but rather the compounds of eliciting conditions. For instance OCC suggest that the emotion anger (belonging to well-being/attribution compound) is experienced when the eliciting conditions of two other emotions namely reproach (an attribution emotion) and distress (a well-being emotion) are experienced concurrently.

Finally when the aspects of objects are appraised as appealing, affective reaction of liking or disliking is resulted and emotions in attraction group (e.g., love, hate) are evoked. For instance one who finds the visual aesthetic [attitude] of a cell-phone cover appealing, develops a liking for it.

Having distinguished all types of emotions that a person could possibly experience when encountering events, agents or objects, the OCC model introduces some global variables of their intensity as follows: 1) *Sense of reality* (i.e., the degree to which the event, agent or object in focus appear real to the person), 2) *Proximity variable* (representing the psychological proximity of event, agent or object), 3) *Unexpectedness* (different from one's expectations, this represents how unexpectedly one is taken by surprise, either positive or negative), 4) *Arousal* (representing the physiological arousal). According to OCC, each emotion necessarily bears a minimum level of intensity determined by these global variables implying that they are necessary for one to potentially FEEL the emotions (Ortony, Clore, and Collins, 1988). For instance a desirable consequence of an event does not automatically result in an emotion (e.g. joy) unless there is a sense of reality to it meaning that a certain level of intensity is necessary for an emotion to be significant to the person. Consequently intensity variable are best described as determinants of the emotion's magnitude however they do not differentiate one state from another.

OCC as a cognitive theory of emotions imply that there is order to emotions and emotions attend to particular purposes for the human organism which is to adapt to the world, the environment and different situations. For this reason, the model has been employed by other fields as discussed in the next section.

1.3. Influence of cognitive structure of emotions on other fields

OCC model has been very influential in the fields other than psychology. In aircraft cabin design, Ahmadpour et al. (2014) studied the experience of aircraft interior and developed a model for analyzing passenger's emotional reaction during the flight based on OCC model. In computer science Steunebrink, Dastani, and Meyer (2009) adapted the model, differentiating the emotions types furthermore and specifying their underlying hierarchical processes with more details. Their model differs from the original OCC in that they eliminated those branches of the hierarchy which differentiate emotions in terms of one's focus on the consequences of events for self or others. They recognize the significance of the model for building computer systems using emotional reasoning and for incorporating emotions in artificial characters. Moldt and von Scheve (2001) discussed emotional agents in human-computer interaction and extended the physical context of cognitive structure of OCC model to social contexts and introduced *emotional agents* which react based on user's emotional state.

In the field of product design, Desmet and Hekkert (2002) used OCC model to explain emotional responses to the perception of consumer products. They proposed a framework within which products are appraised in terms of their consequences (of events), their agency, and attitudes as such, and generate emotions accordingly. The framework, however, acknowledges those three perspectives on products as relevant only when products are perceived with one of the senses

without physical interaction. The reason for this delimitation, as described by authors, is to be able to go beyond the view point of objects as such. It must be noted that without physical interaction, users could only appraise the *prospect* of consequences of events (e.g. perceived usability rather than experienced usability). Therefore emotional responses are limited to what is commonly regarded as perception of non-instrumental qualities of products, i.e. aesthetic aspects, symbolic aspects, and/or motivational aspects (Mahlke and Thüring, 2007). The study details specific user concerns and gives illustrative examples of the expected emotional responses to each. These are listed in Table 1. For instance Desmet and Hekkert (2002) gave an example as follows: "the thought of using this Kangaroo ball makes me enthusiastic". According to Table 1, appraising the desirability of consequences of an event (i.e., playing) taking place through the product (i.e., the Kangaroo ball) to attain goals (i.e., having fun), elicits the emotion response of enthusiasm. Other examples are also provided for products as agents and objects.

Table1. Details related to model of product emotions, as described in Desmet and Hekkert (2002)

Stimulus	Concern	Concern types	Appraisal	Emotional response
Product as event	Goal	To be attractive To have fun To be the first	Desirability	Desire Enthusiastic Jealous
Product as agent	Standard	Social standard Design standard	Praiseworthiness	Indignant Disappointed
Product as such (object)	Attitude	Aesthetic attitude Relationship attitude Social attitude	Appealingness	Attracted Appreciate Despise

The elements of this model promise an interesting interpretation of people's reaction to products, systems or environments. The underlying process of interaction-induced emotions could inform designers to deliberately targeted specific emotional responses or in other words design for emotions. It also enables designers to predict the possible reactions to a product. Indeed further research could create a more comprehensive structure to adapt OCC model in product and interaction design.

1.4. Dimensional models of emotions

The components and dimensions of emotions were the subject of much speculation since the 19th century (e.g., Wundt, 1896). Two dimensions that are commonly proposed to describe emotions are valence and physiological arousal (Arnold, 1960; Lazarus, Averill, and Opton, 1970; Russell, 1980).

The dimensional model of emotions was popularized by Russell's (1980) model of circumplex of core affect. He suggested that affective states (and psychological states, for that matter) are all related to each other systematically through what is called *core affect* (Russell, 1980, 2003) and emotions are best described as a change in core affect which, in turn, is describable as a point in a space between two bipolar dimensions. One dimension is valence or the intrinsic attractiveness or aversiveness of objects and events, as Frijda (1986) defined it, ranging from pleasant to unpleasant and the other dimension is the physiological arousal, ranging from calm to excited (or activated). Russell (1980; 1989; 2003) pinned a number of prototypical affective states around a circular space between those two dimensions, i.e., a circumplex, representing the variety of core affects. Depicting discrete emotion-related categories (i.e., distinct categories denoted by emotion words, each representing a range of similar emotions) in relation to their dimensions has inspired the design and development of a product-specific model of emotions by Desmet (2002) which is discussed in the following.

Desmet (2002) proposed the circumplex model of core affect for emotional responses to consumer products (see Figure 2). A selection of discrete emotions is positioned around the circumplex to outline the potential reactions to the product's appearance. The selection process of these emotions involved eliminating irrelevant emotion terms from a pool based on the degree to which they correspond to valence (on a nominal scale of pleasant, neutral, and unpleasant) and arousal (on a

nominal scale of excited, average, and calm). This process gave 24 emotion terms in eight categories of valence and arousal level combination (e.g., excited-pleasant, calm-unpleasant, neutral-excited) which are very confirmatory of Russell (2003) in terms of the selected used terms. The circular model that stemmed from this process was later used to develop a tool, called PrEmo, which uses cartoon characters symbolizing emotion terms in a non-verbal manner (Desmet, 2005).

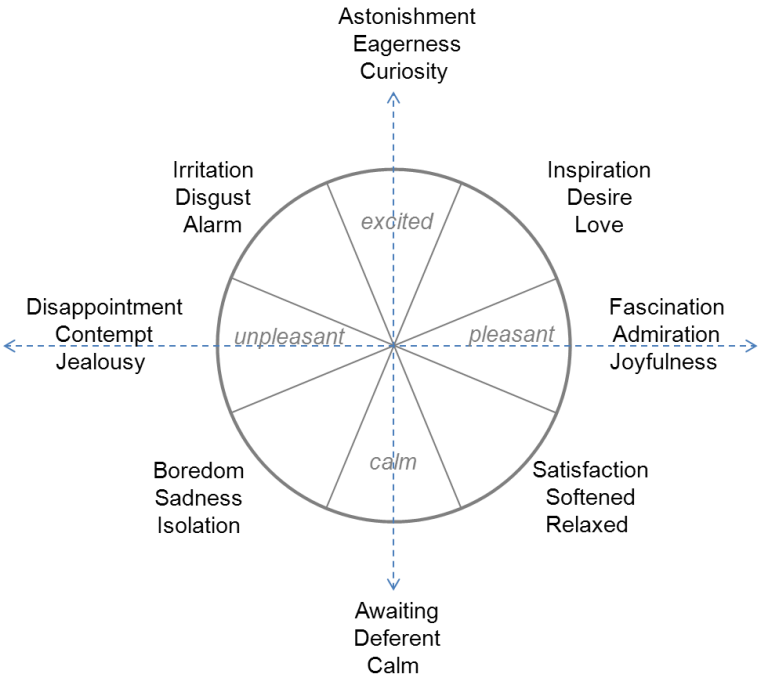

Figure 2. Circumplex of core affect for consumer products (adapted from Desmet, 2002)

2. DISCUSSION

In this section, a comparison is made between OCC model and the circumplex of core affect for consumer products (Desmet, 2002) as a dimensional model. First the similarities and difference between their approaches towards study of emotion are outlined and then a comparison is made with regards to their representation of emotion categories. The aim is to understand how they compare when applied in the field of product and interaction design.

2.1. Similarities and differences of OCC and dimensional models

The major similarity between the models presented earlier is that they all consider emotions to descend from valenced reactions to stimuli or situations. Moreover, they acknowledge the role of arousal in determining emotional reactions in one way or another. Russell (1980) and Desmet (2002) consider arousal as one of the two key dimensions of emotions which could be used to discriminate emotional states to some extent. On the other hand, OCC model recognizes arousal as a necessary condition for emotions which rather gives rise to valence to generate an emotion. The former also accounts for it as a determinant of emotion's intensity, distinguishing among various emotions of a particular type (for instance between fearful, petrified, and scared).

Scherer (2005) argued that arousal dimension in valence-arousal models is relatively fuzzy in definition as it could refer to both the physiological arousal as well as the perceived activation in the situation. He speculated that arousal gives little information about the underlying appraisal of the elicited emotion and proposed to replace it with coping potential which is an appraisal dimension referring to one's perceived control in the situation.

Furthermore, dimensional approach pursued in circumplex of core affect is based on joint features

of emotional reactions (Scherer, 2005) while OCC is based on patterns of antecedent of emotions (Ortony, Clore, and Collins, 1988). This is the fundamental difference between OCC and the circumplex approach of Russell and Desmet. In comparison, OCC model employs causation, attribution and eliciting conditions in order to distinguish emotions while the eliciting conditions or attribution are not directly accessible from dimensional approach. This is likely to be a consideration when choosing an emotion model in product design. A dimensional model might fall short in establishing why certain emotions are elicited. However, when the objective is to identify the generated emotions and their level of pleasantness and intensity, circumplex model brings about a perfect opportunity.

2.2. Emotion representation on OCC and dimensional models

The representation of emotion types on each model could be linked to their sensitivity to language. Ortony et al. (1988) asserted that self-reports of emotions bear a limitation due to innate restrictions of language and our personal reading of emotion words. In addition, it is difficult to control whether a person's use of a certain word corresponds to a feeling or a state. For instance they make an example of the difference between "feeling neglected" and "being neglected". The latter is not an affective state. For that reason, OCC model does not rely on discrete emotion words but rather the cognitive process preceding emotions in order to categorize them. However, the emotion terms on circumplex of affects for products (Desmet, 2002) are discriminated on basis of raters' perception of each word.

OCC employs a cognitive structure to define emotions consistent with the (un)pleasantness of the eliciting condition relative to various concerns (i.e., goals, standards, attributes). This corresponds to the first question in appraisal process as "how beneficial is it relative to the person's concern?" The answer establishes a unique cognitive pattern for each emotion group. However, OCC engages only positive or negative affective reactions in discriminating emotions while leaving neutrally valanced emotions intact. This implies a critical discrepancy between the structural and dimensional points of view. Structural models necessitate positive and negative valence as two basic affective reactions, deviation from which accounts for differentiation of more complex emotions. Dimensional models (such as circumplex of affects by Desmet, 2002), on the other hand, address two neutrally valenced emotion groups namely excited (consisting emotions curiosity, astonishment and eagerness) and calm (consisting awaiting, deferent and calm).

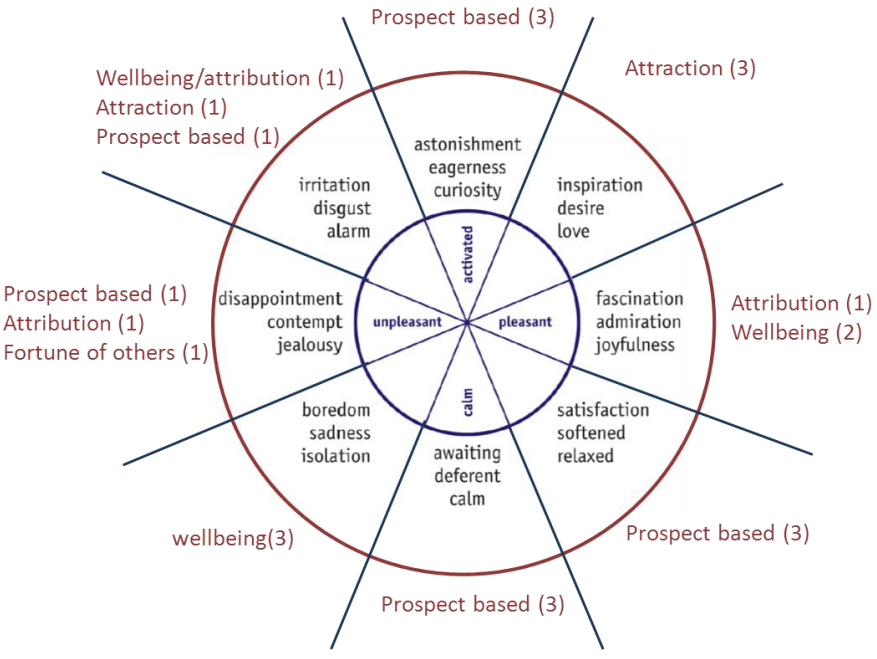

Figure 3. A rough projection of emotion groups of OCC on the circumplex of affect for products (Desmet, 2002). The number of emotions in a section of Desmet's circumplex that fall into an emotion group of OCC are shown

in parentheses. For instance all three emotions on the top section (highly excited-neutrally valenced emotions) fall into prospect based emotion group, hence number (3) is indicated.

To compare the representations of various emotion groups that emerge from the two abovementioned takes on emotion categorization, a comparative study is performed. A rough projection of emotion groups as described in OCC is conducted on the circumplex of affect for products (Desmet, 2002), as shown in Figure 3. The emotion groups from OCC that correspond to each of the eight sections on the circumplex are specified. A discussion of the comparison follows.

Each of the 24 emotions on the circumplex of product emotions was compared to the emotion types provided by Ortony, Clore and Collins (1988) and the emotion group to which they belonged was identified. For instance emotion satisfaction was found under prospect-based group and jealousy under fortune-of-others. In Figure 3, the numbers of emotions that fall within the specified groups are shown in front of them. For instance all the three highly excited-neutrally valenced emotions on top of the circumplex belong to prospect-based group.

Furthermore, the numbers of emotion types in each group are compared for OCC and circumplex of product emotion and summarized in Table 2. Prospect based group contains the highest number of emotions in the circumplex with 11 emotions while there are only four of those emotions on OCC. This is followed by well-being group with five emotions on the circumplex and two on OCC model. Fortune-of-others and well-being/attribution-compound each contains one emotion on the circumplex which makes them the least represented groups.

The study by Desmet was originally performed to elicit emotions generated by products' appearances. Considering this fact and the prominent presence of prospect-based and well-being emotions on the circumplex, it appears that people judge the personal benefits of using products (consequences of events for self, in OCC terms) by their appearance. The eminent presence of attraction emotions also confirms this, proving the effect of visual aesthetics (as a product aspect) on attraction.

Table 2. Comparison of emotions groups as represented on OCC model and circumplex of core affect for consumer products (Desmet, 2002)

Emotion group from OCC	No. of emotion families mentioned in Circumplex of product affect (Desmet, 2002)	No. of emotion types in each group on OCC model
Fortune of others	1	4
Prospect based	11	6
Well-being	5	2
Attribution	2	4
Well-being/attribution compound	1	4
Attraction	4	2
Total	*24*	*22*

Moreover, certain prospect-based emotions on the circumplex fall within excited-neutral (e.g. astonishment) and calm-neutral (e.g. calm) suggesting that pleasantness does not account for emotions within this group while arousal does. On the other hand, OCC clearly described all emotions as valenced reactions (i.e. positive or negative reactions to stimuli) and considered arousal as a global dimension for all emotions types and groups. In particular, prospect-based emotions are regarded by OCC as the result of evaluating the pleasantness of the consequences of an event when relevant to one's prospect. For instance the emotion relief (similar to calm on the circumplex of Desmet) is experienced due to finding consequences of an event a pleasant when it is relevant to one's expectations.

The above differences between the two models suggest that attempts towards analyzing and

evaluating emotions should be performed cautiously and with great consideration for the context. While OCC model elucidates the structural logic of emotions and why they were emerged in variety of situations, it requires more time and analysis. The circumplex of product emotion by Desmet, however, paints an accessible picture of emotional reactions but bears some limitations including its reliance on product appearance as the informant of emotions. Although giving partial information about how and why a certain emotion is evoked, the circumplex model is a valuable tool to compare and benchmark the emotional response to products or interactive systems, compare them with the design objectives and examine whether the product evokes as much valence and arousal as was initially intended.

3. CONCLUSION

This paper showed that both the OCC and dimensional models view emotions as valanced reactions but they have some differences regarding emotion representation. OCC essentially adopts the appraisal process as the necessary condition for emotions and puts an emphasis on the cognitive structures preceding emotional experiences whereas the dimensional model describes discrete emotions in relation to two dimensional references and is thus sensitive to the selection process and context. As the result, prospect-based and well-being emotions have stronger presence in dimensional model.

The result suggests that the choice of method or model for investigating emotional evaluation to products, should take into account the pursued design approach and convoy a clear plan for integrating the findings into the design process. The OCC model could potentially uncover the conditions that elicit the emotions and consequently shed light on their context. This information could inform the changes that should be implemented into the design in order to serve that context. The dimensional model described the nature of emotions and could inform the design efforts in terms of user experience.

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BIOGRAPHY

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about understanding human responses to the social and environmental inputs, her goal is to develop a theory of comfort that accounts for various aspects of passengers' experience. As part of her research, she employs the principles of cognitive structure of emotions to study the appraisal patterns of passengers' emotional responses to the contextual elements.

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Flow Kansei Engineering

Qualifying conscious and unconscious behavior to gain optimal experience in Kansei Engineering

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Abstract

The general tendency of design is that being based on human and the aim of Kansei engineering is to follow the structure of emotions based on human behaviors. As we know, Kansei appears in individual emotions and is able to create different feelings in human mind (Nagamachi, 2010) where Flow is a teleonomy of the self (Csikzentmihaly, 1992). However, Design has a convergent and divergent relation with needs and desires. Accordingly, designers are obliged to meet user's desires but the implicit needs of such an emotional experience are difficult, partly because people express their emotions both consciously and unconsciously. Analyzing the relationship between Kansei and Flow, activities can have optimal behavior output. This article provides a new approach, which can be applied to capture the emotions of users and proposes a new framework of Kansei Engineering (KE) to handle the optimal experience of people besides their needs in a various tangible fields such as interior and product design. In this study we use the KE Model of Schütte because it is understandable and compatible with new tools. We use Flow in semantic and properties space and we created a Flow space during the synthesis step of this level.

Keywords: Kansei Engineering, Flow, Optimal Experience, Product Design, Neuroscience, Positive Psychology, Healthcare Design

1. INTRUDUCTION

Happiness is one of the central concepts in positive psychology (Seligman, 2003; Seligman and Csikszentmihalyi, 2000). Finding the quality of emotion in happiness, designing for happiness, and measuring emotion of satisfied users are all steps capable of increasing the quality of life. These are interesting issues, which are considered both in market and customer satisfaction. Nowadays,

several methods have been created based on emotional design. One of them is Kansei Engineering.

What is Kansei?

Kansei is an unconditional mental function, and more accurate as being a higher function of the brain (Harada, 1998). Psychological phase of Kansei is an outcome through cognition and the five senses. Figure 1 shows the process of Kansei and the five senses within the structure of the brain (Lokman, 2010).

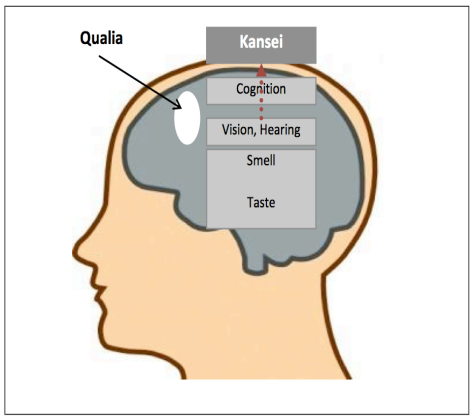

Figure 1: The Process of Kansei (Nagamachi & Lokman, 2009).

What is Kansei Engineering?

Kansei engineering (KE) is a technology that integrates Kansei (feelings and emotions) with the engineering methodologies. It is a field in which the development of products that deliver happiness and satisfaction to users is conducted technologically, by analyzing human emotions and incorporating them into product design (Nagamachi, Lokman; 2009).

KE and design projects

Many Japanese companies have used KE method. Mazda used Kansei Engineering in the development of Miyata model, Sharp LCD display instead of a conventional ocular and Wacol to design underwear are some companies which used KE to increased the their sale.(Schütte,2004)

Measuring Kansei

Figure 2 depicts existing approaches of measuring Kansei. In addition, KE in all eight types (**KE type I** : Category classification, **KE type II**: KE system, **KE type III**: KE Modeling, **KE type IV**: Hybrid KE, **KE type V**: Virtual KE, **KE type VI**: Collaborative KE, **KE Type VII**: Concurrent KE ,**KE Type VIII**: Rough Set KE) (Nagamachi, 2003; Ishihara et al., 2005) measures people's emotion in current mood without any effort to improve their feelings.

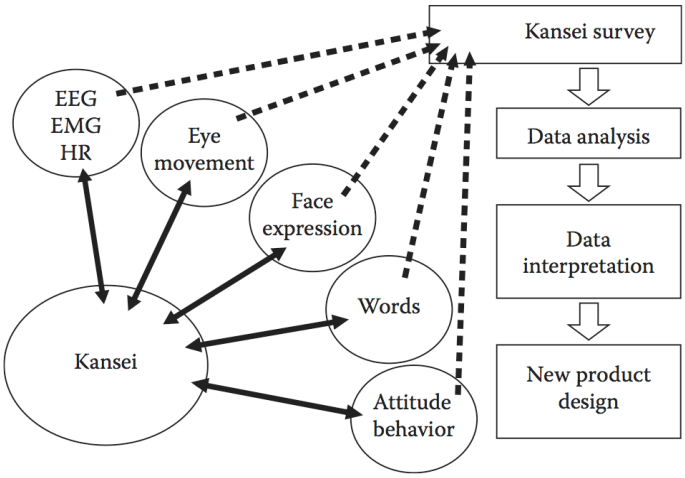

Figure 2: Choices of route to reach the Kansei (Lokman and Nagamachi, 2009).

Where does the Emotional reaction come from?

We can anticipate people's emotional reactions by knowing how input signals are affecting them. According to Marco Maiocchi (M. Pillan, M. Maiocchi and M. Radeta, 2013), below is depicted the process of meaning and emotions felt by users from every signal. Figure 3 demonstrates how users generate meaning emotional reaction of signals by simple and complex perceptions within technical and cultural constraints. Variety of interpretation, memory, judgment is justifiable by this model. Furthermore, we believe that people are constantly affected by environmental signals, which have an ability to affect and change their perception.

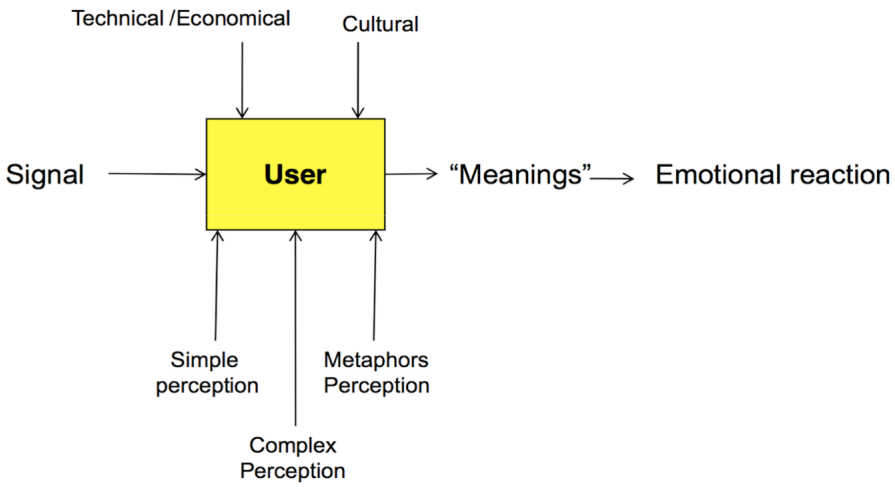

Figure 3: The process of meaning from signals (Pilan, 2013)

How can we affect the user's emotional reactions?
The amount of skills and challenges are forming the user's emotional reaction. As presented in Figure 4, Flow is a function of counterbalance between challenge level and skill level when both are above average level for the individual in that, low skill and high challenge generates anxiety and high skill level and low challenge level result in relaxation. Flow helps people to overcome problems and to bring exhilarating feeling of transcendence into their lives (Csikszentmihaly; 2013). Entering Flow depends on developing a balance between perceiving activities, capabilities and opportunities (Nakamura, 2002). In addition, attention plays a key role in entering and staying in Flow mode. Remaining in Flow mode can only be guaranteed by keeping the balance between skills and challenges. The duration of remaining in Flow mode is the most widely used system for measuring the autotelic personality (Nakamura, 2002).

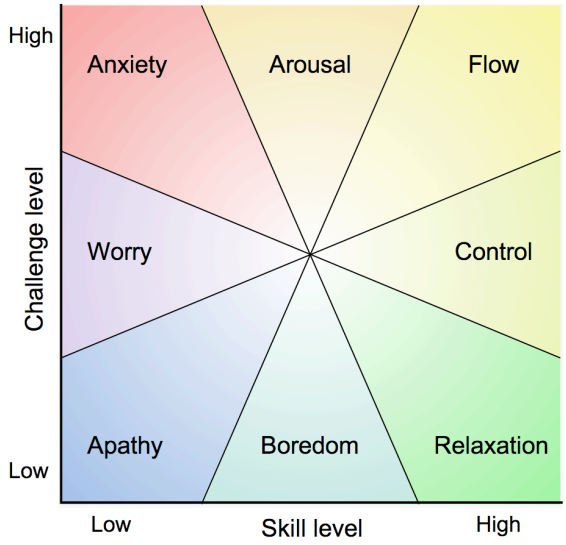

Figure 4: Csikszentmihalyi's Flow mode (Mihaly, 1997)

According to Csikszentmihaly the joy of movements such as dance, exercise, Yoga, sex, listening to music, tasting and hundreds of separate functions do correspond to Flow experience (Csikszentmihaly, 2002). He believes that joy of thinking, working, enjoying solitude and being with other people, communication and creativity have the ability to enter people into Flow mode.

Measuring Flow
Flow is a subjective state based on self-report interviews, paper-and-pencil measures, Flow Questionnaires and the Experience Sampling Method (ESM) (Delle Fave and Massimini, 2004; Jackson and Marsh, 1996).
Flow and design projects
Several art museums have integrated Flow principles during their exhibitions design and buildings, including the Getty Museum in Los Angeles. Flow principles have informed product design, at Nissan USA, for example, with the goal of making the use of the product more enjoyable (Nakamura, 2002).

Entering Flow in KE process

We believe that the customer's point of view is not enough considered to achieve satisfaction in new design. Doing the KE test while the participants who are in their Flow mode, can lead us to new design based on people's happiness. Being in a good mood and using user's skills to make a deep challenge with products provide an appropriate status in achieving better results. In order to get a valuable result besides entering the participants in their Flow mode, we need to keep them in that condition. Measure Kansei of users during their flow by all aforementioned measures of Kansei and Semantic Differential Method (SD) developed by (Osgood et al. 1969) are available to assist us in this evaluation.

2. PROPOSING A FRAMEWORK OF FLOW KANSEI ENGINEERING (FKE) BASED ON SCHÜTTE KE MODEL

KE type I is the simplest and quickest one to try for this new model. We choose KE model proposed by Schütte. As we can observe from Figure 5, this model has a 6-steps process and was used in our previous study to link the product's emotions with product's properties (Shafieyoun, Koleini Mamaghani and Jahanbakhsh, 2010). Shütte anticipated that the "future growth of Kansei Engineering and the application of new areas make it necessary to allow the integration of more tools and methods from other areas" (Schütte, 2004).

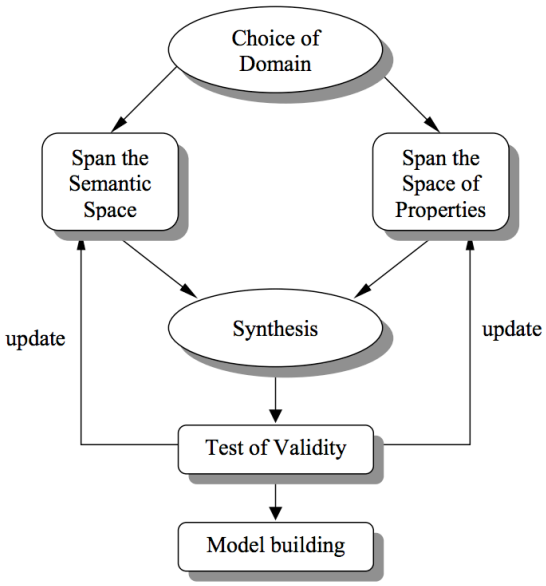

Figure 5: KE model proposed by Schütte (2005).

We choose this model and merged it with the Flow concept. We describe the new approach of KE based on above stated literature reviews and link it with Flow concept to form a new measuring system called Flow Kansei Engineering (in future, FKE).

2.1 Choice of Domain: The choice of a target group is informed by the market and the particular new product. Measuring Flow helps us to know our user better and make a better consequently results in developing a more suitable Kansei word (KW) collection. We also need to measure flow in order to choose the optimal way to enter our users in the Flow. The results of qualitative interview help us to prepare a questionnaire based on the keywords such as whether, how often, in

what specific activity and context. The goal is to compose a picture of the typical subjective experience when things are going well. We can create a questionnaire depending on our research goals to use ESM. ESM helps to change a complex subject to simple one and gain more results about the condition of individual Flow. During measuring Flow we can gain a lot of KW.

2.2 Spanning the Semantic Space: Kansei measure is a part of this step to collect KW. We measure Kansei alongside with measuring Flow. We know about the interest of users and we find how we can enter them in Flow mode. Being in Flow can change the result of Kansei measure for users, which is reflected in their physiological responses, behaviors and actions, and facial and body expressions and words. When Shüttee introduced this method he mentioned, “Unfortunately, all the presently available measuring methods are external methods interpreting different body expressions”. Applying Flow concept we might grasp and measure Kansei and develop interpretations of customer’s emotions. SD Method is the best solution to gain metric parameters during this process.
In order to collect KW, we use magazines, literature, results of measuring Flow, ideas, Internet as well as the result of Kansei measures and further observation. Word reduction can be done by factor analysis, cluster analysis or manually. We can embrace the model proposed by Schütte and use collection, selection and compiling to help us organize the process (Schütte, 2004).

2.3 Spanning the space of properties: This space is similar to semantic space. Same as before, we can follow three steps of collecting, selecting and compiling to choose the product samples related to our KW (Schütte, 2004).
A wide range of sources such as product samples can be selected by considering the future of product. Product should have a potential to be linked with user’s Flow. In this space we can ask about the properties of ideal products from users or designers.

2.4 Synthesis: This step include merging the Semantic space and Space of properties. We use the result of the previous levels to make a suitable situation to use participants’ skills and make a challenge with our product range. In measuring Flow we define the span of high level and high skills.
Different methods can be used in entering the participants in their Flow mode. For instance we can ask an architect to draw the product (paying attention to his/her skills) or in case of a music lover we can play several music and ask for linking one of them with the product. Writing a poem, making a sculpture, playing with the product, taking some photos and so on are all methods to enter users in their Flow mode. During the time of Flow mode, we can ask them to use their skills to give their ideas about the characteristic of ideal product. Then ask them to answer the SD questionnaire.
This method prepares a situation to make a deep relation between user and product, make a pleasurable time by entering them in Flow mode and gain the result from their optimal experience. Furthermore, the time of keeping in Flow mode is important.
In some of KE studies based on Schütte model the picture is used instead of the original product. For example, Grimsaeth used the method of Schütte to design battery drills. They presented 23 battery drill samples in pictures (Grimsaeth, 2005). We used the same methodology as the one applied in our previous study to design table for art students at Art University of Tabriz in Iran. We presented 10 pictures of various tables to our participants (Shafieyoun, Koleini Mamaghani and Jahanbakhsh, 2010). Pictures were in high quality and three dimensioned. The participants were skilled in visualization and capable of considering three-dimensional shapes.

In some surveys, products were used as prototypes and people had the opportunity to touch and use them. For example, Shang et al. used twenty-four real telephone samples presented to 40 subjects (20 designers and 20 users) for subjective evaluation to analyze the subject perception (Hsu, 2000).
However, we know that Kansei measure with tangible products can possibly be more precise compared to tests with intangible products (pictures). Obviously, the emotional engagement with products happens in Flow and it leads to gain more trustable results. The results can be analyzed using factor and cluster analysis. We can use SPSS and EXCEL software to do that.

2.5 Test of Validity: Newly developed models can be tested in the same circumstances that we have described above: entering participants in Flow and asking them to investigate our new model and answering our new questionnaire in SD method.

2.6 Model Building steps: After gaining the satisfactory result we will have a new design of the product.

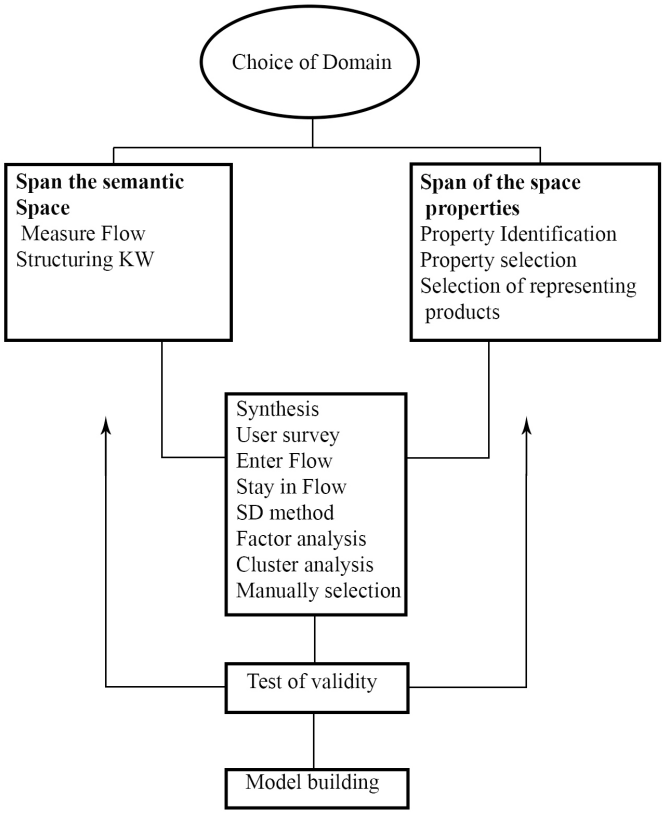

Figure 6: Flow KE model based on Schütte model (2005).

3. THE POSSIBLE APPLICATION OF THE METHOD

Our group is working with the Istituto dei Tumori di Milano, a relevant public cancer research and therapy center since January 2012. In the past, we provided and implemented some proposals, ranging from a new interior design, new way of finding signals, new patients communication, new

info points and so on. Our attention has been specifically dedicated to the waiting rooms. We use KE in one of our ongoing projects to design new waiting room.

Now we proposed a test based on the methods above-mentioned, which is a future project.

The proposed test is just related to the waiting areas in the Hospital, with about 100 users. Before starting the test we have to know about the challenges of patients and their attractions. We have to use ESM (Experience Sampling Method) for measuring Flow mode. We collect KW and make a questionnaire based on both of them.

This test is organized into three phases:

1. In the first phase, we will go in ordinary waiting area and we will measure the related Kansei with no test, by SD questionnaires. In this phase we will observe which activities patients use to distract themselves from the waiting situation.
2. In the second phase, we will prepare a situation to encourage patients in the waiting area to make them concentrated on their disease and will observe their behavior. We will measure the related Kansei after the test, by using SD questionnaires.
3. In the third phase of the test, we will introduce a useful distraction, such as the ones applied in the first test. We will evaluate the user's Kansei before and after the test, by using observations and SD questionnaires.

The results of this test provide useful method for a better understanding of user's emotion and it provides design suggestions to the relevance of introducing useful distractions into that particular site. In the mean time the tests are intended to engage in alternative, more positive experiences. Every test will show us which parameters increase the level of user satisfaction and which parameters decrease it.

Implications: users are our test groups not their caregivers. They do not need to be aware of being in a test at first, therefore we have to know which day we can catch at least twenty people in waiting area. Waiting room has to have at least one window and a TV and has a possibility to close the door. Paying attention to the weather, time and the day are important. A gloomy day is not a good choice. Briefly we need as normal position as possible.

4. A PAST EXPERIENCE

The proposal comes from previous experiences, not formalized and then scarcely measured, that suggested us to prepare the proposed method. In different areas we provided different new "signals" in the environment, and observed the different behaviors of patients and staff, depending on the changes we had done.

The above mentioned intervention were done in any waiting situation (i.e. in waiting rooms, but also in examinations or therapy rooms, when time was needed, without any possible parallel activity), and mainly related to:

· Disguise of analysis or therapy machines (e.g. NMR equipment) to transform them from aggressive equipment to "toys";

· Decoration of the walls with a rich and dense collection of paintings;

· Availability of books, also to be carried home, as in a book-crossing service;

· Availability of crosswords puzzles, and so on.

We compared the behaviors of the users in usual and “equipped” areas, and were able to observe:

· Reduction of anxiety;
· Distraction;
· Increase the number of smiling people” (or, in general, more relaxed facial expressions;
· Increase of positive feelings toward the institution and the staff.

In the other words, they entered very quickly and positively in their Flow mode.

5. CONCLUSION

We developed a method to incorporate unconscious behavior in KE by integrating possibilities that Flow offers in KE. It seems that one of the advantages of this method besides promoting health and happiness in society is the usage of less advanced and low cost technology to measure Kansei. The FKE method is cheaper and easier to apply to different domains and measuring the emotion is done by the participants themselves and not by an external device. By entering persons in Flow mode, we can help them in better understanding and transmitting their own emotions. Then, we measure their Kansei unconsciously.

Psychology and sociology are inseparable parts of KE. For this study, we used KE type I and the feasibility of using other types of KE warrants further investigation.

We can do the same survey for KE and FKE and compare the results to show the amount of user’s satisfaction and happiness. Result can show the amount of user satisfaction and the amount of happiness.

Grimsaeth performed a project in KE Type I and he argued that KE is a time consuming method. We already know that our suggested FKE is even more time consuming in any case, it depends on our ability to keep participants in their Flow mode which can change their perception of time. Obviously, this method is not so simple and use of Flow concept to measure Kansei needs very high perception and patience of users.

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Affective Engineering for Mud Wall Texture using Self-organizing Maps

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Abstract: Affective/Kansei engineering is used to analyze subjective responses to a streetscape plan for a historic townscape. The Chofu area in Shimonoseki was chosen for the research. The appearance of the streetscape is evaluated based on actual photographs using a traditional semantic differential method. Guidelines are often formulated to promote landscaping plans in historic towns; it is especially important to formulate color guidelines so as to unify the colors in an area undergoing change. The guidelines must be formulated according to regional requirements since color planning is strongly influenced by the local identity or brand. The affective engineering proposed in this study reveals representative design elements arising from the regional characteristics of the area and its people. The Chofu area is famous for its streetscapes of mud walls. The pilot investigation using a self-organizing map validated the evaluation of mud wall colors.

Keywords: Affective engineering, SOM, Mud wall, Texture

1. INTRODUCTION

This study illustrates affective data analysis for a historic streetscape. Chofu in Shimonoseki has a historic streetscape that is famous for its beautiful earthen walls. This study examines Chofu's street views with the intention of preserving and conserving such streetscapes. The experimental results are transformed into guidelines for unifying colors. Within the field of affective/Kansei engineering, computing the semantic space has been an important research issue since it was pioneered by Nagamachi at Hiroshima University (Nagamachi, 1995). Affective engineering aims to measure customers' subjective responses to products and to identify the properties from the responses using mathematical models.

This study aims to use self-organizing maps (SOMs) to analyze mud wall colors (Kohonen, 2001).

SOMs have been used to reduce multidimensional variables into a small number of axes. SOM performance has been confirmed in a previous study on affective engineering (Shiraki, W., et al., 2003). Our interest in affective engineering methodology is to compute the position of attributes in a semantic space. This paper illustrates a two-tiered approach for the analysis of mud wall colors. First, a color measurement is used to observe the unity of the color distribution of the walls. The distribution is translated into color guidelines based on the Munsell color system. Next, streetscape samples characterized by a color histogram of the photo image are mapped onto a semantic map computed by the SOM. The map is used to examine the relationship between the textured wall images and the affective meanings. The mapping is used for the maintenance and further improvement of mud wall textures.

2. EXPERIMENT ON MUD WALL COLORS

2.1. A.Target Area for the Experiment

Chofu is a well-known tourist area (Tsuchiya, 2006). It is popular because of its historic streetscape, which includes mud walls built using the distinctive, traditional Japanese construction method. The Chofu mud walls consist of clay mixed with rapeseed oil, giving the red-tinged color that creates the distinctive appearance as time goes by (Figure 1). However, only a small number of walls built in old times still remain. The city office has maintained the old walls, and at the same time, promoted the construction of new mud walls forming a desirable streetscape appropriate to Chofu through a subsidy system. This public support for private landowners started in 1996 and has resulted in Chofu currently being able to show its historic streetscapes. The subsidy system was terminated in 2010, because it had mostly achieved its objective of streetscape planning. Therefore, a system for maintaining the developed streetscape does not currently exist. To retain the constructed streetscape, guidelines for building new walls or repairing existing ones, which will typically impose restrictions on landowners, are required to establish a common understanding. Inspired by circumstances in the city office, this project was initiated to formulate guidelines to maintain the mud wall streetscape. The assigned task of this study was to collect basic data for guidelines in the area (Tsuchiya, 2009), (Tsuchiya, 2013). Unifying the colors of mud walls is especially important to retain Chofu's atmosphere. This paper discusses the investigation of color measurement and an affective examination of mud wall surface texture. The results of these two experiments are formulated into guidelines for streetscape planning.



Figure 1: A mud wall in historic Chofu.

2.2. Distribution of Mud Wall Color

The mud wall colors were measured by display colorimetry to investigate the color distribution in the Chofu area. The data used in this experiment were 90 photographs taken on the streets of Chofu with a compact digital camera. The photo locations were almost uniformly selected using the results of cumulative inspections, which included the historic earthen-walled streets. All the photographs were taken under the same conditions, including the height of the viewpoint. Shooting started at 10 a.m. and continued until 2 p.m. on a day with unchanging weather. The pictures were saved as 2,048 × 1,536 pixel jpeg images (Figure 1). The color of each wall was measured by the "Area Colorimetry System Landscape version by GISS", which includes a color correction algorithm. Figure 2 depicts a CIE 1931 xy chromaticity diagram with the distribution of the 90 mud wall colors indicated by the red markers. The markers are distributed from the center area, corresponding to a white or gray color, to the right middle area, which represents a yellowish red color. The color of the mud walls in Chofu is currently unified as an achromatic or red-tinged color since the 90 markers show a narrow distribution along the white or red-tinged area. This means that the mud walls in Chofu are either white, which is generally the color seen on historic Japanese streets, or tinged with red, which is the characteristic color of Chofu. Therefore, color planning for mud walls in this area is reasonable to focus on maintaining the current color unity. Figure 3 shows the color-projected guidelines using the hue and chroma axes of the Munsell color system (value = 6) for builders of mud walls based on the color distribution. The streetscape can be maintained if landowners in the target areas agree to the projected guidelines.

3. AFFECTIVE EXPERIMENT ON MUD WALL SURFACES

3.1. Affective Experiment on Mud Wall Images

For future streetscape preservation and improvement, it is important to examine the affective influences of the mud walls on the Chofu streetscape. In this study we undertook a streetscape evaluation experiment to obtain visual evaluation data of mud wall designs. We then analyzed the relationship between the obtained affective evaluation and the mud wall designs. The results of the analysis will be used in assessing existing mud walls and constructing new walls.

The aim of the affective experiment was to reveal the relationship between the mud walls and

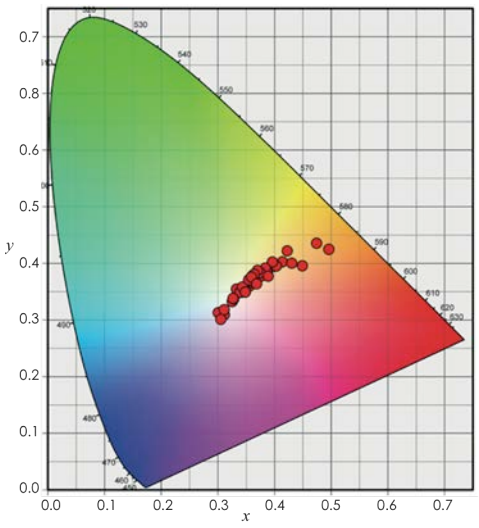

Figure 2: Color distribution of the Chofu mud walls(*CIE 1931 xy chromaticity diagram*).

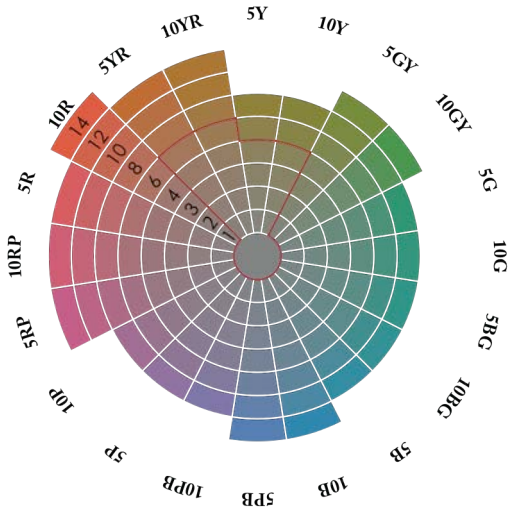

Figure 3: Color guidelines for mud wall builders based on the color distribution.

human sentiment. A general semantic differential questionnaire was prepared for 20 individuals (13 males and 7 females). The stimulus for this experiment was the 90 photographs (2,048 × 1,536 pixels) used in the previous experiment. In the experiment, the photo samples were projected onto a screen and evaluated on a five-point semantic differential (SD) scale using 15 pairs of adjectives (Table 1). The adjectives used as evaluation words were gathered from a previous study (Nakama & Kinoshita, 2010) and from experts in design and regional development. The data obtained from the questionnaire responses by the 20 subjects were averaged, resulting in a 90 by 15-element data matrix.

3.2. Color Histogram of Mud Wall Surface Images

The surface image of the mud wall is essentially treated as a texture. It would appear that an affective feeling is created by the surface texture of the mud wall. It is therefore reasonable to examine the affective relationship between the human sentiment and mud wall images. However, there is really no major difference between the grain patterns of the mud walls constructed using a similar architectural method. The most important element of the affective representation is the color shade created by the material varying over time. Therefore, we employed a color histogram representation to define future measurement of the mud wall design. The histogram depicts the number of the dot for each color value. The input images were 90 digital photographs, that is, 300 × 300 = 90,000 dot full color jpeg images, representing different characteristics of the color shade, clipped from the sample jpeg files used in our earlier affective experiment. The color of each dot, as specified in the digital image, was represented using the Hue, Saturation, Value (HSV) model. The numbers of bins for hue, saturation, and value were 20, 5, and 5, respectively. Frequencies were computed as a three-dimensional histogram of HSV, resulting in a total number of bins of 20 × 5 × 5 = 500. The computed frequency was normalized, since the maximum value is 100. Then, four samples representing different colors, as measured by the display colorimetry, were selected as criteria (Figure 4). D27 was selected as the average color of the sample, while D25, D50, and D76 were selected as distinctive colors. The Bhattacharyya distance was used to measure the difference between the histogram for each criterion and the other 89 samples. The four computed distances for each histogram were employed as future values of the texture. Figure 5 shows the computed distances for the 90 samples with respect to the criteria of samples 76 and 25. The distances were normalized to [0,1]. Then, the 15-elements of the normalized affective evaluation and the four distances were used in the affective analysis of the mud wall design.

4. AFFECTIVE ANALYSIS USING SELF-ORGANIZING MAPS

4.1. Semantic Maps using SOMs

The data gathered from the affective experience and the texture representation were analyzed using a SOM, which can visualize multidimensional data into a sheet-like neural-network array [2].

Table 1: Affective words used in the experiment

realistic - fantastic	modern - classic	wilderness - tidy
noisy - quiet	ugly - beautiful	tasteless - tasteful
artificial - natural	dark - bright	indistinctive - distinctive
uneasy - easy	not high-grade - high-grade	cold - warm
senseless - smart	unfriendly - friendly	atypical Chofu - typical Chofu

The units translate various input signals into certain reduced coefficients. The SOM aims to acquire features of the input data to classify unknown or unlearned data into the correct classes. A basic SOM network is composed of an input layer and an output layer. An output unit has the same dimensions as an element within the input vector or the input layer. A unit in the input layer corresponds to an element, or a variable, of the input vector, which means an evaluation word or a design future in the case of this affective analysis. Therefore, a one-to-one relationship exists between an input unit and an element of the input data. Additionally, the links from each input layer are connected to all output units by an arrow. Thus, the number of elements in the output unit is the same as the size of the input vector or the array of the input unit. The iterative learning process relies on competitive and cooperative learning, which is unsupervised (self-organized) and therefore, no teacher is required to search for appropriate weights for the output units.

4.2. SOM Learning of Mud Walls

The next step involved learning an SOM map from the 90 sample pictures using the SD data gathered in the experiment. Figure 6 shows the resulting SOM map on a 20 × 18 grid (map unit size u = 360). The input data were obtained from the 90 samples (images) of the 19-dimensional normalized vectors (variables). A vector of the sample was used as the input vector for SOM learning. Each learning step was completed by recomputing the output unit vectors, for each iteration of 90 samples. The network structure was a hexagonal topology, which is the most usual form for SOM construction. The number of learning steps was 15,000. The initial learning rate and neighborhood radius were 0.2 and 10, and these were changed to 0.1 and 5, respectively, in the final 10,000 steps. In Figure 6, a hexagon overwritten with a dot or sample number (such as “D1,” which means the nearest unit to sample texture 1) indicates a unit in the output layer. Other hexagons represent the distances of the output unit vector between pairs of neighboring units. The distances between units on the map correspond to the degree of the relationship in the semantic meaning. The model vector represents the characteristics of the SD evaluations and texture distance; therefore, a greater distance in the model vector, which is depicted by a darker shade of grey, implies a greater difference between the units.

4.3. Examination of Resulting SOM Map

As shown by the resulting SOM map in Figure 6, three distinctive type samples, D25, D50, and D76, are allocated at the three corners of the map. It is apparent that the surface texture certainly has an influence on the feeling generated by the mud wall. This means that the map represents

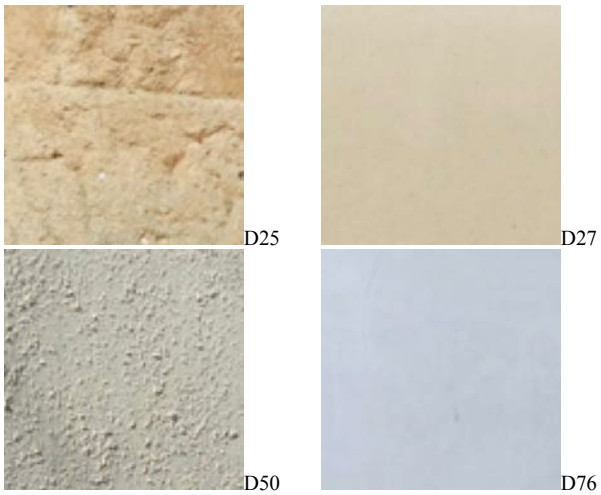

Figure 4: Images of the criteria for computing texture distance.

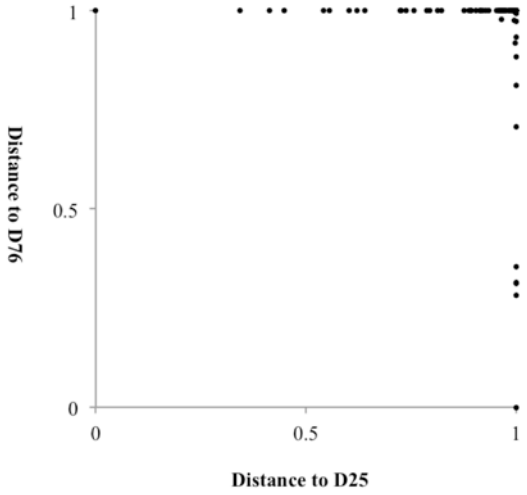

Figure 5: Distance of histogram for 90 samples (using D25 and D75 as criteria).

differences in texture according to the allocation of samples on the unit. Thus, the location of the map includes a correlation of the texture parameter (histogram). To confirm this correlation, Figure 7 summarizes the images near criterion D76. These samples are all white walls constructed using plaster, and thus the correlation of the surface texture is assured from the map location. Correlation of the location and texture surface was similarly confirmed for the other three samples. In a similar way, the photo images near sample D25 are also confirmed in Figure 8. As can be seen, the samples near D25 are aged, red-tinged walls. Thus, it is reasonable to conclude that the map location represents the variation in texture pattern. The samples are mapped according to the distance between the texture histogram and criteria. Thus, the location of a new wall to be built or maintained, can be mapped onto the resulting SOM map in order to compute the texture pattern. This means the SOM map can be used as a scale for mud wall textures.

Next, the scale of the affective evaluations was examined using the resulting SOM map. Figure 9 depicts an element of “beautiful”, which is one of the evaluation words used as an input variable for the SOM. The gray scale of each unit on the 20 × 18 grid, extracted from the output unit of the resulting SOM map, indicates the element values (affective evaluation of “beautiful”). The location of the mapped samples is the same as in Figure 6. The white area means that the mapped sample on the unit has a “beautiful” image. It can be seen in Figure 9 that the area near sample D76 is the location of “beautiful” samples. The dark area implies an “ugly” meaning. Figure 10 shows a mapping of the primary affective words identified from the element maps. The correlation between the map location and affective meaning can be quantified from the resulting element values of the SOM map. For example, samples D25 and D50 correspond to “fantastic” and “ugly”, respectively.

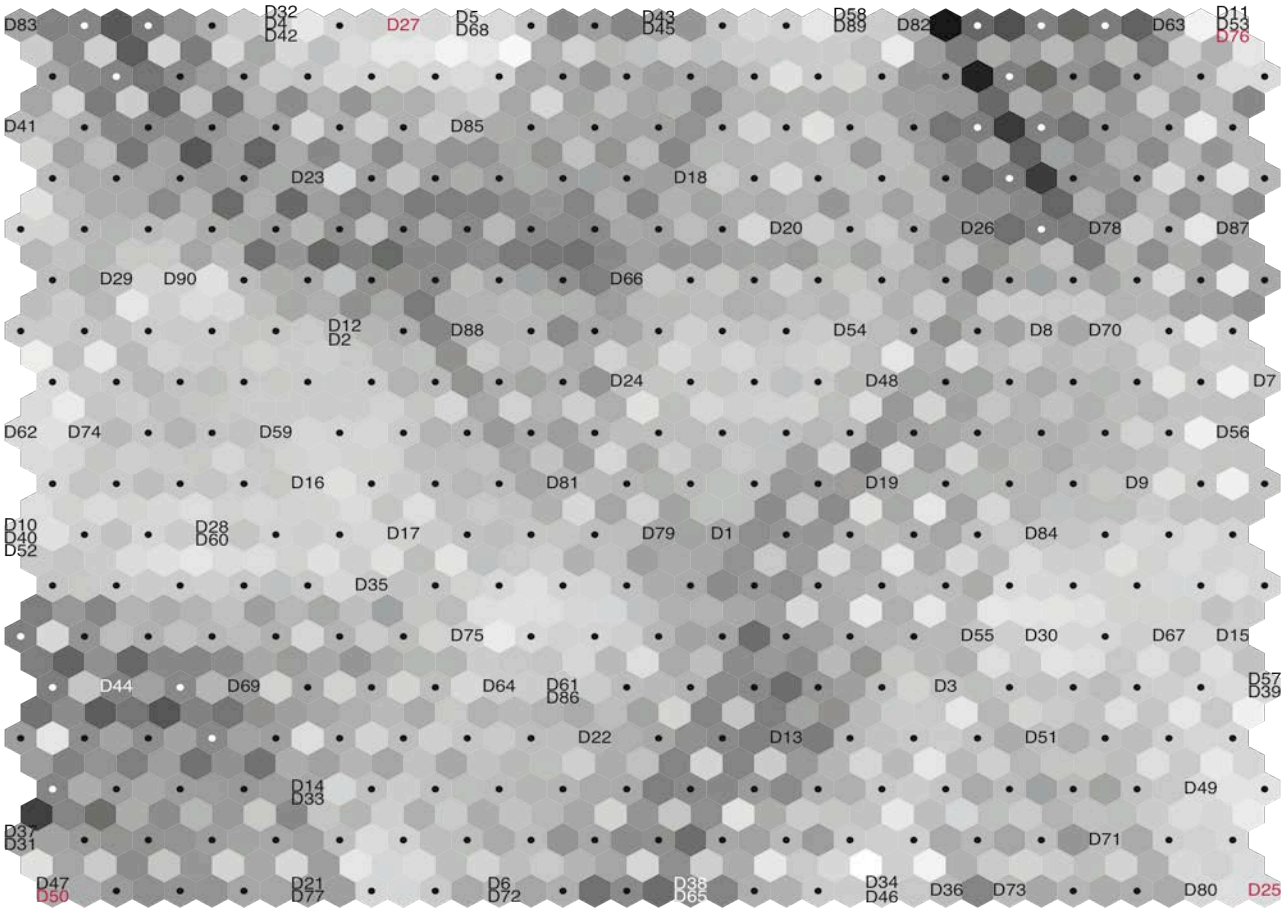

Figure 6: The resulting SOM map of 90 sample walls on 20 × 18 units.



Figure 7: Images allocated around sample D76.

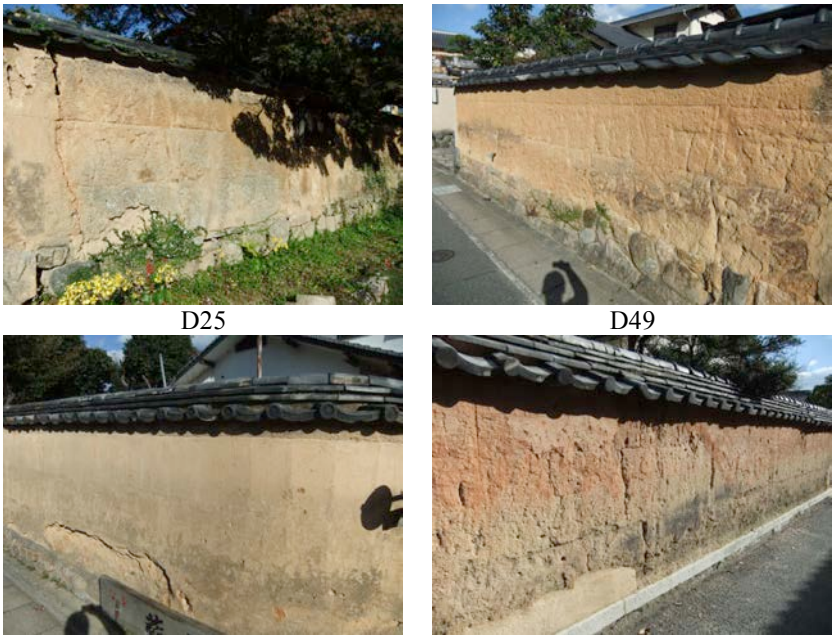

Figure 8: Images allocated around sample D25.

Then, the correlation of the mud wall texture and affectiveness is mapped onto the output units. The map is used as an inference system to define the relationship between texture and affective value, because each unit is quantified by the 19 element values. The computed map can be used for streetscape assessment of the mud walls in Chofu's historic district. It can also be used for streetscape planning or review when building or maintaining mud walls.

5. CONCLUSIONS

The aim of this study was to analyze historic streetscapes in Chofu using affective engineering methodology. The distinctive mud walls are a landmark of the area, with their surfaces exuding a

characteristic atmosphere of red-tinged color. We focused on researching the color effect of the mud wall surfaces. We investigated the color distribution of existing mud walls using display colorimetry with a color correction algorithm. Our investigation confirmed that the color distribution was sufficiently unified at present. We thus, formulated color guidelines using the Munsell color system based on the measured distribution.

Next, we created a SOM mapping through an affective experiment. We found that the SOM map identified the distances between the mud wall textures. A unit of the map also included the element value of the affective evaluation in the form of the location. Consequently, we were able to quantify

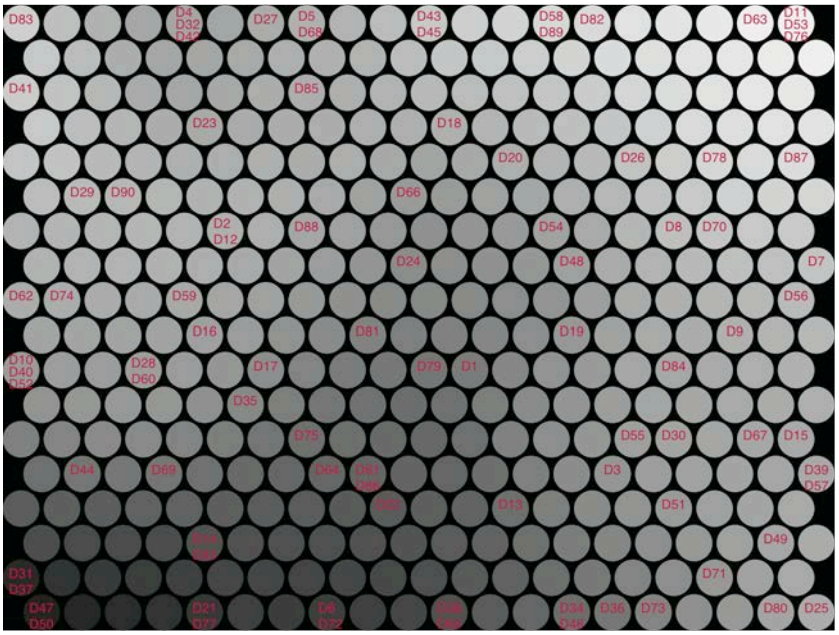

Figure 9: Element plane of the affective words “ugly” – "beautiful”.

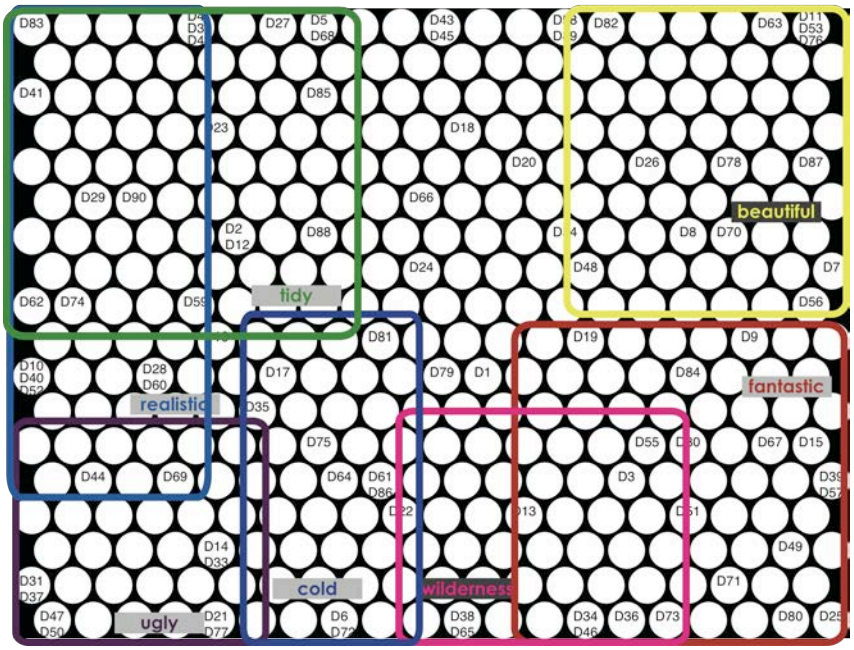

Figure 10: Overlapping affective meanings in the SOM mapping.

the relationship between mud wall texture and affectiveness. The results can be used for streetscaping in Chofu's historic district.

A future issue is the measurement of the distance between wall textures. The Bhattacharyya distance between histograms of texture images was employed in this study. The obtained distribution on the two axes for the criteria is almost square. In other words, samples that are different to both criteria exist. These indefinable samples could not be mapped onto the unit. We therefore need to improve the definition accordingly.

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BIOGRAPHY

Toshio Tsuchiya was educated as a system engineer at Hiroshima University and is currently a professor of Department of International Commerce in the Faculty of Economics at Shimonoseki City University. He received B.S. and M.S. degrees from Hiroshima University in 1990 and 1992 and received Ph.D in Information Engineering from Hiroshima City University in 2006. His research interests include data mining, knowledge engineering, fuzzy set theory and affective/kansei engineering.

3D - Screens 1

Applying Kansei Engineering method on investigating mobile phone's brand image amongst Iranian young designers

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Abstract: As Walter Landor declared “Products are made in the factory, but brands are created in the mind”, brand image in the customer's mind, plays an important role in success of products in today's high-competitive market. With this in mind, the aim of this research is to investigate the brand image of top-selling mobile phone manufacturers amongst a group of young design students in the telecommunication sector of Iranian local market. Iranian population constitutes one of the youngest countries in the world; on the other hand the young designers are generally considered as ICT-savvy individuals that steer the market inclinations. Therefore, this segment of users has been selected as the target group. To achieve the aim of this study, the Kansei Engineering method is utilized for verbalizing the associated qualities of the brand images. To find customer's perception of brand images, 6 brands were chosen respectively as followed in alphabetical order: Apple, HTC, LG, Nokia, Samsung and Sony. According to their relevance for brand characteristics, 30 Kansei pair-words have been selected. In order to analyze the obtained data, one way analysis of variance and factor analysis methods has been used to find the internal relation between the image and the aforementioned Kansei words which are corresponding to psychological mapping of the subject mindset towards these brands. Finally the results of this study can contribute to the market performance of these brands as well as developing a more realistic picture of demographic data of the Iranian young designers.

Keywords: Kansei Engineering, Brand Image, Customer perception, Mobile Phone Market

1. INTRODUCTION TO THE STUDY

In marketing, as one of the main factors of marketing mix, debates related to mental image of a company among different target groups and their emotional responses toward brands, play an important role. Corporates awareness of their brand image among potential and actual audiences in the market, is a valuable input that reveals the compliance rates of their branding strategies and the real facts in the market. This can help companies to define organizational perspectives and strategic plans and draw new horizons for their short term and long term activities. For extraction of mentioned users' emotional reactions to a brand, a specific method is needed for quantifying the qualitative concepts and attributes. One of the suitable methods for extracting and converting the customers' mental and even unconscious feelings and reactions towards brands is Kansei Engineering which is developed in Japan. By applying this method, it would be possible to study and evaluate the emotional reactions in counter with an artifact. Kansei as Nagamachi (2001) stated "is an individual's subjective impression from a certain artifact, environment or situation using all the senses of sight, hearing, feeling, smell, taste as well as recognition".

From philosophical point of view and based on Schütte (2005), Kansei is seen as sensual intuition providing the material for understanding, and through this the mental ability of experiencing affective values like feeling, emotion and desire. Nagamura (1991) brings this into a neuro-physiological context. According to his studies, Kansei is processed by the right half of the brain, processing analogue and fuzzy data while the understanding possessing logical speculative nature is (reason) treated by the left brain side, whose specialization is digital data processing.

Also Lee et al. (2002) studied on 'Kansei' and its counterpart 'Chisei'. Although the concept of Kansei is closely connected to affective, emotional values of human beings, Chisei "works to increase the knowledge or understanding which is measured by verbal descriptions of logical facts" (Lee et al., 2002). Both have in common that they are triggered by a sensory input, which is mapped from both perspectives. The Kansei then builds affection, feelings and emotions, which in turn lead to creativity; the Chisei or reasoning builds logics, recognition and understanding which then become knowledge. Figure 1 displays the ideas of Kansei and Chisei.

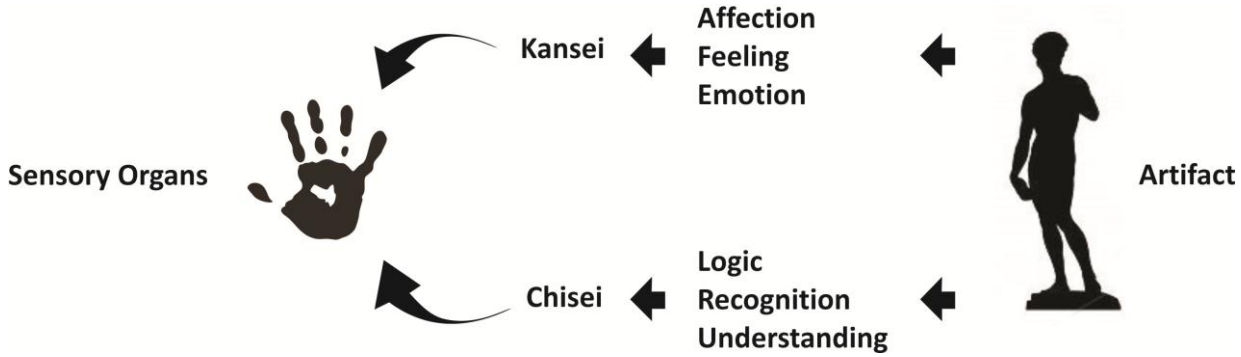

Figure 1: Kansei and Chisei-Based on Schütte (2005)

A practical approach to Kansei in Design world is "Kansei Engineering". Nagamachi was a pioneer researcher in developing of Kansei Engineering in an academic context. His approach was to develop Kansei Engineering as a user-centered approach for translating the human feelings and emotions to tangible outcomes in terms of features and attributes. So, the Kansei which is created in human brain in counter with external stimuli could be measured by Kansei Engineering and

inserted into a system which gives recommendations for Design solutions such as brands, products, etc. The authors named this process as "360° Kansei chain". Figure 2 presents this idea.

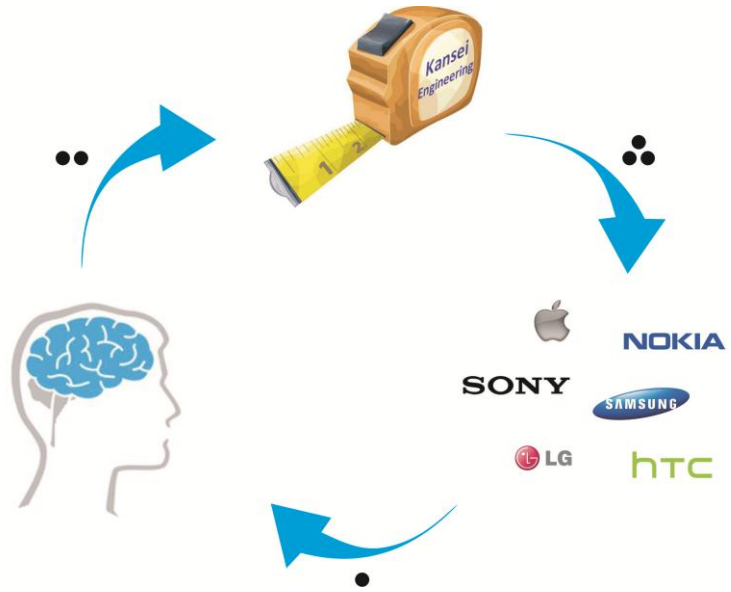

Figure 2: A 360° Kansei chain in branding research methodology

In this study, the mental image of six best-selling mobile phone brands in Iran's market, investigated and analyzed by using Kansei Engineering method. Due to the lack of access to official information and detailed statistics on sales of mobile phones in Iran's market, these six brands, were selected based on a comparative study between various news and information available in some local media such as newspapers and official websites. The figure 3, represents the six brands that were studied in this research.



Figure 3: Six best-selling mobile phone brands in Iran's market (In alphabetical order)

Then, based on some library researches and reviewing previous studies in this field and also with some Focus-groups sessions between the authors and number of Iranian designers and Design professors, several pair-words for brand images, were extracted. After refining these words, finally authors chose 30 Kansei pair-words. Table 1 shows the selected Kansei words.

At the next phase, to evaluate Kansei-words defined in previous phase, the Semantic Differential Method (SD) was used. Each pair-word, were evaluated by an audience for all six selected brands with five degrees valuation method via paper-based questionnaires. Using five degrees in questionnaires, simplified the valuation and evaluation process both for audiences and authors.

In this questionnaire, the participants were asked to evaluate each pair-word separately for each referenced brand, by choosing one of the 5-degree choices. Figure 4 shows a sample of mentioned Semantic Differential method in questionnaires. The target group studied in this

research was one hundred young Industrial Design students. The main reason for choosing these types of audiences was their more relative awareness and sensibility on Design and manufacturing trends of mobile phones. Also according to the existing facilities, the authors preferred to study among a uniform group of mobile phone users. Obviously, the results of this study indicate brand image of this particular segment of the Iran's handset market that enthusiastically follow the latest news and information about different brands and their activities, events and products.

Table 1: Kansei words for evaluating brand images

NO.	Kansei Words	NO.	Kansei Words
1	Funny/Not Funny	16	Exciting/Boring
2	Feminine/Masculine	17	Strong/Weak
3	Future-oriented/Past-oriented	18	Aged/Young
4	Reliable/Unreliable	19	Plain/Gorgeous
5	Durable /Ephemeral	20	Avant-garde/Conservative
6	Experienced/Inexperienced	21	Profound/Superficial
7	Pioneer/Old-fashioned	22	Stable/Unstable
8	Formal/Casual	23	Rich/Poor
9	Modern/Traditional	24	Senior/Junior
10	Excellent/Ordinary	25	Cheap/Expensive
11	Delicate/Rough	26	Trustworthy/Untrustworthy
12	Rational/Emotional	27	Harsh/Soft
13	Innovative/Imitative	28	Classic/Fashionable
14	Credible/Not Credible	29	Global/Local
15	Truthful/Exaggerated	30	Supportive/Unsupportive



Figure 4: A sample of 5-degree Semantic Differential method used in this study

The demographics construction of audiences was included 50 female and 50 male Design students. Six sheets with a specific logo on top of it and 30 pair-words in its bottom, were given to each participant without prioritization and in a random order. This randomization was because of minimizing the possible influence of pre-defined and specific order of brands to the results of the study. After collecting all questionnaires, data extraction phase, was done for each one.

2. RESULTS AND DISCUSSION

This study used a one-way analysis of variance (ANOVA) to examine whether differences existed between the evaluations of the different 6 brands and differences in the evaluations from one brand to another were significant. For post-hoc pair-wise comparisons, we used the Tukey-Kramer Honestly Significantly Different (HSD) test. Table 2 shows the ANOVA results. One-way ANOVA

indicated that differences between 6 brands were significant ($p < 0.0001$). The results of this table clearly show that at least there are significant differences between two brands.

Table 2: The ANOVA results

	SS	df	MS	F	Sig.
Between Groups	68.201	5	13.64	66.188	0
Within Groups	118.703	576	0.206		
Total	186.904	581			

Results of the HSD test (Table 3) revealed a significant difference between the apple and LG, and ($p < 0.05$). On the other hand, the apple brand received the highest evaluations for all questions.

Table 3: Results of the HSD test

	N	Subset for alpha = .05			
		1	2	3	4
LG	100	2.84			
Samsung	100		3.15		
HTC	100			3.38	
Nokia	100			3.42	
Sony	100			3.52	
Apple	100				3.96

Factor analysis has been used in order to find psychological structure of Kansei space. The results of factor analysis are structured by 3 factors (Table 4). In this Table, the bold numbers indicate the groups of associates with factors 1-3. According to Kansei words in first factor, this Kansei space could be represented as ‘Brand Generic Attributes’. The Kansei space of second factor could be represented as ‘Brand Pioneering Qualities’. The third factor consists of Feminine/Masculine, and Funny/Not Funny, and therefore it could be represented as ‘Brand Genus Properties’ Kansei space. These three factors altogether explains 60.55% of the total data.

After extracting data from questionnaires and quantifying them, some charts were drawn for easier analyzing of the results. Comparing these graphs revealed clearly the similarities and differences in brand image among girls and boys. Figures 5 and 6 summarize the overall outcomes of this study in the form of two separate charts for boys and girls. Also, based on these charts and diagrams, the following tips on mobile phone's brand image amongst Iranian young designers were extracted for six best-selling brands in Iran's telecommunication market. This study showed that brands which had not positioned themselves clearly in specific market segment without any competitive advantage would have different and even contradictory brand image between male and female audiences. For example based on the results of the study, there were different mental images between LG and HTC brands among girls and boys. Although HTC is one the 3 preferred brands for girls in the most brand image attributes, the findings showed the reverse brand image for boys. As it is shown in diagrams, HTC is not the favorite brand for boys. Also the same clear difference in brand image between boys and girls, could be mark out for LG brand. For boys, the

brand image of LG was relatively more positive than girls. In most brand image attributes, girls had negative response to LG brand in contrast with boys.

Table 4: The Factor loading of the 30 Kansei words using three factors

Rotated Component Matrix			
	Component		
	1	2	3
Senior/Junior	**0.828**	-0.066	-0.009
Trustworthy/Untrustworthy	**0.82**	0.144	0.012
Credible/Not Credible	**0.815**	0.251	0.042
Experienced/Inexperienced	**0.815**	0.213	-0.031
Reliable/Unreliable	**0.793**	0.21	0.006
Stable/Unstable	**0.779**	0.159	-0.122
Durable /Ephemeral	**0.765**	0.055	-0.111
Truthful/Exaggerated	**0.747**	0.115	-0.124
Strong/Weak	**0.737**	0.333	-0.096
Profound/Superficial	**0.717**	0.255	0.02
Excellent/Ordinary	**0.697**	0.499	0.032
Innovative/Imitative	**0.669**	0.367	0.152
Rich/Poor	**0.665**	0.42	-0.026
Formal/Casual	**0.639**	0.072	-0.266
Global/Local	**0.65**	0.195	0.12
Pioneer/Old-fashioned	0.491	**0.703**	0.083
Modern/Traditional	0.46	**0.701**	0.076
Future-oriented/Past-oriented	0.45	**0.647**	0.221
Exciting/Boring	0.482	**0.639**	0.125
Avant-garde/Conservative	0.341	**0.589**	0.022
Delicate/Rough	0.162	**0.502**	0.512
Feminine/Masculine	-0.099	0.115	**0.802**
Funny/Not Funny	0.308	0.37	**0.603**
Rational/Emotional	0.435	0.015	-0.608
Harsh/Soft	0.343	-0.425	-0.432
Aged/Young	-0.047	-0.764	-0.189
Classic/Fashionable	0.25	-0.718	-0.059
Cheap/Expensive	-0.486	-0.516	-0.011
Plain/Gorgeous	-0.146	-0.501	-0.074
Extraction Method: Principal Component Analysis.			
Rotation Method: Varimax with Kaiser Normalization.			

Also, as participants' first selection, Apple was the most favorite brand for girls than boys; So, as the study proved that, Apple is one of the most feminine brands among 6 brands. Results revealed that Apple was the most feminine and Nokia was the most masculine brands. In contrary with Apple, LG brand had the least attractiveness for both boys and girls. On the other hand, according to the findings of this study, Sony was more popular for boys while HTC is more favorable for girls; So, Sony had a masculine brand image even though HTC had feminine image. From practical point of view, the core message of this result was that Sony and LG could have more focus on

tastes and preferences of females while HTC could concentrate on male interests for expansion of their popularity. Another outcome of this study was that girls had more emotional and intense preferences than boys with more logical and moderate responses to different brands.

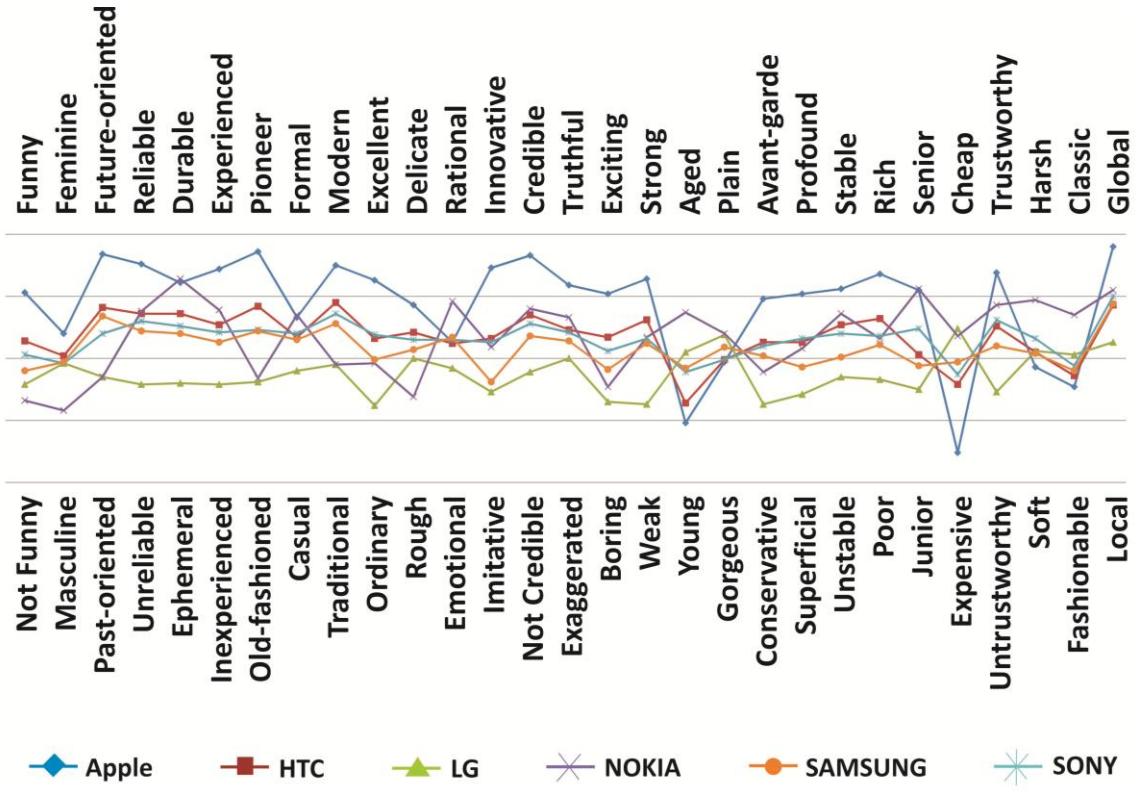

Figure 5: An overall results of the study for girls

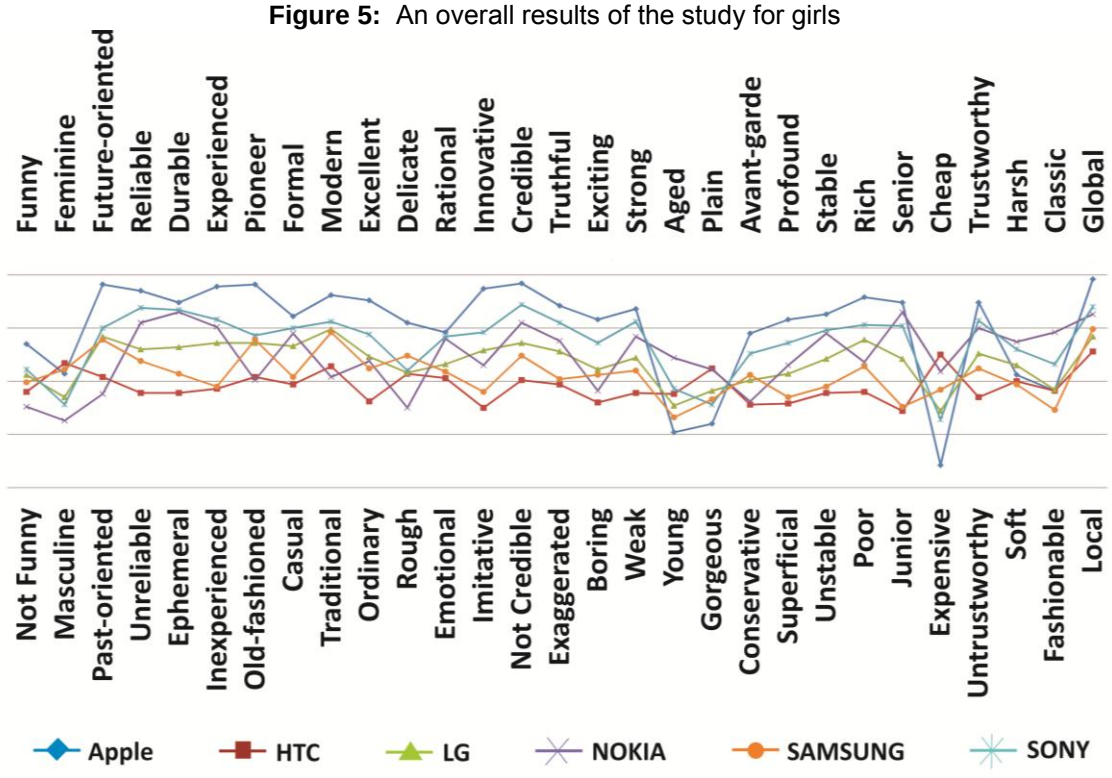

Figure 6: An overall results of the study for boys

Due to the large number of characteristics associated with the brand image, a summary for the results visualized based on selected ten pair-Kansei words in figure 7. As it comes from this figure, meaningful difference in mental image of girls and boys on mobile phone brands, were detectable. But what was clear, stable brand image of Apple almost in every pair-word among girls and boys. According to the survey results, Apple had the most powerful brand image in mobile phone's market amongst Iranian young designers.

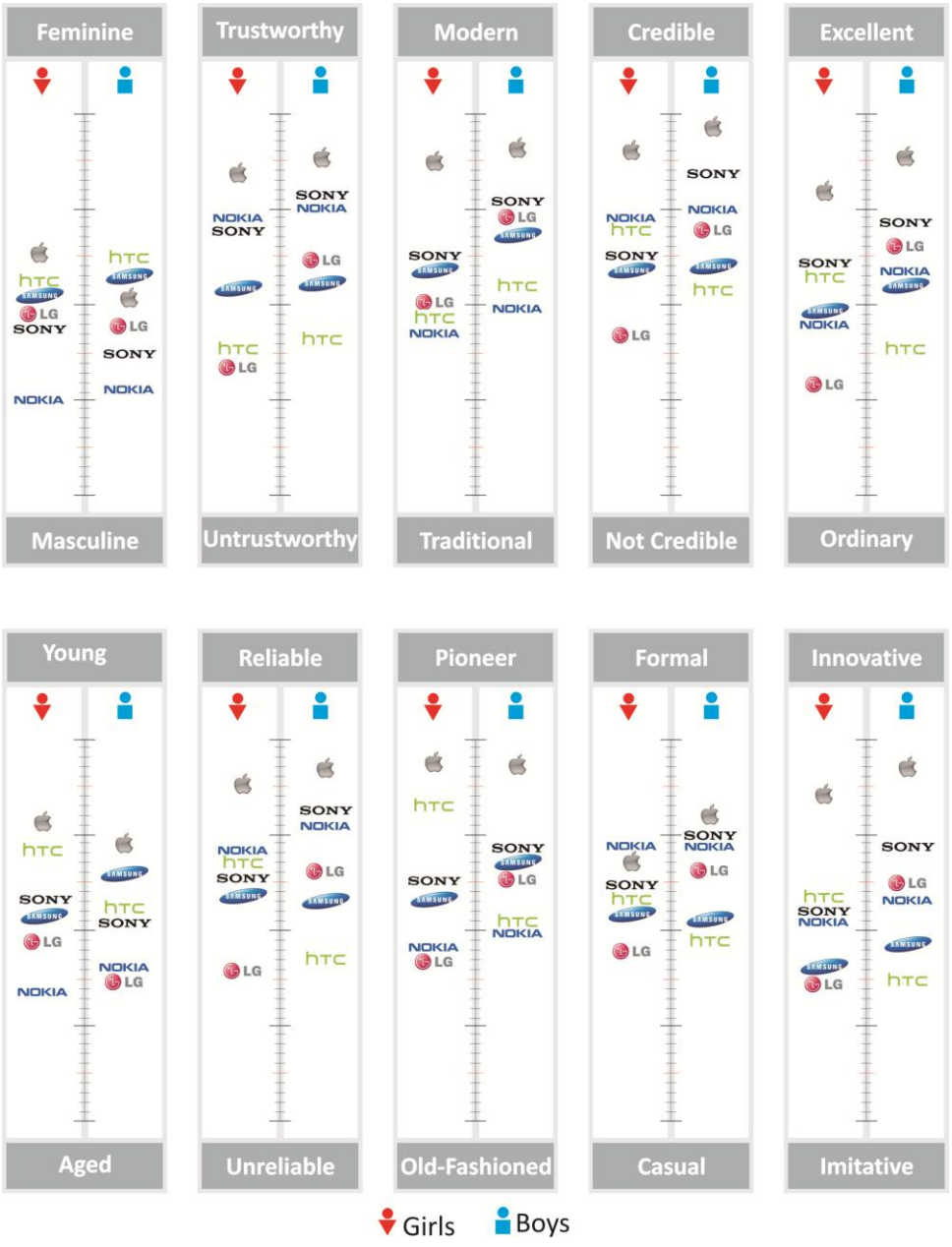

Figure 7: A visualized results of the study for selected Kansei words conclusion

3. CONCLUSION

The results of this study showed that in Iran's mobile phone's market, there is meaningful difference in brand images among boys and girls. Using Kanesi Engineering and the Semantic Differentiation methods, revealed these differences well. On the other hand, it was found that

brands with specific and planned strategies in market, have more sustainable and identical brand image among boys and girls. The result of factor analysis demonstrates that brand image are structured by three factors; 'Brand Generic Attributes', 'Brand Pioneering Qualities', and 'Brand Genus Properties'.

From strategic point of view, this study indicated the typical strengths, weaknesses, opportunities and threats ahead of studied brands. Also it exposed some tips and hints for these brands for empowering their brand images in the market. So, the outcomes of this survey could be used by all six studied brands for developing strategies, new products, marketing campaigns and market segmentation projects at the near future.

At the future, this research could be done for broader target groups in Iran's mobile phone market for extracting the same data and results. Also the same studies could be arranged in further markets such as home appliances, computer products, audio and video products, home furniture, etc. for analyzing the brand image of active companies in mentioned markets.

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BIOGRAPHY

Mehdi A.Fallah received MFA degree in Industrial Design from University of Tehran, Faculty of Fine Arts in 2003. Since then he is faculty member in Design Department, University of Art, Tehran, Iran. He has published three books related to Design Fundamentals. Currently he is educational counselor and official representative of Italian Domus Academy in Iran and responsible for running DA international Design workshops in the country. His research interests include Design Foundation and Design Strategy. Also he has had some Design practices in Street Furniture and Branding Design.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

The Digital Book Design from a point of View of the Universal Design

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Abstract: The average life expectancy extends, independence spiritual not only physically has also become important for the elderly. E-books can be easily adapted for increased visual acuity in the elderly by adjusting the brightness of the font size, font, spacing, screen, etc. In the future, more effort should be applied to improving the applications of E-books for more than just the average person who likes to read. Considering the needs of the elderly in the continued design of the E-book, will greatly add to the value of this device. E-books can make reading more enjoyable for the elderly if they can take advantage of digital device reading. However, the needs of the elderly are not met sufficiently in the existing E-book. This study proposes a design for the E-book that the elderly can easily use and clarifies the elements that affect operability. It is hoped that designing the E-book in consideration for the elderly and further development of the E-book market will lead to an increase in the elderly population taking advantage of this digital device.

Keywords: Elderly people, E-book, Interface Design, Universal Design

1. Introduction

The issue of the elderly is advancing in Japan. The average life expectancy has increased. Spiritual as well as physical independence has become very important for the elderly. Daily leisure activities are needed to feel purposeful in life. According to a countrywide survey, more than 50% of elderly feel more purposeful when absorbed in activities. One of the hobbies that the elderly are doing specifically is reading. However, the amount of reading has decreased due to physical decline, loss of vision due to aging, and the increasing popularity of new hobbies and entertainment. With the spread of smartphones and tablets, the E-book market is expanding. E-books can be easily adapted for increased visual acuity in the elderly by adjusting the brightness of the font size, font, spacing, screen, etc. However, it is hard to say if the current E-book meets the needs of senior citizens considering there are preferences for both hard and soft surfaces. In this research, we focus on the reading behavior of the elderly with regard to E-books and reveal

what elements affect usability.

2. E-book use of the elderly

The E-book market has progressed rapidly and has been attracting attention. There are many benefits for the elderly. The small characters in books and the like contribute to the decline in eyesight in the elderly. With E-books, it is possible to adjust the size of characters freely. It is also possible to change the brightness of the line spacing font, margins, and the screen; it is possible to optimize their readability. In addition, it is assumed for E-book-only reader, are specializing in one function called “read a book,” and there is no complexity, pick up willingly in the elderly are not familiar with digital device. In addition, the accessibility of the E-book is ideal for those with limited mobility. The elderly who are unable to go to the library or bookstore can purchase E-books can while at home. However, the number of people who are using it actually is small at present. If you look at the E-book utilization by age, utilization of this resource is highest among those in the 20-year range. As age increases, the utilization of E-books actually decreases (Figure 3-10).

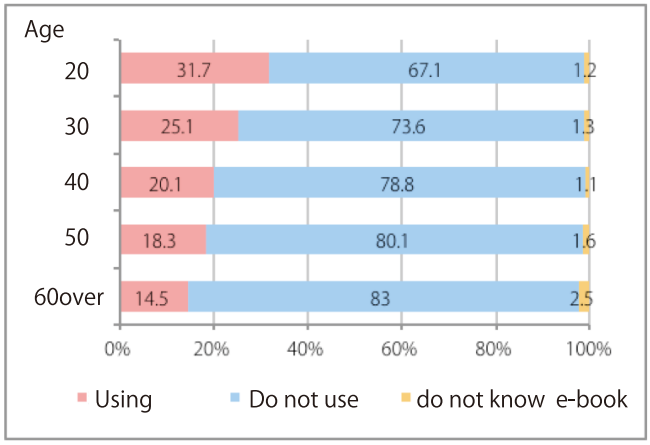


Figure1: By age E-book utilization

We can conclude that while there is widespread use of this device among young people, it is still a neglected activity among the elderly. In fact, the E-book as it stands currently is not fully meeting the needs of senior citizens whose preference fluctuates between books with hard and soft surfaces. In the future, more effort should be applied to improving the applications of E-books for more than just the average person who likes to read. Considering the needs of the elderly in the continued design of the E-book, will greatly add to the value of this device.

3. Awareness survey of E-book and the use of ICT for the elderly

3.1. Research plan

In order to understand the awareness of E-books and the use of ICT in the elderly, we conducted a questionnaire survey. By performing an impression evaluation of existing E-book readers, the analysis revealed opinions of the overall operation of the E-book. Further, a behavioral analysis was performed to characterize the actions of the elderly when reading E-books.

3.2. Survey on E-book and use of ICT(Information Communication Technology) for the elderly

In order to investigate the awareness of E-books and the status of ICT used to target the elderly, we conducted a questionnaire. The questionnaire was conducted in order to understand the current state of the relationship with ICT in the elderly population. We also investigated reading habits of the elderly.

3.2.1. Investigative method

1）Subjects: Twenty-eight university graduates (65 years of age or older)
2）Survey items: PC and Internet use, questions about the E-book

3.2.2. Survey results

There is experience with PCs and the Internet (Figure2) in about 90% or more of the participants in the investigation. The response “had used at work” was the highest (19 people). It is considered to be routinely utilized because 20 out of 28 people use it daily on the job. Using a terminal to access the Internet was most frequent (multiple answers allowed), with 28 people using a personal computer. Six people use smartphones and tablets in the experiments, and is higher than the rate of possession of the same age. People cite tablets, smartphones, and terminal use as something for the future and also show interest in newly developed devices.

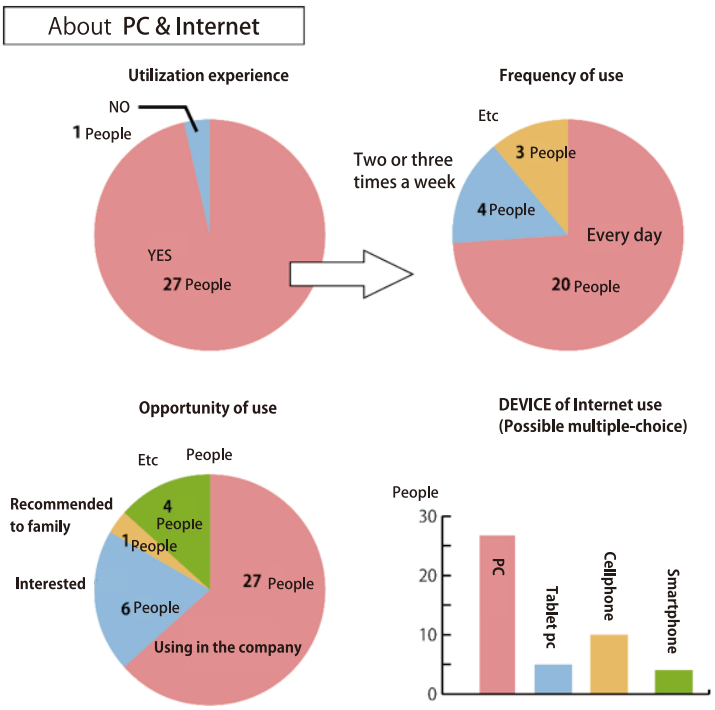


Figure2: Survey results on the PC & Internet

According to the survey results (Figure3), all respondents are aware of the E-book. However, 4 in 28 people actually use it. Personal computer, tablet, smart phone has been mentioned terminal utilizing the E-book. When asked the reason they do not use E-books, the answers obtained were “I like paper books” (17 people) and “seems Unreadable E-books“ (7 people).

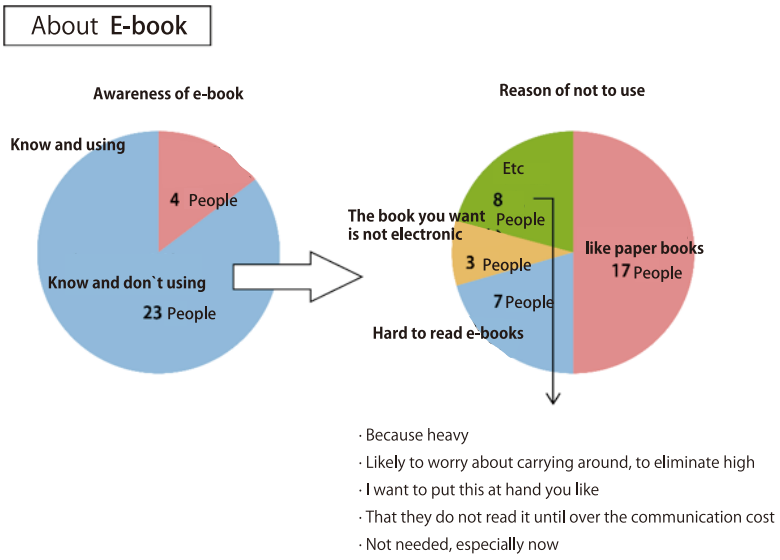


Figure3: Survey on E-book

When asked about everyday reading habits (Figure4), 13 people answered that they read 2-3 books in one month, and 7 answered that they read 1 book per month. From this, we have determined that older people engage in a certain amount of reading in many cases. When asked about where they read, 12 people answered, “Train or Bus” and 1 person answered, “My room.” We can conclude that most people combine reading and travel time.

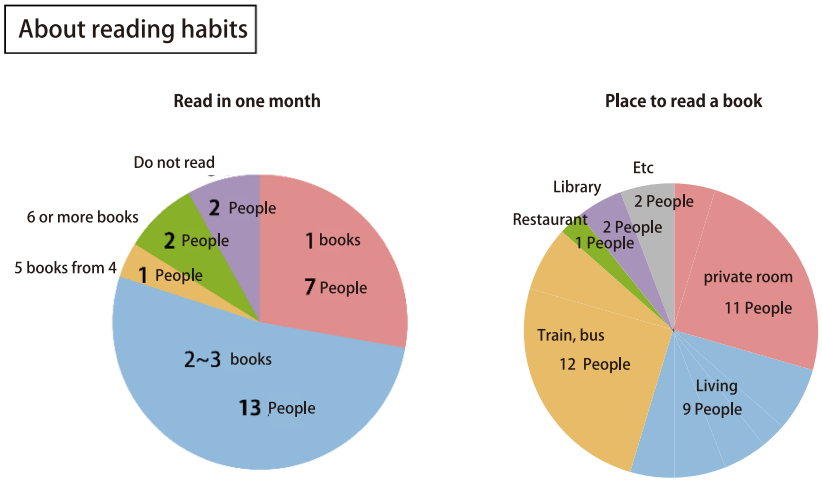


Figure4: Questionnaire results on the reading habits

3.2.3 Summary of survey results

From the above results, it is evident that many older people are familiar with the personal computer due to computer usage in the workplace. The number of people who use smartphones and tablets is not significant, but the responses indicate a desire to use them in the future. All respondents are familiar with E-books; however, the number of people in this population who use the devices is relatively small. We considered the convenience of E-book is not well understood, and the attachment to paper books is due to the preconception that it is more difficult to use the

E-books. In the questionnaire regarding reading habits, 24 out of 28 people responded that they found the following review helpful (two people did not respond). The results do show that that the elderly enjoy reading as a habit.

4. Impression evaluation experiment of E-book reader

We performed the experiment to investigate the impressions of the elderly population regarding the ease of use of the E-book reader.

4.1. Experimental method

1)Subjects：68 years to 79 years of age（7 males）

2)Experiment content : The questionnaire on the E-book reader evaluates the respondents' impressions in five stages. We selected these based on the "telecommunications accessibility guidelines in consideration for elderly persons and persons with disabilities, etc." The evaluation items used were three models of Kindle E-book reader top selling (Amazon), Kobo (Rakuten) Reader, and (SONY).

3)Use of equipment : The figure below shows the details of the E-book reader that was used in the experiment.

Table1: List of E-book readers

Model	photo	size	display size	weight	location of power	Aspect ratio
Kindle Paperwhite (Amazon)		169 x 117 x 9.1mm	6 inch	213g	 Lower body	1 : 1.44
Reader (SONY)		110 x 173.3 x 10mm	6 inch	164g	 Lower body	1 : 1.58
Kobo (楽天)		114 x 157 x 10mm	6 inch	185g	 Upper body	1 : 1.38

4)Property of the subjects: the figure below the attributes of the subject.

Table2: Attributes of the subject

subject	sex	age	job	Experience of PC use	Frequency of PC use	Period of PC use
A	male	68	Unemployed	yes	2-3 times / week	2-5 years
B	male	77	Unemployed	yes	2-3 times / week	Over ten years
C	male	79	Unemployed	yes	Every day	Over ten years
D	male	66	Unemployed	yes	Every day	Over ten years
E	male	72	Company employee	yes	Every day	5 -10 years
F	male	69	Unemployed	yes	2-3 times / week	5 -10 years
G	male	68	Unemployed	yes	Every day	Over ten years

4.2. Result

For operation of the three models of E-book reader, I asked the subjects to evaluate the impression in five steps. The outcome measures were set as the following characteristics: easy to hold or difficult to hold / light / heavy, large / small, easy to push it or hard to push / easy to understand or confusing / safety / risk, the seven items of one hand / both hands. Questions were asked regarding activating the power button—easy to push or hard to push— and if one or both hands were used. The graph shows average score PC frequency of use for each item and PC use life for each device (Figure5).

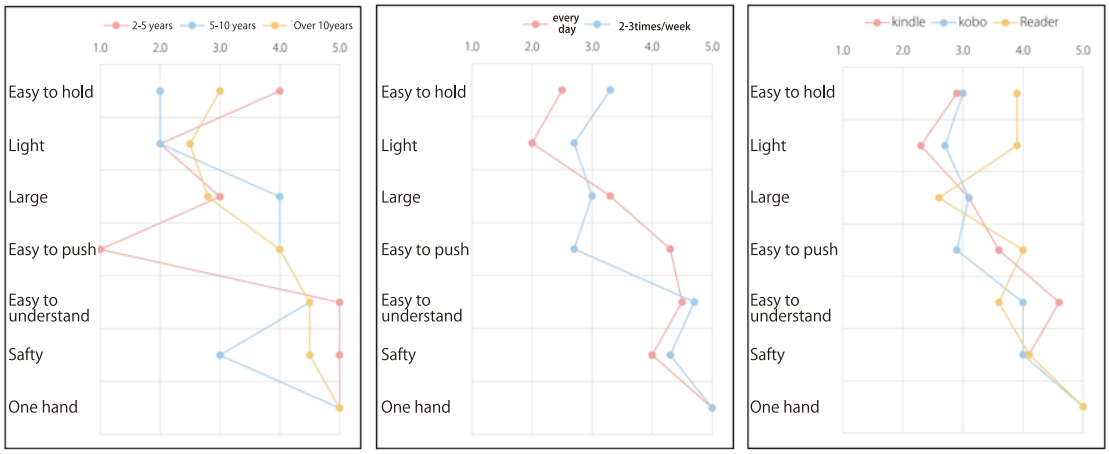


Figure5: The average score of the impression evaluation

●Analysis of variance

Frequency of PC use and the number of years for each device were subjected to analysis of variance to verify significant differences obtained. As a result, “PC frequency of use - easy to push,” “PC use the number of years - Safety” and - significant difference was observed in the “Device light” ($p < 0.05$). The items covering use by one or both hand were evaluated by the same score and were excluded from the analysis.

Table3: Results of analysis of variance

	Frequency of PC use	Period of PC use	Device
Easy to hold	n.s.	n.s.	n.s.
Light	n.s.	n.s.	p<0.05
Large	n.s.	n.s.	n.s.
Easy to push	p<0.05	n.s.	n.s.
Easy to understand	n.s.	n.s.	n.s.
Safty	n.s.	p<0.05	n.s.

1）”Easy to push” and “PC usage frequency”

We concluded that there is a tendency among people who have infrequent PC (or other digital equipment) usage to find the operation of E-books more difficult and to have problems turning the power off and on. Conversely, people who utilize a PC more frequently stated that the power button was “easy to push.”

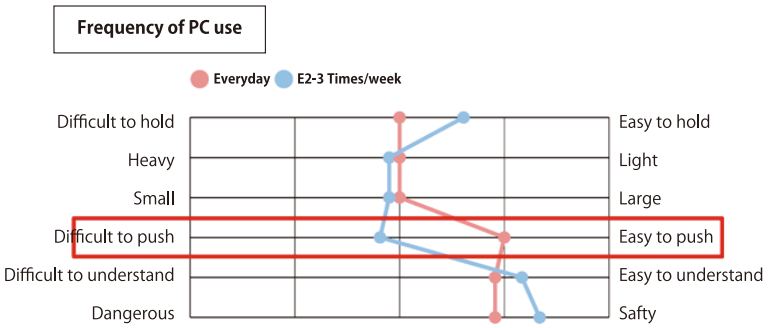


Figure6: Easy to push - PC usage frequency

2）"PC use the number of years" and "safety"

We considered that confidence in the safety of digital equipment is dependent upon length of experience; beginners attach greater importance to safety.

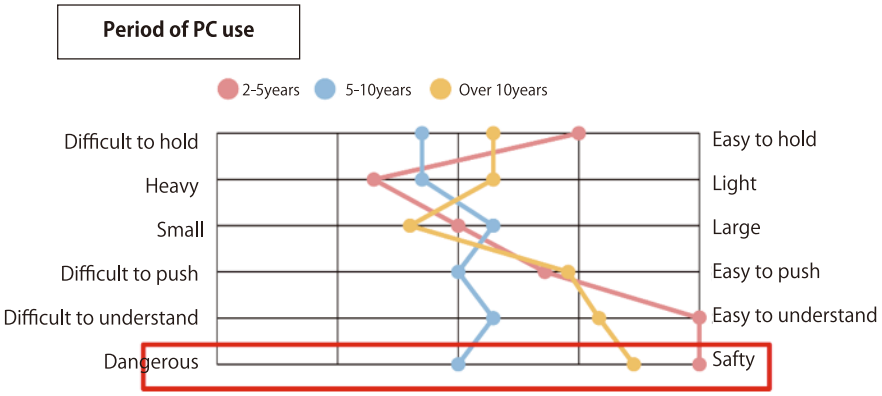


Figure7: PC use life - Safety

3）Device weight

For the weight of the device was found to greatly affect the perception of the usability when there is even a slight difference in weight. The weight of the Reader and the Kindle is a difference of about 50g, but this made a major difference on the evaluation. In other words, weight is a significant factor regarding usability for this population.

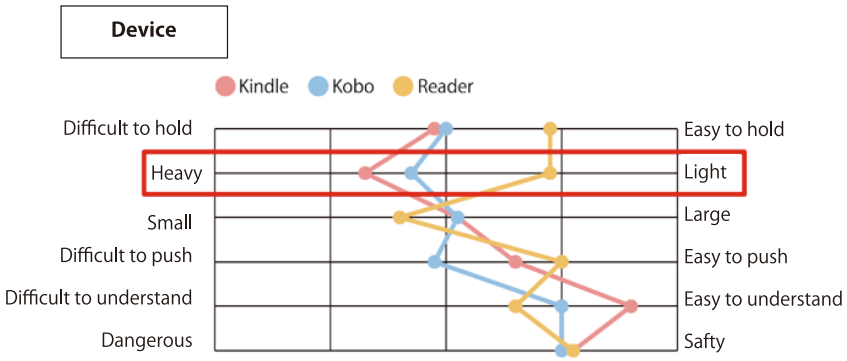


Figure8: Device - Light

・Principal component analysis

The overall operation of the E-book reader was subjected to principal component analysis. As a result, the main component of the two was obtained.

Table4: Result of principal component analysis

	The first principal component	The second principal component
Easy to hold	0.547	-0.102
Light	0.411	-0.376
Large	-0.503	0.134
Easy to push	0.230	0.059
Easy to understand	0.065	0.789
Safty	0.471	0.451

The first principal component included the following characteristics: “easy to hold,” “light,” “large,” and “operation of the hardware surface” of the E-book. The second principal component represents the “clarity of the software surface.” It was found that the hardware and software are not easy to understand in the operation of the E-book reader. In order to improve operability, it is necessary to consider both hardware and software.

5. Behavior observation experiment

The objective was to observe the characteristics of the actions of the elderly in operating the E-book.

5.1. Method

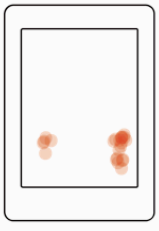
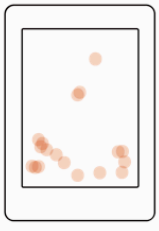
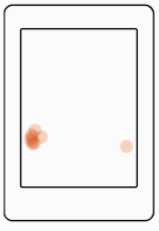
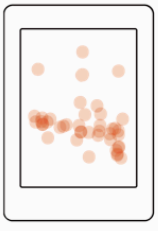
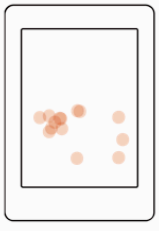
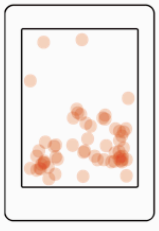
1) Subjects：68 years to 79 years（6 males）

2) Experiment content： We utilized a video camera to observe how the subject operated an E-book reader (kindle) without instruction.

5.2. Result

We used a video camera to observe how the subject operates an electronic book. We have summarized in the following table and record of action, the distribution map of the screen t ap position.

Table5: Record table of behavior observation

subject	A	B	C	D	E	F
age	77	68	79	72	69	68
sex	male	male	male	male	male	male
frequency of use pc	2-3 times/week	2-3 times/week	every day	every day	2-3 times/week	every day
period of pc use	over 10 years	2-5 years	over 10 years	5-10 years	5-10 years	over 10 years
position of the tapping						
used hand	Right hand	Right hand	Right hand	Right hand	Right hand	Right hand
Finger	Index finger	Index finger,Middle finger	Index finger	Thumb, Index finger	Index finger	Index finger,Middle finger
How to hold	左手で持つ 背面全体を覆う	左手で持つ 右手を添える	テーブルに完全に置く 左手を添える	左手で持つ 背面全体を覆う	左手で持つ 背面全体を覆う	左手で持つ 背面全体を覆う
Table	×	△	○	×	×	×
Menu	×	×	×	×	×	○

5.3 Discussion

Regarding the soft surface of the E-book, the elderly are not familiar with the touch panel operation or the “pinch out to enlarge” function. The menu screen that requires a tap and swipe motion to activate the screen was also elusive for the subject. While it may be natural for younger people who are familiar with these functions, the actions are not understood by the elderly. It was difficult for the subject to hold the device as well because of the hard uneven surface with no depth to the device. In addition, we found that two elements of hardware and software affect the operability of the analysis results. In order to improve operability, it is necessary to satisfy both elements. From the research results, we have determined that incorporating the behavior of real paper books with the technology of an E-book would make a real difference as regards usability for this population. We propose that the interface of an E-book should have a page turning function similar to that of actually turning pages when reading paper books and other print media.

6. Conclusion

It is important for the elderly to maintain active lives in order to have a purpose in life. E-books can make reading more enjoyable for the elderly if they can take advantage of digital device reading. However, the needs of the elderly are not met sufficiently in the existing E-book. This study proposes a design for the E-book that the elderly can easily use and clarifies the elements that affect operability. In order to understand the status of ICT use and the awareness of E-books in the elderly, we conducted a questionnaire survey. As a result, we found there is a significant amount of the personal computer experience among many older people, especially for use of at work. However, although the awareness of E-books is high, usage is minimal due to an attachment to paper books. The perception is that it is difficult to use E-books. Next, we investigated the impressions of the elderly using an impression evaluation experiment. The results of the analysis show that in order to improve operability, it is necessary to consider changes in both hardware and software. The weight of the device has a major influence on the perception of ease of use for the device. Further, it is easy to use regardless of the difference in the experience with ICT device is also important. The behavior experiments conducted in order to clarify the characteristics of the behavior of the elderly have shown that the elderly attempt to read electronic books in the same manner they would read a paper book. The result is uncomfortable because they cannot read the E-book as smoothly as a paper book; the touch screen is still something they are not familiar with.
From the above experimental results, as an important element in operability, (1) easy to use for both hardware and software, (2) easy to use regardless of the difference in use experience and (3) gap between paper books is less. It is hoped that designing the E-book in consideration for the elderly and further development of the E-book market will lead to an increase in the elderly population taking advantage of this digital device.

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Consumers' Emotional Responses to Product's Color and Texture by Using LCD Back Cover as An Example

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Abstract: Because the living standard is improving gradually, the consumers' demand has changed from the satisfaction of product function to the satisfaction of product image. And the purchase intention has also changed from "needs" to "wants". In addition, previous research suggests that the consumer's emotion would guide them to make a choice among many products (Helander and Khalid, 2006). Moreover, Norman (2004) particularly illustrates the importance of the "emotion" in his book Emotional Design that consumers' emotion has been affected by the product appearance when the first time they see it. Previous researchers concluded that the important features of the product appearance are Color, Material, and Finishing (King, Yu, Lee, & Jiang, 2011). Thus, this study will discuss how these product features, on laptop LCD back cover as an example, would affect the emotion when consumers see them.

Since the LCD back cover is the most important part to demonstrate the product and brand images, this research would use Laptop LCD Back Cover as example to discuss about it. However, considering that the selections of material are mostly limited to aluminum and ABS plastic when manufacturing the back cover since the company has to consider about the processing cost of the

chosen material and the cooling of the LCD module. Moreover, the use of the material will directly affect the color that consumer see. Thus, in the discussing of visual perception, this study merges the features of material with color and discusses the color and surface texture issues only. In this study we used in-depth interview visit six subjects, 3males and 3 females. After the visit would generalize the interactions between textures and colors.

Keywords: Emotion, Color, Texture, laptop, LCD back cover

1. INDURDUCTION

1.1. Background and Motivation

The appearance of a product consists of three main elements: color, texture and shape (Asakura, 1992). These three elements are important factors affecting the perception of people. Because laptops have little change in shape, we excluded it in the consideration of the research scope of this research. However, all of existing studies emphasis on single factor research, so it lacks the complete description of color and texture together, (Chang, 2004). The texture and color influence each other. The preview study indicated that the feeling of color must be accompanied by the texture. More precisely, human perception of color is inseparable from texture on the appearance of the product (Lin, 1998). Thus this study aimed to investigate the effects of texture and color, two factors applied on consumer product, by using laptops as an example.

Leatrice Eiseman is called America's color guru, who says that color can dominate attention of consumers and cause their emotional reactions. In addition, preview study suggests that products' color not only show the performance of products, but also pass itself rational and emotional significance (Peng, 2009). However, designer might just focus on beautiful color or the trend of color sometimes, which does not correspond to consumers' favorite while doing product color planning.

In terms of color, past studies have pointed out that color is the most influential product attribute for consumers. Color preference influences judgments of consumers and plays an important role to stimulate consumption. In Kuo (2009) paper indicates that consumer preferences are using low Chroma color as one of the color combination. However, in his study treated achromatic color as part of low Chroma (e.g., black is the combination of low Chroma and low

value). Currently mobile phones with achromatic color matching is the mainstream product in the market. In order to consider the consumer's attention to low Chroma, there will be further discussion about chromatic color and achromatic color separately, which is the consumer preference. Therefore, in this study, we would investigate consumer preference between chromatic color and achromatic color.

Texture is the surface of object and affects the overall quality. It has a close relationship to our touches (horn, 1974). Texture is also one of the characteristics to determine the material surface with form and color are the element of molding (Chen, 2001). According to Kim (2011), appearance is an important thing to innovative products, and it is deeply influenced by three main elements: Color, Material and Finishing. Chen (2011) says the texture of the product is dependent on the material and finishing, which make the texture to show the value of the product. Hence, this study would combine the "Material" and "Finishing" to the "Texture" to discuss.

The market is flooded with various styles of products. When consumers want to buy a commodity, they would be influenced by the product's attribute (e.g., performance, price, form and color, etc.). Asakura says that the appearance of a product consists of three main elements: color, texture and form (Asakura, 1992). Though form is important to product, but human visual perception of color is higher than it. That is, in general, the emotional impact of color is quicker and stronger than form (Lin, 1993). Therefore, in this research, the form factor is not considered. We will keep it to the follow-up research further in-depth comparison. As for Texture, Lin suggests that the feeling of color most be accompanied by texture. To be more precisely, human perception of color is inseparable from texture on the appearance of the product (Lin, 1998). Therefore, this research will explore the Consumer-generated emotional impact on color and texture of the product surface.

As the advancement of technology gradually, product lifecycle has grown into maturity. Laptop has become general consumer product. With the laptop market expansion, the competition of this product is much more intense. Consumer demands on product functionality are satisfied, so they become care about the product's appearance. Therefore, the companies continue to push out the old and bring in the new by giving the color and texture of some changes in laptop. Not only do they provide consumers the adequate functionality and friendly interface, but they also offer emotional value and make it like a work of art.

Lin (2011) suggests that significance of consumption have grown from satisfying the basic needs

only to seeking personal style reflections and the value of life. According to Chen (2010), LCD back cover has the largest area in the whole appearance of the laptop. It is not only the part which best shows the feature of the laptop but also the part that consumers care about most.

In order to get to know the image by matching color and texture with the LCD back cover much better, this study would use in-depth interview to explore the consumer feeling. In-depth interview is one of the data collection methods of qualitative research. It exchanges views between the interviewer and the respondent by oral conversations and helps the experimenter to understand what the subject thoughts are. The interviewer could analyze respondent's ideas through the interview. The purpose of this research is to explore the consumer preferences and emotions about the interaction between color and texture, which are two main factors of laptop LCD back cover. Trying to find out the reasons for why the preference increase or decrease and exploring consumer emotion by matching color and texture with the Laptop LCD back cover are the major issues in the research.

Semi-structured interviews are equally rigorous and standardized like structured interview, with the interviewer control on the structure of the interview. But respondents, instead, have freedom to express their views and opinions. Therefore this study would use this method and discuss with the respondent with the prepared questions. It allows the respondent to express their inner thoughts freely. The interviewer should encourage them to think deeper to get the real demands.

1.2. Research Scope

Selected samples

In this study, refer to Bai (2010) he suggests the product texture classification which divide the texture of product into 3 categories and 15 subcategories. The 15 Subcategories contains shiny metal, metal hairline, matte metal, circular brushed metal, glossy plastic, matte plastic, brushed plastic, pearl paint with plastic, embossed plastic, rubber, wood, leather, fabrics, carbon fiber, composite materials（see figure1）.

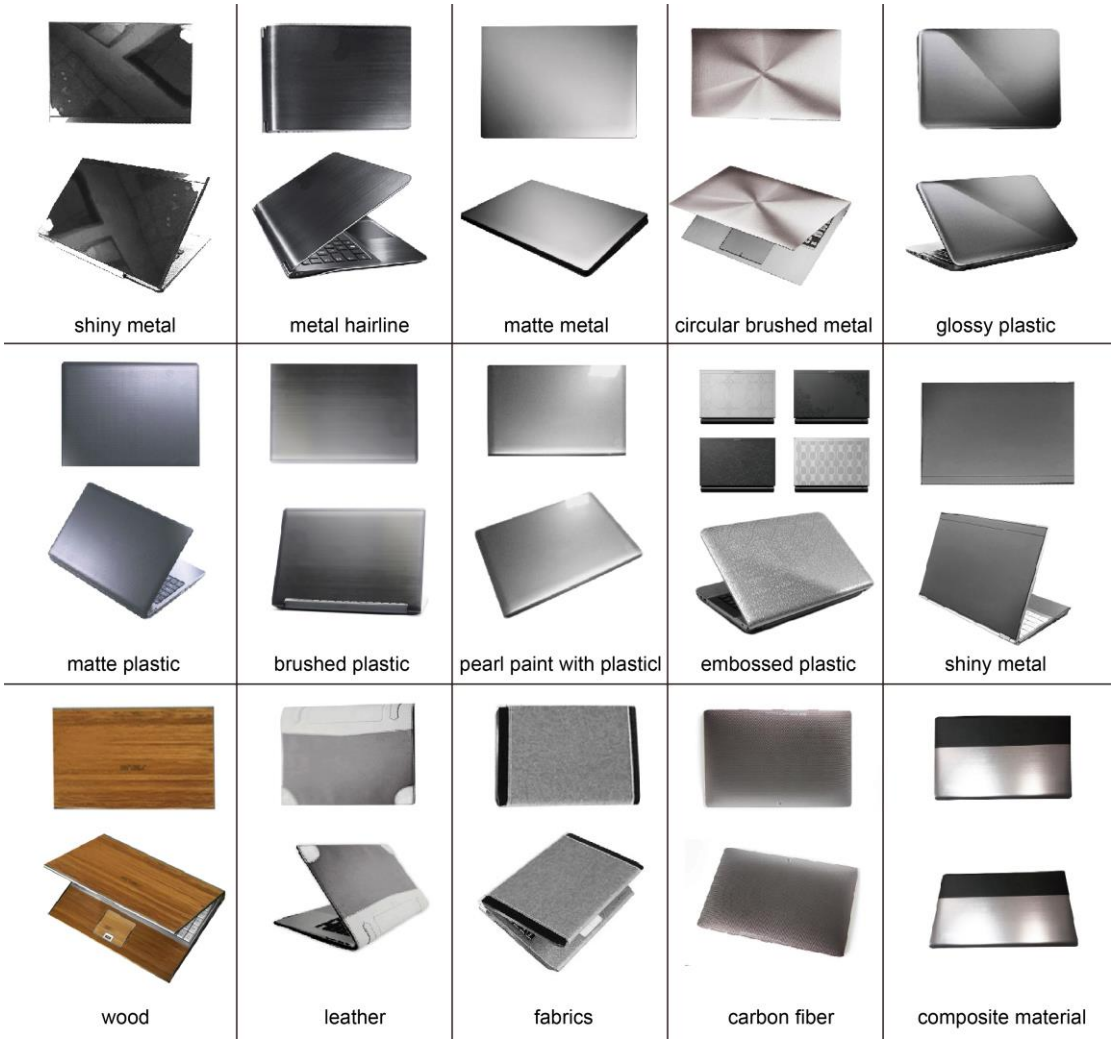


Figure1: Laptop LCD back cover's texture samples

In terms of color, Practical Color Co-ordinate System (PCCS) is a practical color matching system by Japan Color Research Institute in 1965.

Comprehensive three attributes of color from Munsell and the structure of Oswald. The color system is based on the three additive primary colors (RGB) and the three subtractive primary colors (CMY). The PCCS contains four primary psychology colors, makes the color system have more specific concept in color planning. PCCS combine the Value and Chroma to the "Tone" and can express color more effective in the future. Therefore, this research would use the PCCS 24 color wheel (see figure 2) and PCCS 12 Tone (see figure 3) for subject to select.

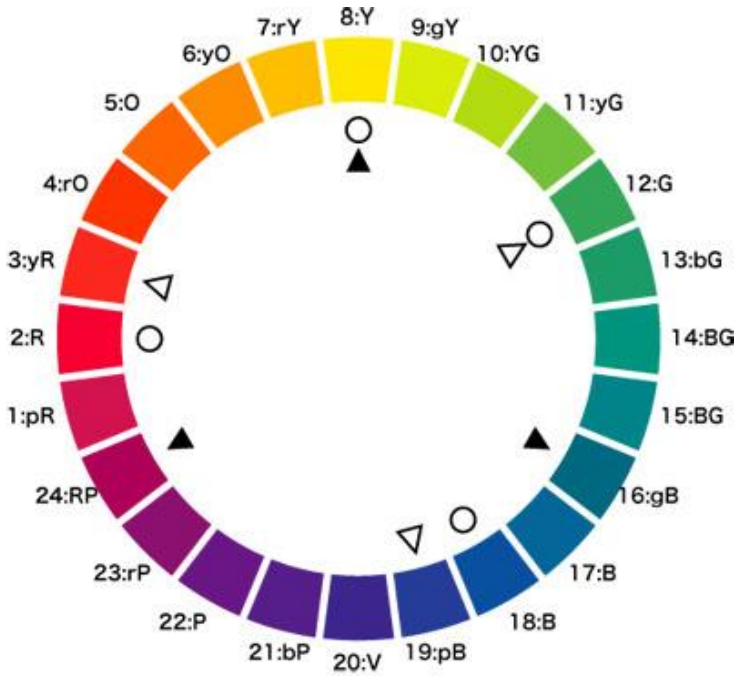


Figure 2: PCCS 24 Hue color wheel

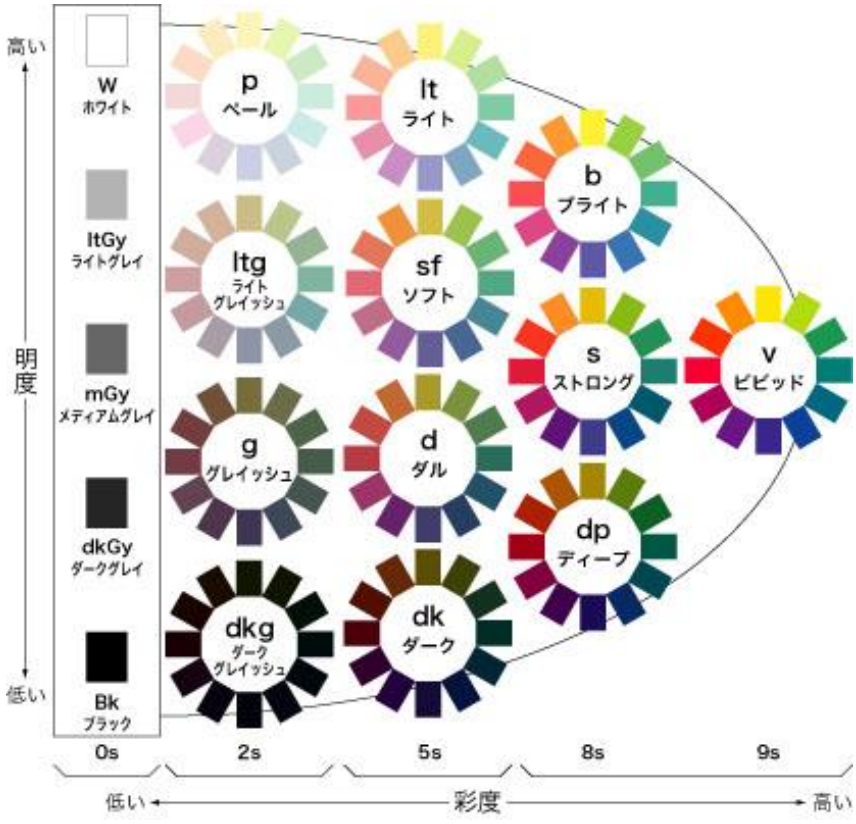


Figure 3: PCCS 12 Tone

2. EXPERIMENTAL

In this research would interviews six subjects and included three male and three female, with semi-structured interview and asking them the preference for these 15 laptop LCD back cover's texture samples and the preference for the Hue from PCCS 24 Hue color wheel and the preference for the Tone from PCCS 12 Tone. Then, generalize the subjects' emotional interactions from matching color and texture with laptop LCD back cover.

Empirical approach

(a) Subjects have to choose the favorite texture and the least favorite texture among those laptop LCD back cover's texture cards. The subjects have to explain why.

(b) Subjects have to choose the favorite hue and the least favorite hue by the PCCS 24 Hue color wheel. The subjects have to explain why.

(c) Subjects have to choose the favorite tone and the least favorite tone by the PCCS 12 tone. The subjects have to explain why.

(d) Experimenter simulated the matching from hue, tone and texture with Laptop LCD Back Cover on the computer make subjects say their feeling and preference. There are 12 parts among this step.

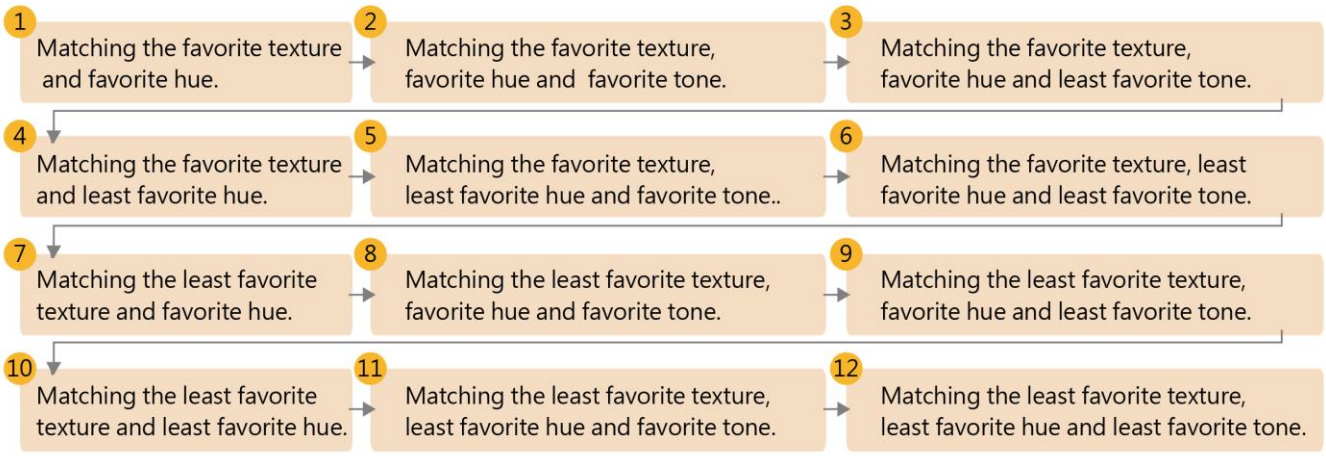


Figure 4: Experimenter simulates the matching of texture and color with laptop LCD back cover on computer.

3. RESULT

Subjects choose the favorite texture and least favorite texture from the laptop LCD back cover's texture samples and explain the reasons, then choose the favorite hue and least favorite hue from PCCS 24 color wheel, Finally choose the favorite tone and least favorite tone from PCCS 12 tone. The following table is each subject favorite and least favorite texture, hue and tone. Table1 is subjects favorite color, hue and tone and the reason.

Table 1: the subjects favorite texture, hue and tone and the reason.

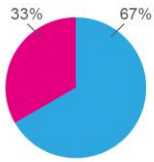
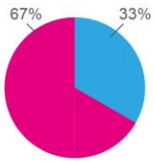
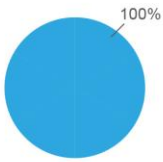
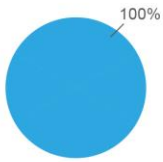
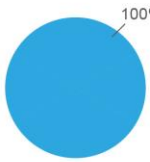
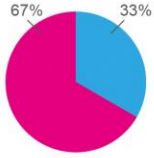
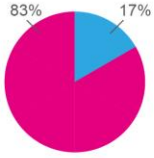
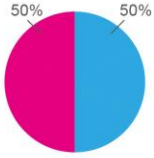
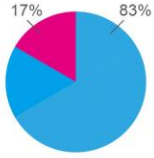
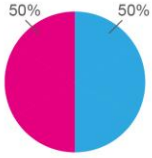
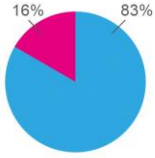
	The favorite texture	The reason for	The favorite hue	The reason for	The favorite tone	The reason for
subject 1	wood	Technology products with wood texture would feel more warm, and make technological sense less / wood : high-quality and relaxing and special / high-quality is the key to buy a laptop / relaxed feeling, good close	7:ry	Warm and bright make people feel happy / cheerful / positive color/ soft color.	Light (lt)	Lighter / more relaxed and casual
subject 2	metal hairline	High quality /when you are working will feel more effective / make users feel great confidence in this laptop/ cool feeling tools make people feel more efficient in work	10:yg	The color seems like grass/ nature / relaxed feeling / young feeling	Pale (p)	make thing feeling very light
subject 3	shiny metal	Looks very clean/ very fashion / fashion is the key to buy a laptop	9:gy	Nature /energetic / comfortable	Light grayish (ltg)	Refreshing/ harmless /less vivid looks more comfortable

subject 4	metal hairline	High-quality, introverted, calm / feel things have efficiency	23:rp	Purple is the color of emperors / noble / noble calm	Dark (dk)	Calm
subject 5	matte metal	May look clean and comfortable / calm	16:gb	Looks very comfortable catching	Dull (d)	Not too bright nor too dark / feel very calm and comfortable
subject 6	matte plastic	High-quality , fashion, make sense / high quality is the key to buying laptops	3:yr	Very bright very energetic / youthful enthusiasm	Vivid v	Bright and Vivid / Sunny

Table 2: the subjects least favorite color, hue and tone and the reason.

	The least favorite texture	The reason	The least favorite hue	The reason for	The least favorite tone	The reason for
subject 1	embossed plastic	Too complicated/ too fancy /too over / too deliberate	16:gb	dirty/ not pure / gloomy / feeling heavy	Dark (dk)	Looks dirty and feel heavy
subject 2	fabrics	feel Indifference and without professional	22:p	tacky / weird	Vivid (v)	Too vivid make me feel too strong /heavy
subject 3	Embossed plastic	Complex / extra cumbersome feeling / heavy	23:rp	Vague ambiguous, dirty / filthy sense	Dark (dk)	Looks pressure, look dirty / both bright and dark / too much discomfort color
subject 4	Embossed plastic	complicated	15:bg	Cheap	Pale (p)	Flirty / feminine
subject 5	wood	Looks not like a computer / easily be scratched / too special	5:o	Too harsh /feminine / ugly	Vivid (v)	Feel busy
subject 6	robber	Low-quality / cheap	21:bp	Metamorphosis / dark / evil	Grayish (g)	Dirty / not pure

Table 3: After matching the texture and color, the subject preference.

Matching the favorite texture andfavorite hue.	Matching the favorite texture, favorite hue and favorite tone.	Matching the favorite texture, favorite hue and least favorite tone.	Matching the favorite texture and least favorite hue.	Matching the favorite texture, least favorite hue and favorite tone.	Matching the favorite texture, least favorite hue and least favorite tone.
					
Matching the least favorite texture and favorite hue.	Matching the least favorite texture, favorite hue and favorite tone.	Matching the least favorite texture, favorite hue and least favorite tone.	Matching the least favorite texture and least favorite hue.	Matching the least favorite texture, least favorite hue and favorite tone.	Matching the least favorite texture, least favorite hue and least favorite tone.
					

Subjects like this matching more than matching the texture and theachromatic color with laptop LCD back cover.

Subjects like this matching less than matching the texture and theachromatic color with laptop LCD back cover.

4. DISCUSSIUN

The change about the emotion and preference of subjects, in this part would divide into six sub-parts to discussion. Which 1-4 would divide into three small sub-parts to discussion by matching texture, hue and tone with laptop LCD back cover, some of which refer to the original tone is the hue' original tone from the PCCS 24 color wheel, which is the vivid tone . For example, 4-1-1 is discussing that matching the subjects' favorite texture, favorite hue and original tone with laptop LCD back cover, in this part the tone we are discussing is that appear from PCCS 24 color wheel, so the original tone is the vivid tone.

And 4-1-2 is discussing that matching the subjects' favorite texture, favorite hue and favorite tone, in this part the tone we are discussing is the favorite tone, which chosen by the subjects. The part 4-5 and 4-6 is discussing in the general direction of color and texture, the emotional impact on subjects from color and texture, which is stronger. Is the color affecting texture image to subjects' emotion or the texture affecting color image to the subjects' emotion, is the purpose.

4.1. Matching the subjects' favorite texture and favorite hue with laptop LCD back cover.

In this part we can find that, the tone impact on the subjects' emotion more than others. When matching the subject's favorite texture and favorite hue with LCD back cover, they would not increase their preference necessarily, but when matching the favorite tone with it, they would, in the contrary if matching the least favorite tone with it, the preference were decreased significantly. Therefore consumer has high sensitivity about the value and saturation. They care about the matching of color and texture, if it is a good matching would make consumer increase their preference, in the contrary, if it is a not a good matching even the same hue but different tone, consumer would feel differently totally. The following is three sections to observe it.

4-1-1. Matching the subject's favorite texture and favorite hue and original tone with laptop LCD back cover.

In this part, all of six subjects think the quality is decrease when matching color with the favorite texture, but they feel it looks more fashion and special. Maybe it's too fashion make four subjects dislike it. Such as subject 6, when the matching the matte plastic, which he feel high-quality and make sense and the hue 3:r:y, which he feel energetic and youthful he said "it's really special but it's too over, I don't like it " .

But there are two subjects like this special feeling of the matching. We can learn by the verbal information, they think there is a feeling of being supported in their mind when matching their favorite texture and favorite hue with the laptop LCD back cover. Such as subject 4 has mentioned that matching the metal hairline, which he feel high-quality, clam and introverted with the purple color, his favorite color, he feels noble and clam makes him feel complete, harmony and a sense of worth and seem like a limited good, sell in a special festival. He wants to buy it really.

Therefore, we can find that everyone feel differently in the "special", Some people like to collect something special or limited while others are more like the general products.

4-1-2.Matching the subject's favorite texture and favorite hue and favorite tone with laptop LCD back cover.

In this part, there are four subjects like this matching more than the achromatic color laptop LCD back cover's texture. All of them feel this matching is really beautiful. Although each person describes the feeling is not the same, but the verbal information can be learned, this matching can increase their emotion about color.

Such as the subject 1, when she describes her favorite color and favorite tone, she think the hue, 7:r:y make her feel happy and cheerful and the light tone make her feel lithe and relaxed, when matching with wood texture of laptop LCD back cover. She said the quality decrease, but only a little, instead it's impact on spiritual more. It makes her feel very relaxed. The subject 2 also said, matching the nature and younger hue, 10:y:g and the pale tone, She feel lithe with the metal hairline texture of laptop LCD back cover makes her feel retro. Retro is the popular trend now. She said this matching decrease technology sense and give people relaxed feeling more, If you can be relaxed when you are using computer is a good thing.

The subject 5 also said matching his favorite hue, 16:g:b and the dull tone, he feel clam with the matte metal texture of laptop LCD back cover, he feel comfortable. He said the quality of the laptop is decreased but the metallic feeling of the matte metal is increased and it would give a comfortable and relaxed feeling when people using the laptop.

Based on the above, we can find that if the laptop LCD back cover's texture can increase the feeling from the color image and affect consumer psychology and spiritual, consumer would like it more. Both of these two subjects, who likes the achromatic color laptop LCD back cover's texture more are said that they like black color laptop because it's the most general color laptop in the market, but if the achromatic color texture is white or gray, they would prefer the laptop LCD back cover, which is matching by their favorite hue and tone. Therefore, the matching of the color and texture is important. Although some consumers prefer black color laptop sparingly, but some consumers want to be able to have a laptop, which can affect his spiritual and make them feel happy when they're using the computer.

4-1-3. Matching the subject's favorite texture and favorite hue and least favorite tone with laptop LCD back cover.

In this part, all of the subjects have indicated that they don't like it. There are three subjects said it's a good look and have technology sense, but still prefer the achromatic color laptop.

Such as subject 3 and subject 4, they said it's look great and hi-tech feel, but they prefer their laptop has the introverted feeling, so they would rather to choose the achromatic color one, even if they think the matching is beautiful.

The subject 5 also said matching his favorite hue, 16:g:b and the vivid tone, he feel busy with the matte metal texture laptop LCD back cover, he feel it's hi-tech, but like a toy, so he dislike it. He said "computer should make people feel them can work efficiently.

4.2. Matching the subjects' favorite texture and least favorite hue with laptop LCD back cover.

In this part, we can find that, the matching of the favorite texture and the least favorite hue would not make people like it. However, when it is matching with the least favorite tone, all of the subjects' preference is decrease. Based on above, we can say that the Hue and the Tone have a great influence in laptop LCD back cover's texture. Also we can infer that color can affect the laptop LCD back cover's texture image. Even the texture is the subject's favorite, when it be matched with their dislike color would make subject dislike the laptop. And the reason for why they dislike it is similar to the color image. Therefore, we can explain that the subjects' emotion is affecting by the color from the verbal information. The following discussion is divided into three parts.

4-2-1. Matching the subjects' favorite texture and least favorite hue and original tone with laptop LCD back cover.

In this part, all of the subjects prefer the achromatic color laptop LCD back cover. Such as the subject 1, when matching the hue, 16:g:b, she feels cloudy with her favorite wood texture laptop LCD back cover, she dislike it and feel all shortcomings are on this laptop and she feels the laptop is both cold and stupid kind of feeling, makes her feel very cloudy. Therefore, we can find that the texture image is easy be influenced by color. Since the color match with the texture, it is easy to cover the image about the texture itself. People seem to feel more intense by color.

Such as the subject 2, when matching her favorite texture, the metal hairline, which makes her feel that she can work efficiently with the hue, 22:p, she feels very tacky, she said "It makes me feel great pressure and if use this laptop to work, it's seems like I have lots of work to do"

4-2-2. Matching the subjects' favorite texture and least favorite hue and favorite tone with laptop LCD back cover.

In this part, all of the subjects increase their preference. However there are still five subjects think that although the preference has been increased, but still dislike it. Such as the subject 2, when matching her favorite texture, the metal hairline, which makes her feel that she can work efficiently with the hue, 22:p, she feels very tacky and the pale tone, she feels light, she said " It's become more beautiful and like a noble and elegant girl, but I'm not going to use it, I am a simple person."

4-2-3. Matching the subjects' favorite texture and least favorite hue and least favorite tone with laptop LCD back cover.

In this part, all of the subjects said they do not like it, there are three subjects said that they dislike it very much. Such as the subject 2, when matching her favorite texture, the metal hairline, which make her feel that she can work efficiently with the hue, 22:p, she feels very tacky and the vivid tone, she feels heavy ant too stronger, she said "It's very ugly and make me feel there are lots of work can't be finished. And such as subject 3, when matching his least favorite hue, 23:r:p and dark tone with the laptop LCD back cover, she said:" It's looks very alert and makes me feel that when I using this laptop would be very stressful.

And the other three subjects also said that matching the least favorite tone with favorite texture and least favorite hue is better than matching the original tone with it, but they still prefer the achromatic color one. Such as the subject 5, when matching his least favorite hue, 5:o and the vivid tone, he said" I hope that the laptop has both comfortable and calm feeling, I can get the work done efficiently, but now it makes me feel casual, so if I'm going to travel I'll choose this one.

By the subject's verbal information, we can learn that the hue of the color has a great influence more than the texture and the texture is affected by the color. When matching the subject's favorite texture with their least favorite hue, all the subjects dislike this and the reason is similar to the why they do not like this color. Thus we can say color can effect the subject's emotion. Matching the hue and the tone is an important thing, when we match the subject's least favorite hue and least favorite tone with laptop LCD back cover's texture, the preference is increased. However, the reason for this can generally be assumed that if match the tone can be mitigated subjects antipathy to the hue and then turned negative emotions to positive, then increases their preference.

4.3. Matching the subjects' least favorite texture and favorite hue with laptop LCD back cover.

In this part, the subjects increase their preference, no matter it's the subject's favorite tone or not, when matching the subject's least favorite texture with their favorite hue, their preference would be increased, makes subjects changed their mind. Because of the color, their favorite, the subject's negative emotions are also turned into positive gradually.

4-3-1. Matching the subjects' least favorite texture and favorite hue and original tone with laptop LCD back cover.

In this part, the subjects decrease their preference obviously. Such as the subjects 3,

when matching the leather texture, which makes her feel unprofessional with the hue, 10:y:g,she feels nature and relaxed, she says it's kindly and just like a friend and makes people feel confortable and relaxed. And such as the subject 5, when matching the wood texture, which makes him feel too special and the hue, 16:b:g, which makes he feel confortable, he says "It's look confortable and lively, the lines of wood played down, the uncomfortable feeling is disappear ". This seems like subjects' emotion was impact on the color original image.

4-3-2 Matching the subjects' least favorite texture and favorite hue and favorite tone with laptop LCD back cover.

In this part, all of the subjects' preferences have further increased. Such as subject 1, matching embossed plastic texture, which makes her feel too complicated and fancy and the hue, 7:r:y, she feels warm, bright and cheerful and the light tone, she says this laptop makes her feel vitality and soft.

And such as the subject 2, matching the leather texture, which makes her feel unprofessional and indifferent and the hue, 10:y:g, makes her feel nature and relaxed and the tone, pale, she feels lithe, she says "The color of this laptop looks like in the winter, it's nature, and decrease the stressful feeling, makes me feel romantic. This feeling of the subject is similar to the hue, 10:y:g, so we can infer that this change is affected by the color.

4-3-3. Matching the subjects' least favorite texture and favorite hue and least favorite tone with laptop LCD back cover.

In this part, only three subjects increase their preference, such as the subject 5, matching his least favorite texture, wood and his favorite hue, 16:g:b, he feels relaxed and confortable and the tone, dull, he feels clam and comfortable, he says" It's not bad, makes me feel lively, comfortable, calm and clean ". The matching image of this is similar to the color image.

Based on above, when matching the least favorite texture and favorite hue and favorite tone, makes subject's preference increase, but if it's matching the subject's least favorite hue, their preference would be decreased a little.

Based on above, we can find that the color can affect human feeling than the texture. The hue of the color will be significantly affect the human feelings and change the mind of the texture. Although the tone is not as strong as the hue for consumer emotional feeling, but it can still affect people preference about the texture.

4.4. Matching the subjects' least favorite texture and least favorite hue with laptop LCD back cover.

When matching the subject's least favorite texture and hue, their preference is totally decreased. However, when matching it with their favorite tone, they would increase their preference a little. In this part, we can learn that the tone, which impact on the human emotion is less than the hue.

4-4-1. Matching the subjects' least favorite texture, least favorite hue and the original tone with laptop LCD back cover.

In this part, there are four subjects say that they dislike this more than the achromatic color one. Such as subject 5, when matching the wood texture, which makes him think it's not like a laptop's texture and the hue, 5:o, he feels too feminine, he said: this laptop looks like a failure and like a defective thing.

4-4-2. Matching the subjects' least favorite texture, least favorite hue and the favorite tone with laptop LCD back cover.

In this part, all the subjects increase their preference and prefer it than the achromatic color one. Such as subject 1, when matching the embossed plastic which she feels too deliberate and complicated and the hue, 16:b:g, she feels dark and cloudy and the light tone, she feels light and relaxed, she says "It becomes more intimate and less complexity, like the elements occur in nature now. Based on above the feeling by the match is similar to the tone image, by the subjects' feeling. And such as the subject 2, matching the leather texture, she feels too cold and not professional and the hue, 22:p, she feels vulgar and the tone, pale, she feels light, she says the imagery feeling becomes more elegant. Maybe the image of the tone changes the feeling about the texture, which makes her feels unprofessional.

4-4-3. Matching the subjects' least favorite texture, least favorite hue and least favorite tone with laptop LCD back cover.

In this part, when matching the tone, which is the subject favorite change into the one, the subject least favorite, all of the subject decrease their preference. Their reactions are similar to matching their least favorite hue and texture with laptop LCD back cover, even more annoying. Such as the subject 5 when matching the wood texture, which make him think it's not like a laptop texture and the hue, 5:o, he feels too feminine and the vivid tone, he said: this laptop looks like a failure and like a defective thing. These can be explained that the change of the tone will affect the subject's feelings about texture and hue. Change

lightness and saturation of color can increase the subjects' preference.

4.5. By using the hue as the topic

To the favorite hue, we can find that, the Laptop LCD back cover's texture does not have strong impact on the subjects' emotion by using the hue as the discussion topic. When matching their least favorite texture and the favorite color and tone, the subjects' preference would be increase. However, when matching their favorite texture and the least favorite color and tone, the subjects' preference would be decrease. Therefore, we can infer that the color effects human emotion stronger than texture does. Such as the subject 2, matching the leather texture, which makes her feel unprofessional and indifferent and the hue, 10:y:g, she feels nature and relaxed and the tone, pale, she feels light, she says "The color of this laptop looks like in the winter, it's nature, and decrease the stressful feeling, makes me feel romantic . This feeling if the subject is similar to the hue, 10:y:g, so we can infer that this change is affected by the color.

To the least favorite hue, when matching their favorite texture, the preference can not be increase. Such as the subject 1, when matching the hue, 6:g:b, which makes her feel cloudy with her favorite wood texture of laptop LCD back cover, she dislikes it and feels all shortcomings are on this laptop and she feels the laptop is both cold and stupid kind of feeling, make her feel very cloudy. Therefore, we can find that the texture's image is easy influenced by the color. Since the color match with the texture, it is easy to cover the image about the texture itself. People seem to feel more intense by color.

However, when match their least favorite texture and least favorite hue and tone with the laptop LCD back cover, the preference is increase a little. The subjects in the face of this, they say it look match. We can infer that maybe it's a phenomenon about two negatives make a positive. Such as the subject 1, matching her least favorite texture, embossed plastic and the least favorite hue, 16:g:b and the least favorite tone, dark, she says it's look nature and the color match the texture look like waves.

4.6. By using the laptop LCD back cover's texture as the topic

To the texture, match the favorite hue or favorite tone with it both can increase the preference obviously. Such as the subject 4 has mentioned that matching the metal hairline texture and the favorite hue, 23:r:p, and the dark tone, he feels complete harmony and sense of worth and this is like a limited good, sold in a special festival. He wants to buy it really.

On the contrary, when matching the least favorite color or the least favorite hue, the subject's preference decrease obviously. Such as the subject 2, when matching her favorite texture, the metal hairline, which makes her feel that she can work efficiently with the hue, 22:p, she feel very tacky and the vivid tone, she feel heavy ant too stronger, she said "It's very ugly and makes me feel there are lots of work can't be finished.

To the least favorite laptop LCD back cover's texture, when it matching with the favorite hue or tone, both of can make the subject increase their preference. Such as the subjects 3, when matching the leather texture, which makes her feel unprofessional with the hue, 10:y:g, she feels nature and relaxed, she says it's kindly and just like a friend and makes people feel confortable and relaxed.

On the contrary, when matching the least favorite color or the least favorite hue, the subject's preference decrease obviously. Such as the subject 5 when matching the wood texture, which makes him think it's not like a laptop texture and the hue, 5:o, he feels too feminine and the vivid tone he said: this laptop looks like a failure and like a defective thing. Thus, this study find that the color has stronger effect on the laptop LCD back cover, so we can infer that human emotion is impact on the color more than texture.

4.7. SUMMARY

Lin has mentioned that, form is important to product, but human visual perception of color if higher than it. That is, in general, the emotional impact on people of color is quicker and stronger than form (Lin, 1993). And this research finds that, the emotional impact on people of color is stronger than not only form but also color.

This research has found that, human has high sensitivity to color than form, here we can echo Lin (1993) has says that the emotional impact on people of color is stronger than form. However, this research also finds that human has high sensitivity to color than texture.

In terms of color, the past studies have pointed out that color is the most effective product attribute for consumers. Color preference influence judgments of consumers and plays an important role to stimulate consumption. Also prove that Leatrice Eiseman is called America's color guru, who has says that color can dominant consumer's attention and cause their emotional reaction is really and this research infer that, the hue of the color has the strongest impact on human emotion. Although the tone is not as strong as the hue but it can be a role to moderate some reflection, belong the changes in lightness and saturation can increase or decrease the emotion refection by the hue of people feeling.

5. CONCLUSION

People's psychological need for laptop is top quality and fashion, but they don't want it look too avant-garde. And people cares about the laptop, which makes them feel that they can work efficiently and be comfortable when they use it. In the future may be able to research that how to design the product, which can meet the consumer's inner demand. If matching some color with laptop LCD back cover can make people feel pleasure and can work efficiently, people would increase their preference. At the same time, this research find that people do not like too complicated and not professional things. If matching some color with laptop LCD back cover makes people feel stressed, they would decrease their preference. Via depth-interviews, we found that people care about the appearance of the laptop secondarily, the mental feeling by they use it is the most important thing they care about.

This research has found that human has high sensitivity to color than not only form but texture. And this research infers that, the hue of the color has the strongest impact on human emotion. After the analysis of this research, we can find that the subjects' description about the matching by color and texture with laptop LCD back cover is similar to the description about the color. It can be seen, there is a strong sense of color, which can affect the texture image and the feeling of laptop.

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At the same time, this research has an unexpected discovery about matching the vivid tone with the laptop LCD back cover, which is that the subjects will decrease the preference, no matter they like the vivid tone or not. All of the subjects think that, matching the too bright color with the laptop would make them feel awkward and stressful. About the above can match the Kuo (2009) Consumer preferences low saturation color.

Finally, this research use semi-structured interview and analyze the verbal information. This research is still not completely clear. Each one of the subjects has their own subjective awareness about the color and texture. Such as the hue, 23:r:p, some subjects think it's a noble color , but some subjects think it's a tacky and disgusting color. Therefore, this research is not matching each color and texture one by one but matching the color, which is their favorite one or not with the laptop LCD back cover, makes the subjects feel about. Thus maybe some future researches can match each color and texture one by one in order to enhance the reliability and validity by some statistical method. It can offer a method to tell designer how to match the color and texture with the laptop LCD back cover, which can make people increase their preference about the laptop in the future.

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KEER2014, LINKÖPING | JUNE 11-13 2014
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EVALUATION FOR ATTRACTIVENESS OF ANIMATED PAGE TRANSITIONS ON SMARTPHONES

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Abstract: Nowadays, advances in technology have made smartphones equipped with high performance chips and high resolution displays. The overloaded data displays are increasingly complex in user interface and exceed human perceptual capacity to efficiently interpret them. Consequently, animated transitions in user interface play a fundamental role of supporting the user in integrating and relating information across displays and representations. In fact, judiciously applying animated transitions can make the user interface easier to understand, feel smoother, more natural, and be more appealing. In general, animated transitions are frequently and broadly applied in reader applications on smartphones, because the screen size of smartphones is limited so that users have to frequently switch different contents and categories between screens. In this way, the form of animated page transitions crucially affects the reading experience, and helps to create the uniqueness and appealing of reader applications. This paper describes how the constituent elements of animated page transitions affect user emotions, and clarifies the relationships between different types of page transitions and users reactions. The goal of this paper is to build an interface design principle of animated page transitions on smartphone for helping mobile application developers to select the suitable page transitions according to user emotions. This study applied Evaluation Grid Method and Quantification theory type I to figure out the attractiveness of various types of animated page transitions.

Keywords: Animated Page Transitions, Attractive Factors, EGM, Quantification Theory Type I, Interaction Design

1. INTRODUCTION

Nowadays, advances in technology have made smartphones equipped with high-performance chips and high-resolution displays. The overloaded data displays are increasingly complex in user interface and exceed human perceptual capacity to efficiently interpret them [1]. According to Shneiderman (2009)'s “Eight Golden Rules of Interface Design” [2], the good user interface not only offer informative feedback but also reduce short memory load of users. Consequently, the great user interface should provide subtle feedback according to the user’s actions, and display multiple contents in one single view to reduce the memory loading of users. However, the screen size of smartphones is limited so that users have to frequently switch different contents and categories between screens. In order to provide good user experience and smart interaction in such frequently view switching, animated transitions play a fundamental role of supporting the user integrating and relating complicated information across displays and representations.

In fact, judiciously applying animated transitions make the user interface easier to understand [3], feel smoother, more natural, be more appealing, and of high quality. For instance, when the user simply deletes an object from the menu, and the object just disappear abruptly without any transition effect. It seems to be unnatural because the result is a loss of context. Relatively, subtle animations of transitional interface help users to comprehend the changes of current state and old state, and able to reliably expect how to perform next action by the form of transition. Furthermore, well-designed animated transition make up the lack of tactile feedback on current touch screen and make the interaction more natural and realistic [6].

In recent years, reader applications have been accounted for a great proportion of mobile app markets. Diverse animated transitions are frequently and broadly applied in reader applications on smartphones because the screen size of smartphones is limited so that users have to frequently switch different contents and categories between views. In this way, the form of animated transitions crucially affects the reading experience, and helps to create the uniqueness and appealing of reader applications. Such as the famous reader application, Flipboard, has exceeded 50 million downloads. The unique and memorable page transitions of flip not only provides users great reading experience but also echoes its brand name, which enhancing the brand popularity.

However, from literature review, current research mostly focus on the animated transitions of overall interface on smartphone, the page transitions of specific browsing behavior is relatively unexplored. This paper determined user’s feelings while operating a smartphone; which is the attractive factors of animated page transitions on smartphone.

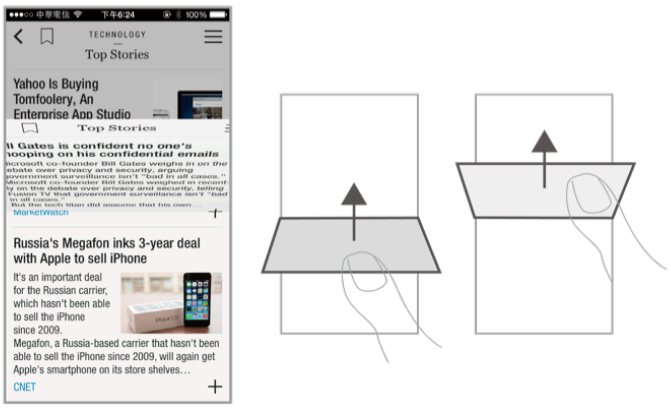

Figure 1: Flip transition effect in Flipboard

2. LITERATURE REVIEW

2.1. Animated Transitions

Animated transitions can build a clear causal connection between the old state of the screen and the new state of the screen [6]. Furthermore, animations provide the appearance of motion or change over time. It plays multiple role suck as to giving feedback, indicating actions, showing the relationship between objects, drawing attention to change, or extending / hiding spaces. Wise use of animated transitions can make the user interface more natural, feel smoother, and be more charming. Oppositely, unnecessary and excessed use of animated transition makes users feel annoying and disturbing.

From the Johannes's research [6], he analyzed and summarized commonly used animated transitions, and all transitions are divided into six categories in order to differentiate between their applications. All six categories are stated as follows:

Table 1: Six categories of animated transitions (Cited from Johannes's research)

Category	Icon	Explanation	Transitions
Orientation		Orientation describes the way in which a logical connection can be created and visualized between objects and object's states.	Slide / Popup / Minimize / Object Switch / Fan of Stack / Page turn / Add to List / Fixed Label / Device Rotation / Button to Label / Combine-Split / Scroll / Pan / Scroll Bar / Page Indicator / Saving Indicator
Spatial Extension Transitions		Spatial Extension reduces the complexity of the user interface by extending the virtual space.	Accordion / Flip / Popup / Preview / Half Flip / Folding / Mask Expand / Zoom / Text Truncation / Area Split / Growing Input Field
Awaking Control		Awaking Controls allows the user to focus on contextual controls.	Swipe to Delete / Mode Switch / Spring Refresh / Appealing Controls / Slide-In Control
Highlight		Highlighting is the guidance of attention by using animations.	Scale to highlight / Rotate to Highlight / Color to Highlight / Fade to Highlight / Blur to Highlight / Darken to Highlight / Flip to Highlight / Glow to Highlight / Change Depth to Highlight / Gray out to Highlight / Expand to Highlight
Feedback		Feedback comprehensively indicates what the result was of the user's interaction.	Position Accepted / Position Denied / Heal / Close / Activate-Deactivate / Invitation-Dis invitation / End of List Indicator / End of Page Indicator / Button Relabel / Progress bar / Refresh Indicator / Availability
Feedforward		Feedforward functions as a conveyor of possible interactions.	Explaining Direction / Affordance / Hidden Feature / Explaining Length / Explaining Interaction / Explaining Position / Solidarity

3. RESEARCH METHOD AND PROCEDURES

The study was designed to find out attractiveness factors of diverse animated transitions of reader application on smartphone. We investigated this question by constructing and administering Evaluation Grid Method (EGM) and Quantification theory type I. The research procedures are stated as follows:

3.1. Samples Selection

First, the leading reader applications were investigated on smartphone, and 10 commonly applied page transitions were integrated as the samples. Furthermore, Xcode (Developing software for OSX and iOS) was applied to design the testing application with CATransition to simulate the real context. 10 sample transitions were built, including Fade, Page Curl, Push Un Curl, Move In, Reveal, Push, Cube, Suck Effect, Flip, and Ripple Effect (Figure 2).

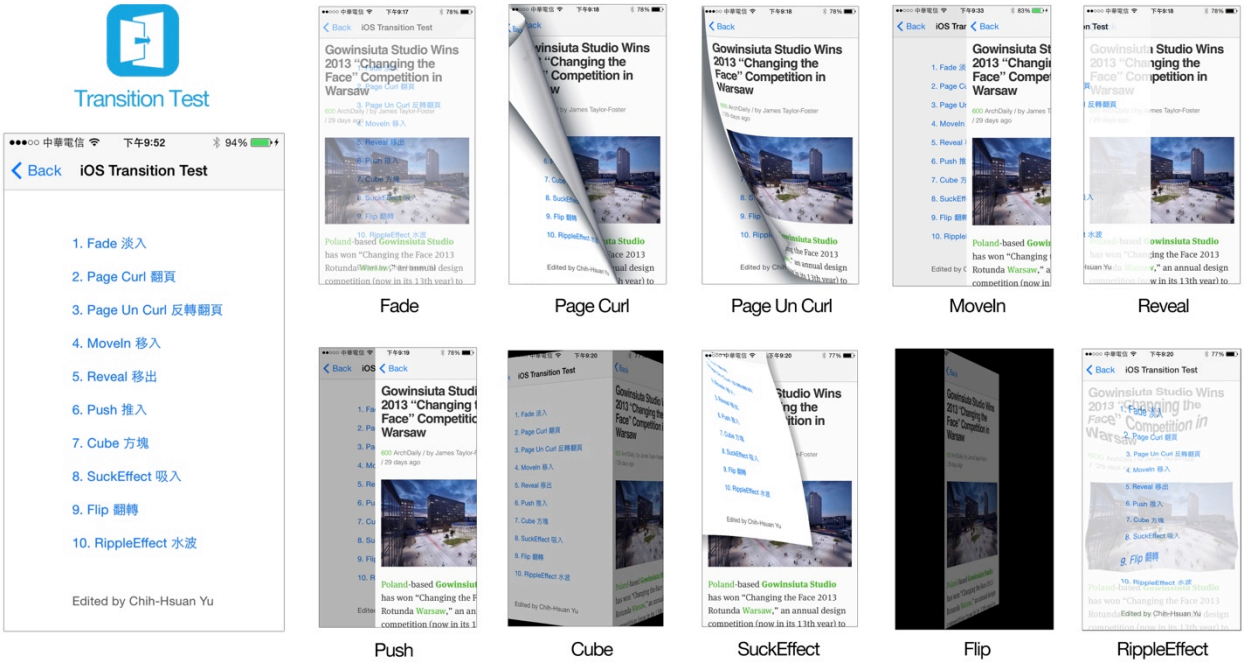

Figure 2: CATransition testing samples

CATransition is an Objective-C wrapper for creating page transitions. It not only provides an efficient way to use various styles of page transitions, but also reserves adjustable parameters for developers to conduct detailed control. In this study, key parameters of sample transitions were set uniformly as follows (Table 2):

Table 2: Key Parameters of Sample Transitions

Transition Duration	**1.0 sec**
Transition Direction	**From Right to Left**
Swipe Direction	**From Right to Left**

3.2. In-depth Interview

Before compiling the quantitative questionnaire for Quantification Theory Type 1 to analysis,

In-depth interview was proceeded which following the principle of the Evaluation Grid Method (EGM). EGM is a kind of in-depth interview method, which pairs comparison and interpretive structural modeling for structure identification [9]. In this study, EGM was used to figure out what the attractiveness factors of page transitions that users may like. A total of 10 experts were invited to participate in this interview, and all subjects with a minimum of five years of design or programming experience, who were proficient application programmers or user interface designers. Furthermore, most of them were heavy reader application users who using reading application 3 times per day averagely, which means their user involvement of page transitions were high. The participant structure is shown below (Figure 3):

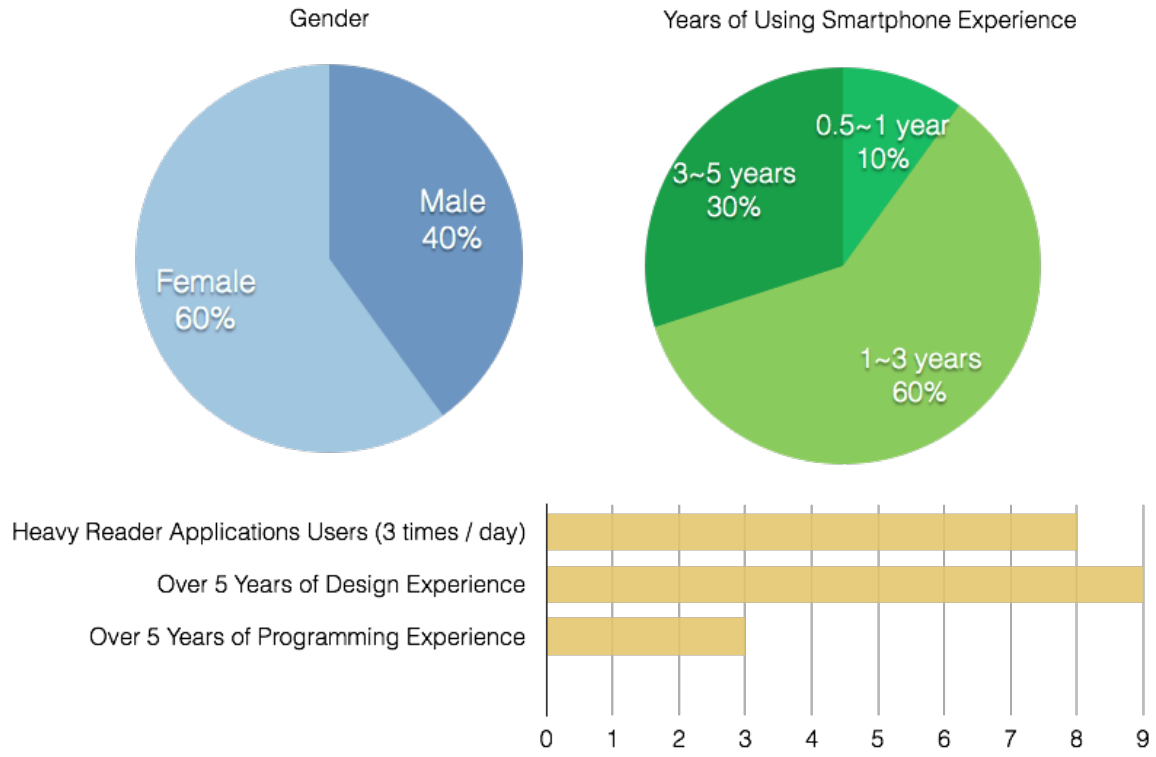

Figure 3: Participant Structure

3.3. Evaluation Grid Method

The In-depth interview took approximately a half hour spread over 2 weeks. The interview consisted of five sections, the first of which was intended to elicit demographic information on the subjects. The second section asked subjects to operate the testing application samples on smartphone, and to feel the difference of diverse page transitions while they were reading the articles. Section 3 was designed to ask subjects to classify and rank 10 sample cards (Each cards were labeled with the names of page transitions) by their preference. The fourth section focused on how they made decisions and the reason of preference through comparing different types of page transitions. Finally, the verbal data from the interview about the attractiveness factors are qualitatively analyzed with EGM, and we integrated it to draw EGM network.



Figure 4: Flowchart of the interview

4. EXPERIMENT RESULTS AND DISCUSSION

4.1. EGM Network

After integrating the verbal data from the interview, we got the EGM network as following:

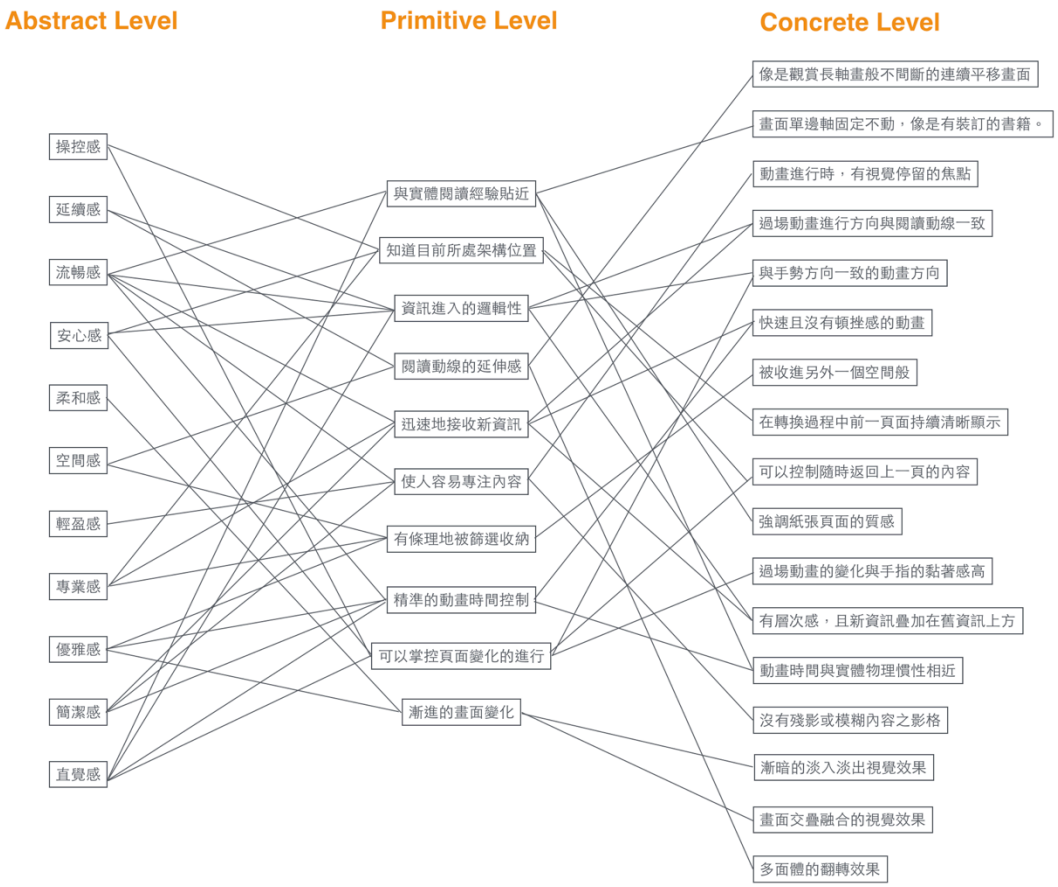

Figure 5: EGM network

According to the In-depth interview for 10 subjects, KJ method was applied to exclude the rare factors and generalize the content of the EGM network. From integrating the similar characteristics, the common names were used to replace them. This step contributed to describe each

characteristic more simple and precise, and helped researcher to observe diverse factors easily. After integrating the content of the EGM network, abstract reasons included five items, original reasons included 11 items, and concrete features included 34 items. Furthermore, the characteristics were also coded, which contributed to survey questionnaire analysis in next stage.

4.2. Quantification Theory Type I Analysis

For the purpose of analyzing the relationship between original reasons and concrete features, Quantification type I theory was used. According to the research written by Sugiyama & Inoue (1996), the relationship between Multiple Correlation Coefficient and Reliability showed as Table 3. For example, the multiple correlation coefficient (R) of "User Control" was 0.503, which means the reliability of "User Control" had strong relation.

Table 3: Range and Reliability relation table Key

Range	Reliability
0.00~0.20	Reliability shows low relation.
0.20~0.40	Reliability shows relation.
0.40~0.70	Reliability has strong relation.
0.70~1.00	Reliability has very strong relation.

After Quantification Theory Type I analysis, the experimental results included five essential dimensions (abstract reasons): "User Control", "Fluency", "Spatial Extension", "Reading Satisfaction", and "Natural and Intuitive". The analysis results were as follows:

(1) User Control

There are two items and seven categories on the dimension of "User Control". The partial correlation coefficient of "The transition provides impression of information architecture" was 0.429, which means it had the highest impact on this dimension. Among the features, "During the page transition, the previous page still clearly shows on the screen" and "Page transitions closely follow the movement of gestures to change the state" were relatively influential concrete features of attractive page transitions.

Table 4: On the part of dimension "User Control"

User Control				
Item	Code	Category	Score	Partial Correlation Coefficient
The transition provides impression of information architecture.	A11	During the page transition, the previous page still clearly shows on the screen.	0.305	0.429
	A12	The page transition hints the direction of gestures and visual movement.	0.064	

	A13	Different functionalities of transitions are clearly distinguishable.	0.008	
	A14	Page transitions are consistent in the same application.	-0.730	
Users have the authority to control the state of page turning.	A21	Using gestures to instead of buttons to backward and forward pages.	-0.361	0.281
	A22	Users can backward to the previous page anytime during the page transition.	0.150	
	A23	Page transitions closely follow the movement of gestures to change the state.	0.157	
$R = 0.503$, $R^2 = 0.253$				

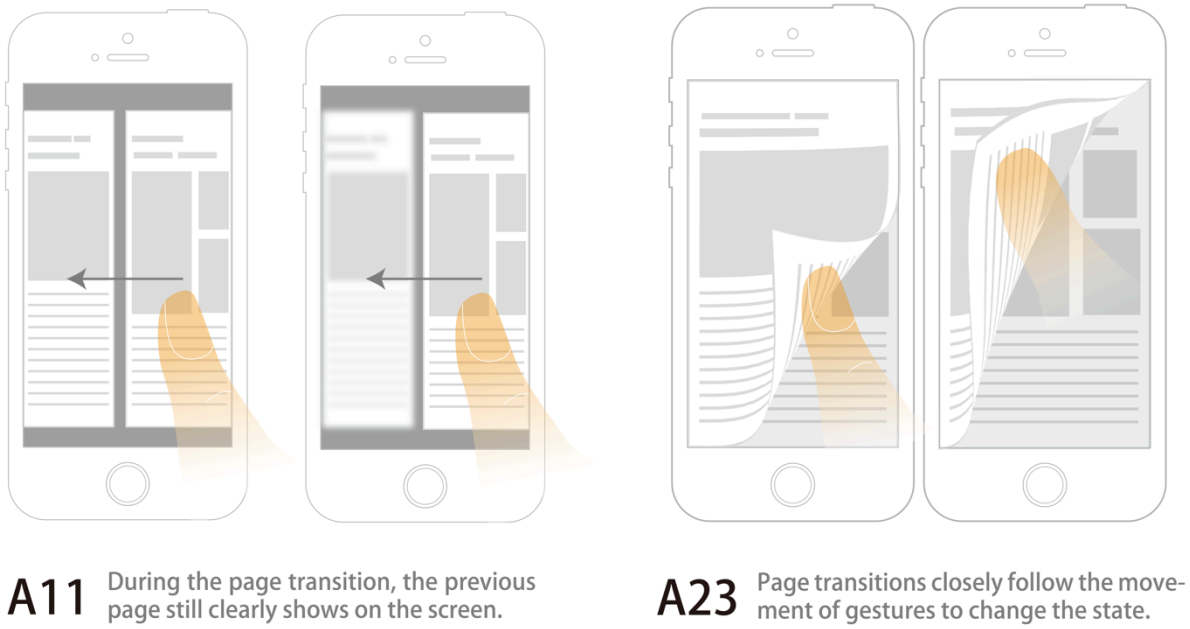

Figure 6: Influential concrete features of “User Control”

(2) Fluency

There are three items and ten categories on the dimension of “Fluency”. The partial correlation coefficient of “The page transition reduces the disturbed factors” was 0.296, which means it had the highest impact on this dimension. Among the features, “The new page stays longer than the current page during the page transition”, “The page transition applies parallel shifting instead of view scaling”, and “This transition hints users that the system is still working during a running process” were relatively influential concrete features of attractive page transitions.

Table 5: On the part of dimension “Fluency”

Fluency				
Item	Code	Category	Score	Partial Correlation Coefficient
The logicality of how new information gets into the current state.	B11	Page transitions are consistent from moving in to moving out.	-0.818	0.259
	B12	The Page transition has layers, and the new page covers the current page.	-0.085	
	B13	The new page stays longer than the current page during the page transition.	0.915	
	B14	The page turning is like a sequential view, not a loop.	0.190	
The page transition reduces the disturbed factors.	B21	The start direction of the page transition follows the visual movement.	-0.279	0.296
	B22	The start direction of the page transition is as same as the gesture.	0.015	
	B23	No blur effect on the previous page.	-0.977	
	B24	The page transition applies parallel shifting instead of view scaling.	0.992	
The page transition reduces users’ anxious waiting.	B31	During the page transition, users can find the focus point on the screen (e.g. interface frames / category labels).	-0.518	0.220
	B32	This transition hints users that the system is still working during a running process.	0.446	
$R = 0.450$, $R^2 = 0.203$				



Figure 7: Influential concrete features of “Fluency”

(3) Spatial Extension

There are two items and five categories on the dimension of “Spatial Extension”. The partial correlation coefficient of “Extension of the visual movement” was 0.401, which means it had the highest impact on this dimension. Among the features, “Page-flipping with a central axis” and “The previous page is like to be sucked to another space” were relatively influential concrete features of attractive page transitions.

Table 6: On the part of dimension “Spatial Extension”

Spatial Extension				
Item	Code	Category	Score	Partial Correlation

				Coefficient
Extension of the visual movement.	C11	Horizontal movement of sequential pages.	0.145	0.401
	C12	Page-flipping with a central axis.	0.509	
	C13	Turning the page is like a polyhedron rotation.	-0.924	
Pages are seems to be tidy up to another space.	C21	The previous page is like to be sucked to another space.	0.437	0.274
	C22	The previous page is like to be fold up.	-0.262	
$R = 0.464$, $R^2 = 0.215$				

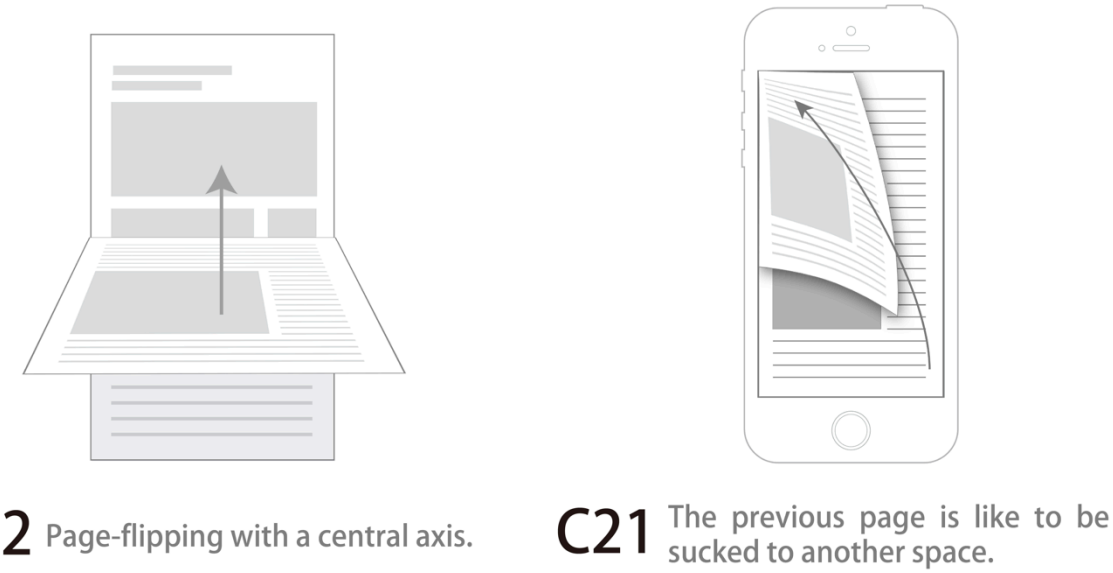

Figure 8: Influential concrete features of “Spatial Extension”

(4) Reading Satisfaction

There are one item and four categories on the dimension of “Reading Satisfaction”. The partial correlation coefficient of “The page transition provides the physical and mental feedback after reading” was 0.296 on this dimension. Among the features, “The previous page follows the swipe gestures to leave the screen” was relatively influential concrete feature of attractive page transitions.

Table 7: On the part of dimension “Reading Satisfaction”

Reading Satisfaction

Item	Code	Category	Score	Partial Correlation Coefficient
The page transition provides the physical and mental feedback after reading.	D11	The previous page follows the swipe gestures to leave the screen.	0.928	0.565
	D12	The previous page is like to be sucked to another space.	0.045	
	D13	Imitating the way of page turning of paper books.	-0.643	
	D14	The previous page smoothly fades out off the screen.	-0.263	
$R = 0.565$, $R^2 = 0.319$				



Figure 9: Influential concrete features of “Reading Satisfaction”

(5) Natural and Intuitive

There are three items and five categories on the dimension of “Natural and Intuitive”. The partial correlation coefficient of “The page transition follows physical principles” was 0.347, which means it had the highest impact on this dimension. Among the features, “Imitating the texture of paper to turn pages”, “There is a bounce effect while user slides a page to the end”, and “The page smoothly fades in and fades out” were relatively influential concrete features of attractive page transitions.

Table 8: On the part of dimension “Natural and Intuitive”

Natural and Intuitive

Item	Code	Category	Score	Partial Correlation Coefficient
To Simulate the reading experience of paper books.	E11	Imitating the texture of paper to turn pages.	0.559	0.206
	E12	Turning pages with a fixed axis.	-0.299	
	E13	The backside page subtly reveals the content of the front page.	-0.168	
The page transition follows physical principles.	E21	While swiping the page, the previous page follows the direction of gestures to leave the screen.	0.054	0.347
	E22	The new page turns into the current view with a bounce effect.	-0.625	
	E23	There is a bounce effect while user slides a page to the end.	1.077	
Gradually variation of transitions.	E31	The page smoothly fades in and fades out.	0.125	0.075
	E32	The page smoothly zooms in and zooms out.	-0.145	
$R = 0.413$, $R^2 = 0.170$				

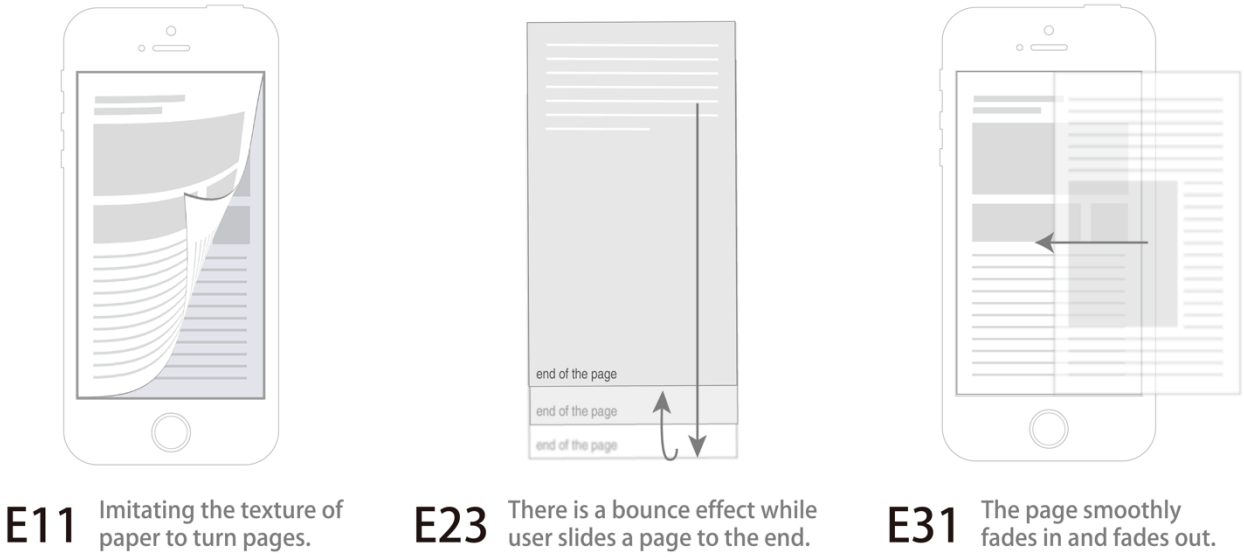

Figure 10: Influential concrete features of “Natural and Intuitive”

5. CONCLUSION

Throughout the experiment and analysis, it is concluded as follows. Firstly, one essential function of animated page transitions is that guiding users to explore interface smoothly and friendly. For this purpose, to design precise animation depends on how to interact with users. A well-designed animation should follow the movement of user's gesture closely, make user feel the animation realistic, and help user to realize the current location in the information architecture.

Furthermore, visual movement and layout of contents also should been consideration. The appealing animations smooth view transitions while user is reading, not affect user's flow. Consequently, initial direction and duration of animations should match contents to make users feel more fluency and nature.

Finally, wisely following physical principles and imitating physical books prepare users for an action, and make the action appear more realistic. From applying realistic reading experience also make user interface more instinctive and friendly.

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Consideration on English Learning for Undergraduates Using a Portable Game Machine

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Abstract: The Nintendo DS handheld game console, which was developed by Nintendo and has been sold worldwide since 2004, is a game console which features/incorporates dual touch screens, voice-recognition features and innovative controls, and has been used not only as a video game device but also in the fields of education and as an education tool. In this study, I conducted research regarding Nintendo DS software for learning English with the objective of exploring the possibility of introducing and utilizing such software as an education tool in universities. The result was that when not only the students who were proficient in English, but also the students who initially displayed little interest in learning English using the Nintendo DS, actually started using it, they began to realize that it was fun and helpful to work with.

Keywords: e-Learning, Nintendo DS, English education, Educational technology, Educational psychology.

1. INTRODUCTION

The Nintendo DS, which was developed by Nintendo and has been sold worldwide since 2004, exceeded 30 million units in the total number of consoles sold in Japan in 2010, and its successor device named the Nintendo 3DS was also announced (Famitsu). The Nintendo DS is a game console which features/incorporates dual touch screens, voice-recognition features and innovative controls, and as Nintendo had stated its intention for it to become a "machine that enriches the livelihood of its owner," it has been used not only as a video game console but also in the fields of education and as an education tool (Iwata) (Sankei).

In recent years, as globalization progresses, the need for English communication abilities has become more and more important. There are countless paper-based exercise books published for use as educational materials. On the other hand, various educational software has been released

in recent years as a form of e-learning.

In this study, I conducted research regarding Nintendo DS software for learning English with the objective to explore the possibility of introducing and utilizing such software as an education tool in universities.

2. RESEARCH

I conducted the following two types of research on university undergraduates with regard to the use of the Nintendo DS for English education.

2.1. Research 1

First, I conducted research on whether there were any differences in attitudes towards using the Nintendo DS for education between students that were proficient in English and those who were not, and also between the different year groups.

2.1.1. Research Method

I conducted an anonymous survey using questionnaire sheets.

[Target Subject] Engineering faculty of F University located in Fukui prefecture

Freshman: English proficiency level group: A-class 21 people, C-class 42 people

Sophomore: English proficiency level group: S-class 24 people, A-class 39 people, B-class 56 people

Proficiency class grading is composed of S/A/B/C for freshman, and S/A/B for Sophomore.

[Survey period] Mid-April to Early May 2012

The questions asked included two questions concerning the Nintendo DS itself and four questions on education using the Nintendo DS.

2.1.2. Survey results and Observation

First, I asked whether they were interested in the Nintendo DS game console itself. As a result, as shown in Table 1, the Freshman A-class students showed the highest interest, with 76% of its students responding positively, followed by Sophomore S-class students with 63%. The positive rates were higher with classes that had higher proficiency. In contrast, 27% of the students in the Sophomore B-class answered "No interest," which, combined with "Not very interested," came to 60%, which was the only class for which more than half expressed disinterest in the console.

Table 1: Are you interested in the Nintendo DS?

Q. 1	Very interested	Somewhat interested	Not very interested	No interest	No answer	Total
Freshman A-class	5 (24%)	11 (52%)	2 (10%)	3 (14%)		21 (100%)
C-class	5 (12%)	18 (42%)	15 (36%)	4 (10%)		42 (100%)
Sophomore S-class	3 (13%)	12 (50%)	8 (33%)	1 (4%)		24 (100%)
A-class	2 (5%)	18 (46%)	14 (36%)	4 (10%)	1 (3%)	39 (100%)
B-class	7 (13%)	13 (23%)	19 (33%)	15 (27%)	2 (4%)	56 (100%)

Then, when I asked if they owned a Nintendo DS (regardless of the model), 57% of the students in the Freshman A-class and 67% of the students in the Freshman C-class said they owned one, showing that 10% more students in the C-class owned a Nintendo DS. For Sophomore students, 50% of S-class, 51% of A-class, and 52% of B-class said they owned one. All classes showed that roughly 50% of students owned one, and there was little difference between the different classes. As we can see in Table 1, when considering that 54% of the students in the Freshman C-class and 36% in the Sophomore B-class showed some form of interest towards the Nintendo DS, we can deduce that there are students in these classes that own a Nintendo DS but have no interest in them.

Next, I asked whether they had used educational Nintendo DS software before. The ratio of students that responded affirmatively were: 43% in the Freshman A-class, 40% in the C-class, 42% in the Sophomore S-class, 36% in the A-class and 30% in the B-class, which indicates that the ratio of students that had used such software increases along with higher proficiency levels in both year groups. Also, over 40% of the freshman students in all class groups had experience using such software, which showed that there were generally more students in this year group than among the sophomore students that had experience using such software.

When I limited the software to English educational software, the ratio of students that responded affirmatively were: 24% in the Freshman A-class, 12% in the C-class, 17% in the Sophomore S-class, 10% in the A-class and 18% in the B-class. Except for the Freshman A-class, the percentage of those that had experience using one was below 20%. Also, we can note that over half the students that had experience using educational software had experience using English educational software.

Next, I asked whether they have an interest in using English educational Nintendo DS software. As shown in Table 2, 100% of the students in the Sophomore S-class said that they would like to use such software. 76% of the students in the Freshman A-class and 54% of Freshman C-class students responded positively, so 22% more students in the higher proficiency classes in the freshman year showed an interest in using such software. While 29% of the students in the C-class said they "Absolutely (did) not" want to use such software, the percentage of students showing an interest in using such software were comparatively higher in the freshman year students than the sophomore year students, where the percentages were 38% for the A-class and 39% for the B-class.

Table 2: Would you like to use English educational software?

Q. 5	Very much	Maybe	Not very much	Absolutely not	Total
Freshman A-class	4 (19%)	12 (57%)	2 (10%)	3 (14%)	21 (100%)
C-class	5 (12%)	18 (42%)	7 (17%)	12 (29%)	42 (100%)
Sophomore S-class	3 (13%)	21 (87%)			24 (100%)
A-class	2 (5%)	13 (33%)	17 (44%)	7 (18%)	39 (100%)
B-class	3 (5%)	19 (34%)	20 (36%)	14 (25%)	56 (100%)

Finally, I asked which software they would prefer between Nintendo DS-based software and PC-based software. As shown in Table 3, students that preferred PC-based software in the Freshman A-class and Nintendo DS-based software in the Freshman C-class were both 4% higher than those who answered otherwise. For sophomores, all classes answered higher for Nintendo

DS-based software. Especially in the B-class, although 34% of the students answered “Neither,” there was a larger 30% difference between the respective preferences for the two software.

Table 3: Which English educational software would you prefer: PC-based software or Nintendo DS-based software?

Q. 6	Nintendo DS	PC	Neither	No answer	Total
Freshman A-class	9 (43%)	10 (47%)	2 (10%)		21 (100%)
C-class	14 (33%)	12 (29%)	15 (36%)	1 (2%)	42 (100%)
Sophomore S-class	14 (58%)	10 (42%)			24 (100%)
A-class	16 (41%)	12 (31%)	11 (28%)		39 (100%)
B-class	27 (48%)	10 (18%)	19 (34%)		56 (100%)

2.2. Research 2

Next, I conducted research on what the students thought after actually using English educational software, and the differences in thinking between students that were proficient in English and those who were not.

2.2.1. Research Method

After using the software, I conducted an anonymous survey using questionnaire sheets.

[Target] Engineering faculty of F University located in Fukui prefecture

Freshman: English proficiency level group A-class 10 people**,** C-class 10 people

[Survey period] December 11, 2012 - February 6, 2013

During said period, the period between December 11 and January 7 was considered "Period 1," the period between January 8 and 21 was considered "Period 2," and the period between January 2 and February 6 was considered "Period 3."

[Software that was used]

1. *Eigo ga Nigatena Otonano* DS *Training Eigozuke* (Nintendo, January 2006)
2. *NOVA Usagi No Game* de *Ryugaku!?* DS (Konami Digital Entertainment, February 2007)
3. *Eigo ga Nigatena Otonano* DS *Training Motto Eigozuke* (Nintendo, March 2007)
4. *Eigo wo Taberu Fushigi na Ikimono* Marsh (Dimple, October 2007)
5. *Zombie Shiki Eigo Ryoku Sosei Jyutsu* ENGLISH OF THE DEAD (Sega, May 2008)
6. *Motto*TOEIC® TEST DS *Training* (IE Institute, June 2008)
7. *Gakken Eigo Zanmai* DS (Gakushu Kenkyusha, November 2009)
8. *Steve Soleici no Business Eikaiwa Pera-pera* DS *Training* (IE Institute, March 2010)
9. *Eigo de Tabisuru Little Charo* (Nintendo, January 2011)
10. TOEIC® *Test Chosoku Training* (IE Institute, April 2012)

(In Software release date order)

I leased out the latest Nintendo 3DS LL console (the latest model at the time of this research) to each subject, and assigned one software cartridge chosen arbitrarily from the 10 listed in the above to be used freely at home for each class and each period. At the end of each period, I conducted an anonymous survey using questionnaire sheets. I used the same questionnaire sheet for all three periods. The questions asked included one question concerning handheld game consoles, and one question on education using the Nintendo DS, and nine questions on the Nintendo DS software that was assigned.

Software No. 10 supported 3D, so I notified the subjects using this not to use it continually for an extended period of time.

2.2.2. Survey results and Observation

First, I asked whether they had interest in handheld game consoles such as the Nintendo DS and PSP (PlayStation Portable). As can be seen in Table 4, the result was that 94% of students in the A-class and 83% in the C-class answered positively, which showed a high degree of interest for both classes. Especially notable was the A-class, where 61% of the students answered "Very much." On the other hand, 10% of the students in the C-class answered "None."

Table 4: Do you have interest in handheld game consoles?

Q. 1	Very much	Somewhat	Neither	Not very much	None	Total
A-class	18 (61%)	10 (33%)	1 (3%)	1 (3%)		30 (100%)
C-class	13 (43%)	12 (40%)	2 (7%)		3 (10%)	30 (100%)

Then, I asked if they had interest in education (not limited to English) using the Nintendo DS. As is seen in Table 5, 77% of students in the A-class and 60% in the C-class expressed interest. Especially notable was the A-class, where 33% of the students answered "Very much." However, both classes showed lower interest for the use of the Nintendo DS for education in comparison to their interest in handheld game consoles shown in Table 4.

Table 5: Do you have interest in education using the Nintendo DS?

Q. 2	Very much	Somewhat	Neither	Not very much	None	Total
A-class	10 (33%)	13 (44%)	6 (20%)		1 (3%)	30 (100%)
C-class	4 (13%)	14 (47%)	9 (30%)		3 (10%)	30 (100%)

Next, asking whether they knew of the software that was assigned to them, there were seven cases where the subject replied that they already "Knew" about it. On how they came to know about the software, six cases said they came to "Know of it by themselves or through the internet/magazines." and there was one case where it became known "Through hearing from friends."

Then, I asked whether they had actual experience using the assigned software before, and only one subject in the A-class answered positively, and it was for "Software for personal use at places such as home."

Next, I asked whether they had interest in the assigned software before actually using it. As we

see in Table 6, the result was that 64% of students in the A-class and 50% in the C-class expressed interest in it beforehand. Although those that answered "Very much" were 10% higher in the C-class than in the A-class, 27% in the C-class said they had "Not at all (no)" interest towards it.

Table 6: Did you have interest in the assigned software beforehand?

Q. 5	Very much	Somewhat	Neither	Not very	None	Total
A-class	2 (7%)	17 (57%)	4 (13%)	7 (23%)		30 (100%)
C-class	5 (17%)	10 (33%)	6 (20%)	1 (3%)	8 (27%)	30 (100%)

The results of whether they enjoyed using the software are given in Table 7. 60% of students in the A-class and 57% in the C-class said they "Enjoyed" using the software. Although the A-class has 3% more students saying they enjoyed it, the ratio of students that answered "Very" were 6% higher in the C-class. Note that in both classes, 13% of the students answered "Not very" enjoyable, but none answered "No (Not enjoyable)."

Table 7: Did you enjoy using the assigned software?

Q. 6	Very much	Somewhat	Neither	Not very much	No	Total
A-class	5 (17%)	13 (43%)	8 (27%)	4 (13%)		30 (100%)
C-class	7 (23%)	10 (33%)	9 (30%)	4 (13%)		30 (100%)

For the question regarding whether they thought the assigned software was useful for improving their English abilities, as we can see in Table 8, 83% of students in the A-class and 73% in the C-class answered that it was "useful" and 17% more students in the C-class than in the A-class answered “Very useful.” Although 17% of the students in the A-class and 27% in the C-class answered "Neither," none of the students for both classes answered "Not very" or "No (Not)" useful.

Table 8: Do you think the assigned software was useful for improving your English?

Q. 7	Very	Somewhat	Neither	Not very	No	Total
A-class	4 (13%)	21 (43%)	5 (17%)			30 (100%)
C-class	9 (30%)	13 (43%)	8 (27%)			30 (100%)

However, when I asked whether they would like to use the assigned software in the future, as we can see in Table 9, only 43% of the students in both classes responded positively, while 23% of students in A-class and 17% of C-class answered negatively.

Table 9: Would you like to use the assigned software in the future?

Q. 8	Very much	Maybe	Neither	Not very much	Never	Total
A-class	6 (20%)	7 (23%)	10 (34%)	6 (20%)	1 (3%)	30 (100%)
C-class	7 (23%)	6 (20%)	12 (40%)	5 (17%)		30 (100%)

When I asked "How would you like to use it?" to those that answered positively (multiple answers allowed), there were eight cases for the A-class and nine cases for the C-class where they answered "for personal use," five cases for the A-class and three cases for the C-class where they answered "For use with friends," two cases for the A-class and one case for the C-class where they answered "For use with family members" (all three cases being "With younger brother/sister" and three cases for the C-class where they answered "For use as educational material with other people." On the other hand, when I asked the reason to those that answered negatively (multiple answers allowed), there was one case for the A-class and three cases for the C-class where they answered "Did not think it would help improve my English." There was one case for both the A-class and the C-class where they answered "The controls were too awkward," and one case in the A-class who answered "There was no game in it." There were five cases for the A-class and one case for the C-class where they answered "Others." These included answers such as "It was not very stimulating having to do voice training with a game," "The mini-games seemed like a routine exercise," "It took time to play," "I couldn't keep up with the game," and "The atmosphere was wooden." In the C-class, we noted answers such as "We were expecting a more basic kind of education, but that was not the case."

3. CONCLUSION

In this research, it has become apparent that for English education using the Nintendo DS, although both students that are proficient in English as well as those who are not showed little interest in the beginning, when they started actually using it, they began to realize that it was fun and helpful to work with. I would like to introduce this in my lectures, and to conduct research on its effect.

[ACKNOWLEDGMENT]

This study is part of the results based on the Fukui University of Technology in-campus special study budget for FY2012. I would like to express my deep appreciation with this mention here.

Also, I would like to express my utmost appreciation to the students that participated in my research.

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4A - Evaluation 2

KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Surface design methodology – the cleanability investigation

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Abstract. A conservative culture and a robust material with a genuine past is probably the best way of describing the medical healthcare environments around the country. Stainless steel has dominated for decades, and it is not only because of its technical properties. The feeling of a clean surrounding and sterile equipment are high rated within this culture, you have to trust the material and its surface. However, what will happen when stainless steel is replaced with another material, still meeting the same (or higher) technical requirements? Is it possible to challenge the steel and its robust and hygienic experience? Will the users of the equipment have fate in the new material and its surface? The purpose of this paper is to link the technical- and customer requirements of current materials to surface textures in medical environments. By focusing on parts of the theory of Kansei Engineering, improvements of products are possible. In collaboration with the topical company for this project, three new materials that fulfil the technical requirements –easy to clean and anti-bacterial came to be in focus for further investigation in regard to a new design of the steriliser for medical equipment using the Kansei based Clean ability approach CAA. Focusing on the correlation between the cleaning, the surface design parameters and the experience of the new materials/surfaces; discussions regarding the optimal material/surface design of the product and the challenging of the stainless steel are initiated. The results of this study show that materials with similar or better cleanability properties very well can exchange the traditional brushed stainless steel materials. Also, the optimal wipe material and cleaning agents system can be developed using the modified Kansei Engineering method. The continuation of this study will be to further include surface properties to influence on bacterial growth to complete the CAA.

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Keywords: Cleanability, material design, functional surfaces, Kansei Design, stainless steel.

1. INTRODUCTION

Stainless steel has dominated as a material in the medical healthcare environments for decades, and it is not only because of its technical properties. It feels secure and it mediates a sensation of a hygienic environment, (figure 1).



Figure 1: Figure illustrating the topical domain, sterilizers in a medical healthcare environment.

However, a material/surface could only be considered as a success if the person who matters understands the message (Krippendorf K, 2006) and (Wikström L, 2002). Nevertheless, the material selections are not only about ensuring the safety in a construction or optimize weight in a product for instance. Zoom into the material beyond what we can see with naked eye, and the microstructure will expose a landscape that affects us as users more than we can understand. Blood residues; and other soils need to be removable from the surface and microstructure of products in the healthcare environment, and the supplier has to be able to guarantee a surface with good cleanability. It is important for a company supplying the health care sector with products to not only impose a feeling of good cleanability, but to also take responsibility of the products actual performance and verification in terms of cleanability.

Professor Mitsou Nagamachi (Hiroshima International University) had a vision about improve products on a more detailed level than before. Hence, he developed the method Kansei Engineering (KE) in the 1970's which has its roots from the Japanese concept of Kansei, ("intuitive mental action of the person who feels some sort of impression from an external stimulus") (Nagamachi M and Lokman A M, 2011). According to Professor Nagamachi the Kansei concept include; "a feeling about a certain something that likely will improve one's quality of life". KE can also be defined as a customer-oriented approach to product development (Nagamachi M, 1997),

(Nagamachi M, 2002), (Frisk M, and Järlskog H, 2002) and (Hedberg Ö M, 2004).

By using the framework of KE as an approach and focusing on finding correlations in between the functions; customer requirements, function requirements, design requirements and process requirements; a higher level of user quality could be obtained.

The majority of people on earth navigate through life using their impressions and feelings, and the confidence of our intuitive religion and preferences; often with a good result (Kahneman, D, 2013). The perceived quality is related to the experience of the product, and the experience is directly connected to the interaction and stimulation of the senses (Wolfe J M, et al. 2012). The costumer describes their experience of a product with describing words as; elegant, plastic or stylish and so on (Bergman M, et al. 2012). Yet, what they describe is only their feeling of a visual or haptic experience for instance, a stimuli of the senses, nothing else! By focusing on the sensation and the emotions by varying materials and surfaces textures, the perceived experience of the product will vary, and by that also the qualitative customers feeling impression (Bergman M, et al. 2012). Now, is it possible to link those parameters to the costumer's feelings and experience (and put a number onto it), but at the same time fulfil the technical requirements of the product?

The KE method modified to be adaptable to material and surface design has been used systematically to be able to develop a tailor made toolbox for designers where special tools for product surface properties optimization are introduced (see also (Bergman M, et al. 2012).

The research approach used in this project handles 6 different phases/steps, (figure 2);

1. Pilot Study – In this phase it is important to define the questions; what, who, where, how, why, and when? But also to implement a market analysis.
2. Describe the Experience – In this phase focus is lying on the description of the experience, which is possible by firstly collecting adequate describing words of the typical domain which the user express when interacting with it.
3. Define Key Product Properties – In this phase it is important to know the product and its features. It is about finding properties that affects the user, yet it is important that the properties are measurable and adjustable.
4. Connect the Experience and Product Properties – By gathering typical users into a focus group which mission is to analyse and evaluate the domain; it is possible to obtain information about the product experience. In this phase focus is lying on finding connection between the describing words (experience) and the key product properties.
5. Validity Check Point – When the correlation is established, it is important to verify potential other domains tested in the project. This is possible by measure and compares the key product properties, either the competitive domain fails the test or it will precede to the next level.
6. Synthesis and Modelling the Domain – When the experience is evaluated towards a number of different product properties and the correlation is verified, the development of a new domain is possible.

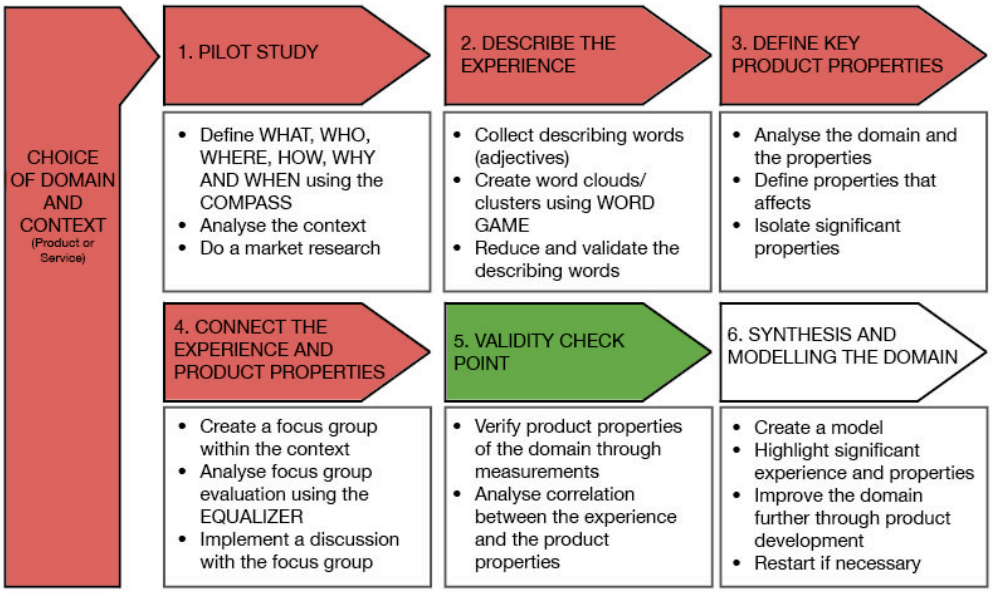


Figure 2: Illustration of the research approach. Phases 1-4 (red), is already covered in previous case studies. Phase 5 is highlighted in green and indicate the position of this case study in the overall research approach.

2. METHOD

However, the main issue in this project mainly handles the “cleanability” of materials and surfaces. Focus is lying on finding differences in three new materials for the topical company in regard to the cleanability, which in this study is implemented by a “wipe off”-test. This case study briefly handles step 5 in the research approach, the “Validity Check Point”. But focus also lying on finding correlations in-between the cleanability and the surface appearance (surface properties). This approach will be called “Clean Ability Approach” (CAA) from now on in this project. The CAA is about analysing the material and surface, which is directly linked to the product properties of the domain, EU report, (2013). Hence, the CAA could be placed in Phase 3 (if defining a material/surface) and/or 5 (if analysing a material/surface) in the research approach. However, verification of an analysed material is difficult without a reference. Hence, the topical company´s trademark surface (stainless steel with brushed texture) will be used as a reference in regard to surface parameters. The continuation of this study will be to further include surface properties to influence on bacterial growth to complete the CAA.

2.1. CAA – A “wipe off” test

The test in this case study handles different factors of importance in regard to the cleanability of the product materials and surfaces. Three different materials/surfaces were involved in the test; glass, spray painted aluminium and acrylic plastic. Three different solvents were used; 70% alcohol[5], chlorine[6] and “all-purpose cleaner”[7]. Three different materials for cleaning the surface were used;

[5] DAX, 70+ Surface disinfector – Opus Health Care AB, Malmö Sweden

[6] Refin, chlorine – Rusta AB, Upplands Väsby Sweden

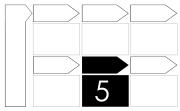
[7] All-purpose cleaner – Biltema AB, Helsingborg Sweden

microfiber fabric[8], drying paper[9] (extra good absorbency) and industry paper[10] (rough paper).

The soil that was used in the test was a blood-like chemical[11] (artificial blood), which the topical company developed and uses in their own tests. The idea of using this soil is obviously because blood in itself is difficult to remove from surfaces, fabrics and so forth.

The wiping process was made by means of a simple custom made tool that basically was a thin flexible steel arm with a clip for attachment of the wiping materials. The contact area of the wiping materials was restricted to 12cm^2, which is about the contact area of the fingertips of one hand. The realistic wiping force was estimated using a simple wiping test and a dynamometer. The results turned out to be in between 5-15N, therefore the force in this test were fixed to 10N throughout the whole test. The amount of wiping cycles was limited to three.

3. RESULT



The result is based on a literature study, a previous case study, a cleanability-test and measurements of the company´s reference surface (stainless steel), and additional materials challenging the stainless steel in regard to the material/surface design. As mentioned earlier the result is focused on phase 5 in the research flow chart (figure 1), therefore phase 1-4 is not highlighted in the result. For a deeper understanding in the result regarding Phase 1-4 the reader is recommended to reed Surface design methodology – challenge the steel by (Bergman M, et al. 2013).

The validity check provides the opportunity of a checkpoint where selected materials are measured and evaluated, or such in this case study analysed through a special test. The material samples that advanced through the focus group in the previous case were measured using a MicroXAM phase shifting- and coherence scanning interferometry instrument[12] and analysed in Mountains Map Premium 6[13] to establish quantitative measures of the surface texture. Initial focus was concentrated on the surface texture arithmetical mean height**,** *Sa*, according to ISO 25178:2011. *Sa* is considered as the surface texture property closely connected in internal company standards to the legislative demands on *bacterial resistance*, and *clean ability* i.e. connecting *Sa* and CAA. In the previous study the cleanability was to be considered “OK” when the Sa value for a given surface is <0.8µm, mainly focusing on stainless steel in general, Detry, J G, et al. (2010), Hilbert, L R, et al. (2003) and EU report, (2013). NOTE: *Originally the “Ra maximum 0.8µm rule” was determined for the profile ISO 4287:1997 Ra parameter, in this study replaced by the areal defined Sa parameter according to ISO 25178-2:2012*. Detry, J G, et al. (2010) and Hilbert, L R, et al. (2003) however claims, that there is no report of a direct relationship between the Ra/(Sa)-value and the cleanability, even though the majority of investigations of cleanability focusing on this parameter. Detry, J G, et al. (2010) also says that a surface could have a Ra-value up to 3.2µm and still be acceptable as long as the cleaning fluid flow rate is “sufficient enough to remove the soils from the surface”.

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[8] Turtle Microfiber Exterior – SEAB, Märsta Sweden

[9] Turtle Drying paper – SEAB, Märsta Sweden

[10] “Grov Tork” industry paper – Biltema AB, Helsingborg Sweden

[11] Getinge Soil artificial blood – Getinge AB, Getinge Sweden

[12] ADE Phase Shift MicroXAM Optical interferometric profiler characteristics [online]. http://www.tcd.ie/CMA/misc/MicroXam.pdf

[13] Digital Surf, Besançon, France, http://www.digitalsurf.fr

3.1. Developing a new quantitative method for “wipe-off” cleanability

In this study the three challenging materials where measured and analysed in terms of the CAA, and the “wipe-off”-effect. The main idea was to link the Key Product Properties with the experience of the materials and the CAA. However, the Glass, Spray painted aluminium and Acrylic plastic was measured and analysed and they all appear to pass a criteria of a Sa value of <0.4µm. The glass and the spray painted aluminium is even below <0.05µm (table 1).

Table 1: Surface Roughness; with both the 2D- and 3D parameter; of the glass, spray painted aluminum, acrylic plastic and the reference surface Stainless Steel.

ISO 25178:2011/4287:1997	Glass	Spray-Painted Aluminium	Acrylic Plastic	Stainless Steel (Reference)
Sa (3D-parameter)	0.01 µm	0.03 µm	0.39 µm	0.70 µm
Ra (2D-parameter)	0.01 µm	0.05 µm	0.33 µm	0.40 µm

To get a deeper understanding of the microstructure, and have a chance to evaluate how the microstructure correlate with the cleanability; the surfaces were compared not only with the parameters in table 1, but also visually judged and compared to the surface microstructures, (figure 2). The surface microstructure might appear very rough to the reader, although the area of the measured surfaces is 800x600 µm, and the vertical scale is magnified compared to the horizontal scales to enhance the microstructure.

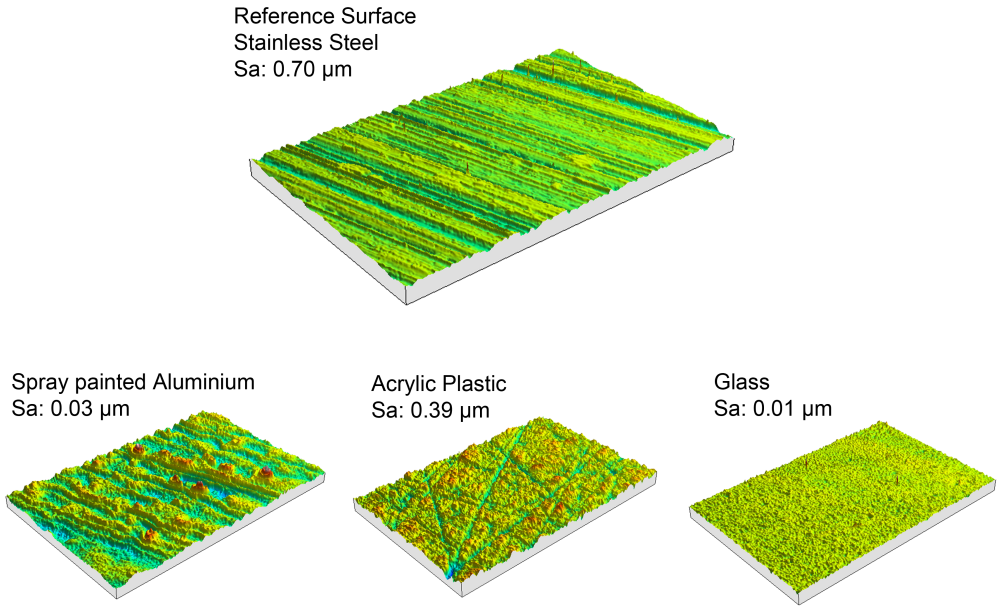

Figure 3: Illustration of the surfaces microstructure including the reference surface stainless steel.

With the three new materials and the stainless steel reference surface, the cleanability test was implemented, the “wipe-off”-test described earlier.

The main idea with the “wipe off”-test was to compare the cleanability of the surfaces, quantifying the “wipe off effect” and the adhesion of the artificial blood that were used as a soil/dirt.

Initial tests with the different chemicals and wipe of fabrics gave some unexpected outcomes though. The microfiber fabric (which is to be considered as a good one on the market), did not handle the 70% alcohol very well, it started to lose its colour onto the material/surface (in this case blue). Therefore, the microfiber fabric was excluded for the moment. It also turned out to be difficult to measure what was left on the surface after each wiping test. A photo of the surface was not enough as a result due to the fact that it became to clean to see a difference between the materials with naked eye. Hence, a new chemical were introduced in the test, Flourecinnatrium[14], which have got a fluorescent effect with UV light (black light). The Flourecinnatrium were mixed with the artificial blood, and the test could be re-established. Thanks to the mix of Flourecinnatrium in the artificial blood, after wiping the surface, the artificial blood that did not disappear were easier to see by means of UV light. However, by using UV light and focusing on the fluorescent effect the blue discoloration of the microfiber fabric would not interfere with the result of what was left from the artificial blood anymore. Hence, the microfiber fabric "was back" in to the test again.

After the initial pre-tests, 27 different tests were made in the following phase, one for each material (Glass, Spray painted aluminium and Acrylic plastic), the chemicals (70% alcohol, chlorine and "all-purpose cleaner") and fabrics (microfiber fabric, paper with extra good absorbency and industry paper – rough paper).

The result of this test gave some answers and a few more questions. The pictures that were taken were imageprocessed to get a clearer view of the difference between the Flourecinnatrium and the surface; firstly the all pictures were inverted, secondly they were turned into black and white and thirdly the contrast was increased.

The evaluation of the cleanability were handling three different factors; "the ring" (the coagulated soil that is left after wiping the surface), "the spot" (the soil inside "the ring") and "the leftovers" (the soil that is left after removing the fabric from the surface), see figure 4.

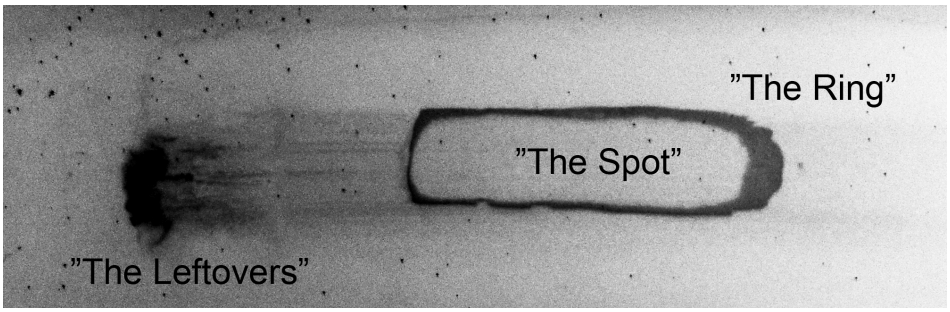

Figure 4: Picture illustrating the cleanability evaluation factors; the ring, the spot and the leftovers.

3.2. Wipe-off test results –the CAA score

The surfaces and the factors are evaluated in a scale of "1 to 10", -the CAA score were "1" is to be considered as the worst result in the test and "10" is the best result in the test in regard to the cleanability. The score is judged by a skilled operator as the "relative absence" of fluorescent dark areas in the images. The whole test with its result is illustrated in table 2.

[14] Scharlau, Flourecin Sodium, C.I. 45350 – Fisher Scientific, Gothenburg

Table 2: Table showing the test result for the cleanability.

		"Wipe-off material"									
		Microfiber fabric, *MF*			**Drying paper** (extra good absorbency), *DP*			**Industry paper** (rough paper), *IP*			
		Solvent			*Solvent*			*Solvent*			
SURFACE	**AREA**	70% alcohol, *70%*	Chlorine, *CH*	All-Purpose Cleaner, *APC*	70% alcohol, *70%*	Chlorine, *CH*	All-Purpose Cleaner, *APC*	70% alcohol, *70%*	Chlorine, *CH*	All-Purpose Cleaner, *APC*	SUM
SPRAY PAINTED ALUMINA	The Ring	5	7	5	4	3	4	6	6	4	44
	The Spot	9	9	7	8	4	5	9	7	2	60
	The Leftovers	7	6	7	7	7	7	2	3	3	49
	SUM	**21**	**22**	**19**	**19**	**14**	**16**	**17**	**16**	**9**	**153**
GLASS	The Ring	10	10	8	4	4	2	7	6	6	57
	The Spot	9	9	8	6	5	3	9	7	8	64
	The Leftovers	6	6	7	6	6	6	1	1	1	40
	SUM	**25**	**25**	**23**	**16**	**15**	**11**	**17**	**14**	**15**	**161**
ACRYLIC PLASTIC	The Ring	3	8	5	4	2	4	3	3	2	34
	The Spot	9	8	7	8	2	7	6	7	3	57
	The Leftovers	7	8	7	4	4	4	1	1	1	37
	SUM	**19**	**24**	**19**	**16**	**8**	**15**	**10**	**11**	**6**	**128**
STAINLESS STEEL	The Ring	8	7	6	7	5	4	5	2	3	47
	The Spot	8	8	6	6	5	3	5	2	2	45
	The Leftovers	8	7	8	6	5	3	4	3	3	47
	SUM	**24**	**22**	**20**	**19**	**15**	**10**	**14**	**7**	**8**	**139**
	Total of sums	**89**	**93**	**81**	**70**	**52**	**52**	**58**	**48**	**38**	
	Sum of total of sums		263			174			144		

3.3. The "wipe-off" results for the four surface materials

To support the analyse of the results in table 2, radar and bar diagrams were created, as illustrated in figure 5 and 6 below, with the sum of remaining soil in focus. The "total CAA" results in fig. 5, and 7-9 exposes a number of answers; the glass together with the microfiber fabric and the 70% alcohol or the chlorine, provides the best result. The Glass is a favourable choice in terms of the cleanability, measuring the surfaces respectively area in the radar diagram (top) in figure 6. The other materials are yet not far behind. Interesting thought is the fact that acrylic plastic (which have got a lower Sa-value) in the total score became last place; even though the difference is just 8% compared stainless steel.

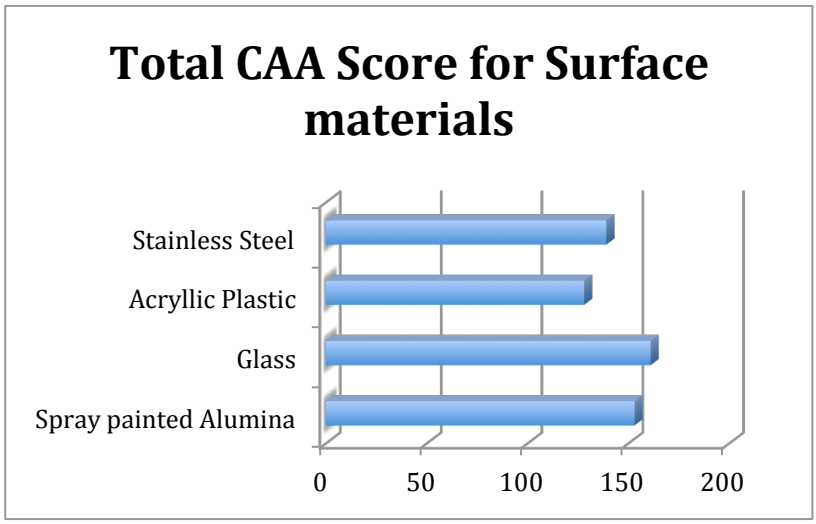

Figure 5: Figure illustrating the CAA score for the different surfaces.

The radar plot in figure 6 below adds to the results here the decreased performance for all surfaces while using the Industrial paper.

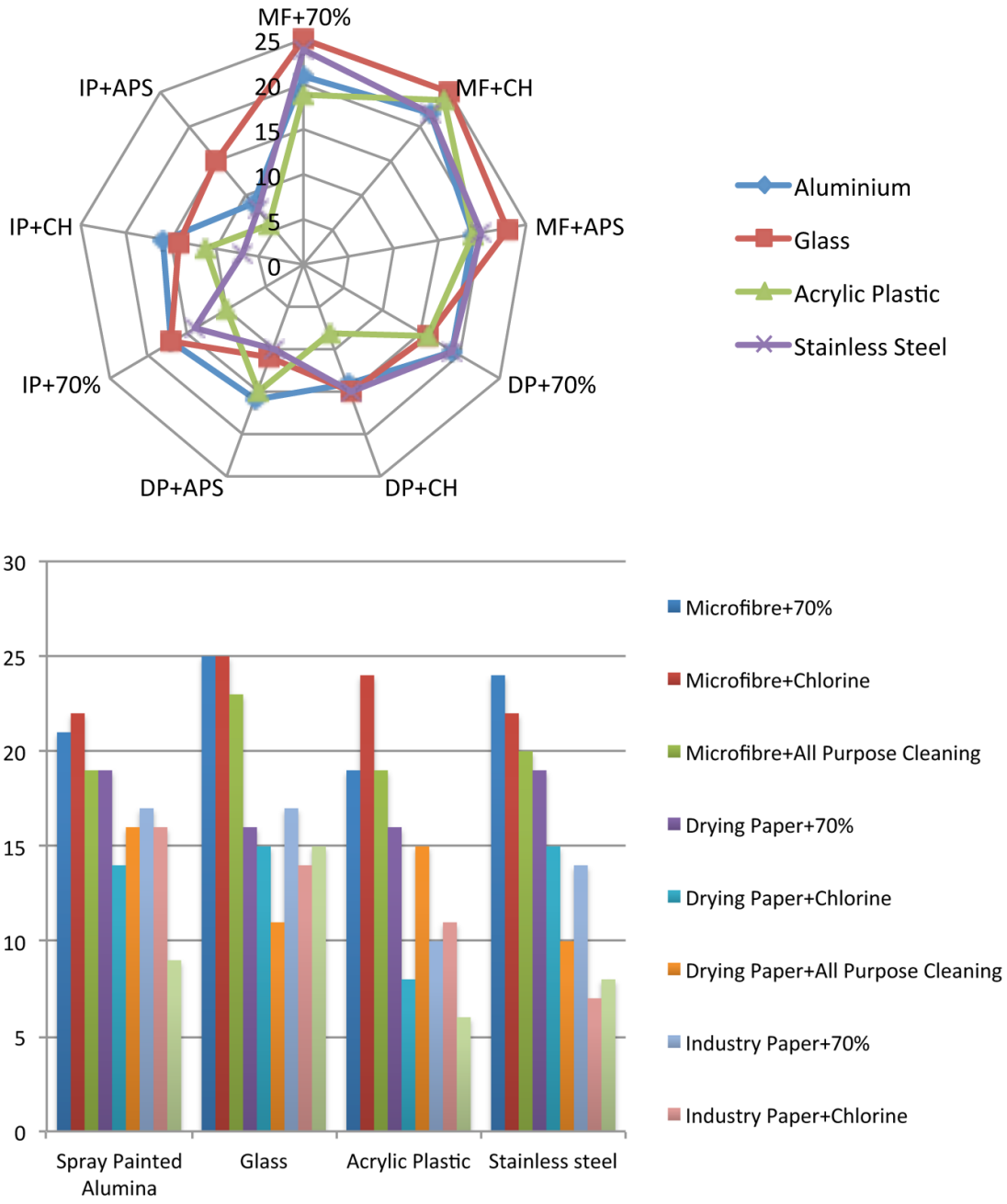

Figure 6: Figure illustrating the sum-result of the cleanability test. The bar-diagram (bottom) illustrating the "Total" score for the wipe material and cleaning agent for the spray painted aluminum, glass, acrylic plastic, and the reference, Stainless steel.

From figure 6 above, it is possible to deduct optimal combinations of wiper materials and cleaning agents for the different surface materials with regards to the total CAA score. All surface materials perform well with the microfiber wiper.

This analyse does not show the differences between the factors (the ring, the spot and the leftovers), hence new diagrams were made with major focus on the differences in between the factors and the wipe material/solvent, (figure 7-9).

3.4. The results for the three different “wipe-off” materials

It is not to surprising that the microfiber is on the first place with a 34% advantage to the next competitor, Drying paper. More surprising though is the minor different between the more expensive drying paper and the cheaper industry paper, only 17%.

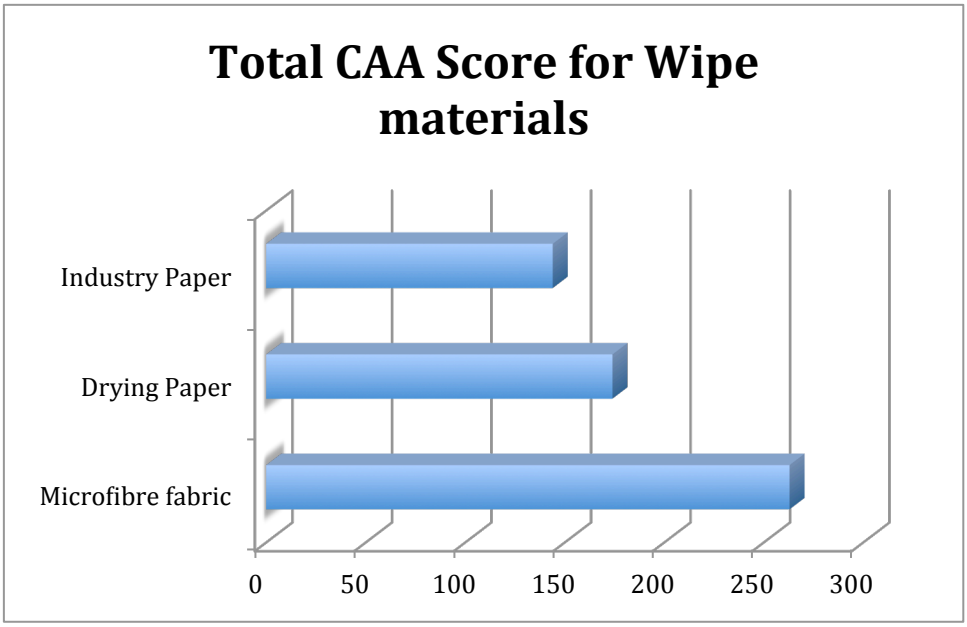

Figure 7: Illustrations of the differences in CAA score for all the three Wipe materials.

The major reason why the microfiber is 34% better score, depending on the consistently absorb-efficiency through the whole test. Yet, the test was about what is left on the surface after the test, and it is clear that the microfiber provides a better result.

3.5. The “wipe-off” results for the cleaning agents

From figure 8 below, for all the materials, the 70% alcohol display the best ability to move the soil “clean” from the surface independent of cleaning material.

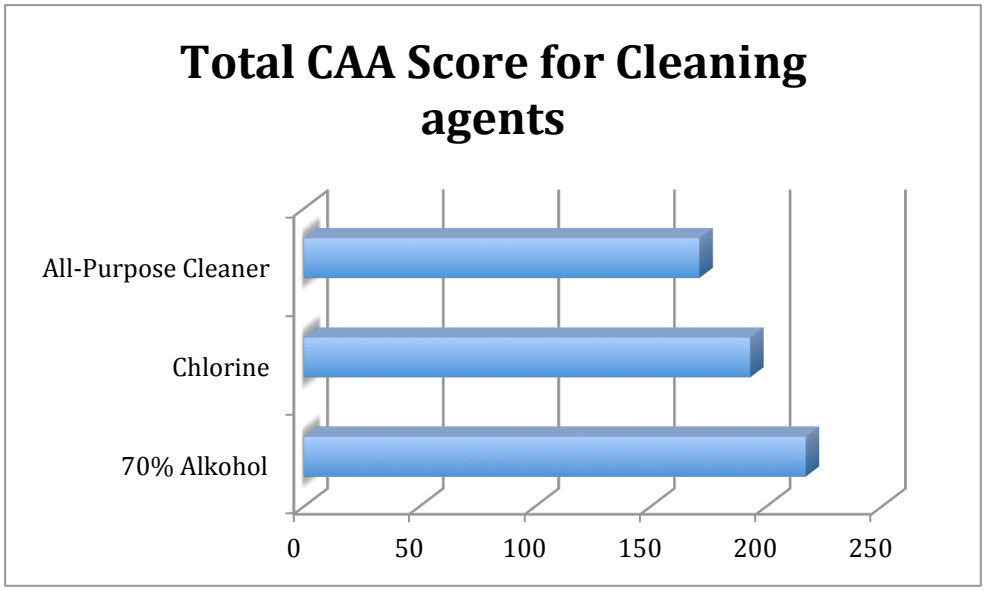

Figure 8: Illustration off the differences between the cleaning agents summed for all four surfaces respectively.

3.6. The "wipe-off" results for the combination of cleaning agents and wipe materials

From the results above, microfiber fabric wiper and the 70% alcohol or the chlorine, provides the best results. In figure 9 the total CAA score for cleaning agents and the wipe materials is illustrated.

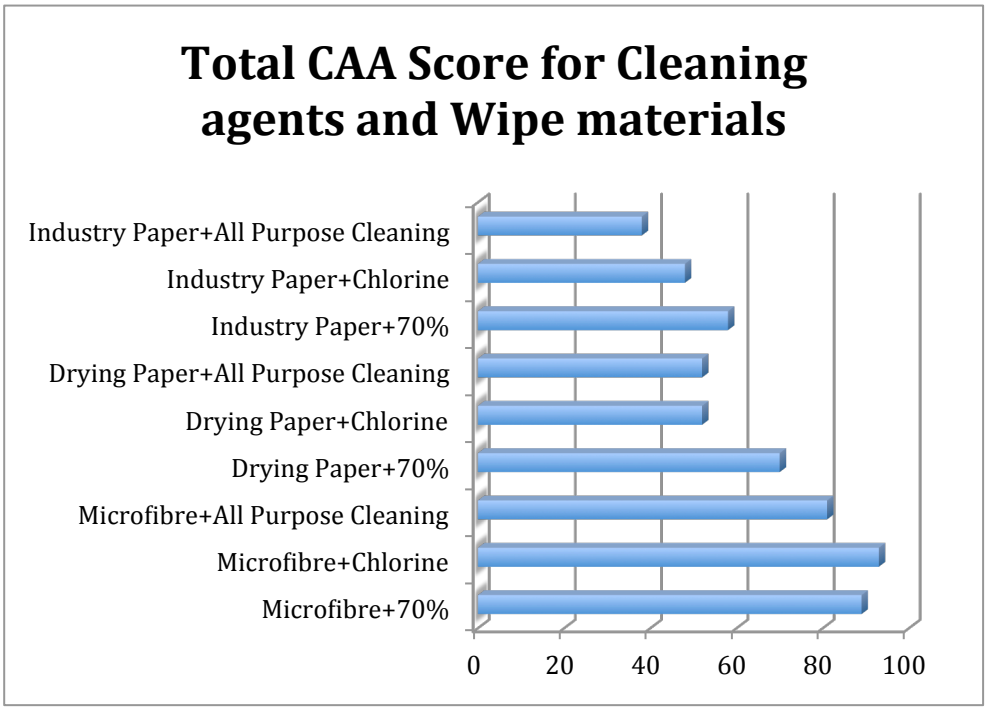

Figure 9: Graph illustrating the differences in between the combinations of cleaning agents and wipe material.

However, interesting in this diagram is the difference in between the Industry paper+70% and the Drying paper+chlorine (and APS) for instance. Even though the drying paper in general have got a better score regarding the cleanability, the Industry paper together with the 70% alcohol have got a higher score. Therefore it is important to know about the different combinations of wiping materials and cleaning agents.

3.7. The detailed "wipe-off" results for the surface materials –CAA scores for part areas

Again the microfiber is confirmed as the superior wipe material for all surfaces for all combinations of wiper material and cleaning agents for the ring- the spot- and the leftover areas. The leftover score is low for the paper material combinations for all materials, Spray painted alumina-, Glass- and Stainless steel surfaces. A big difference between Ring- and Spot scores compared to the Leftover Scores indicate either a low performing Cleaning agent (a negative difference) or a low performing wipe material with a low soil absorbance capability (a positive difference). For the Glass surfaces its clear from Fig. 10 (top right) below that the Industry paper can't absorb the dissolved soil while the Drying paper in combination with all cleaning agents have a problem to both dissolve and to absorb dissolved soil.

By not focusing on one of the materials, but only the factors of artificial blood, shows consistently that the ring was the most difficult factor to remove. This is obviously caused of the coagulation process of the artificial blood; it coagulates faster at the edges. However, the Spot on the other hand was consistently the easiest factor to remove due to the opposite; it coagulates slower and therefore the adhesion is lower to the material. Now, how about what is left when deviate from the

surface with the wiping material? Well, the leftovers expose how good or bad the wiping materials actually absorb the artificial blood. This is primary varying in between the wiping materials and the different surfaces/materials, as mentioned above. The Industry paper for example, might appear to be effective wiping the spot although it is basically just pushing the soil in the front of the paper and leaving a sizable leftover. Although the Microfiber fabric wiper, consistently absorbs the artificial blood better and leaving less soil on the surface. The differences of the factors and the four surfaces are illustrated in figure 10.

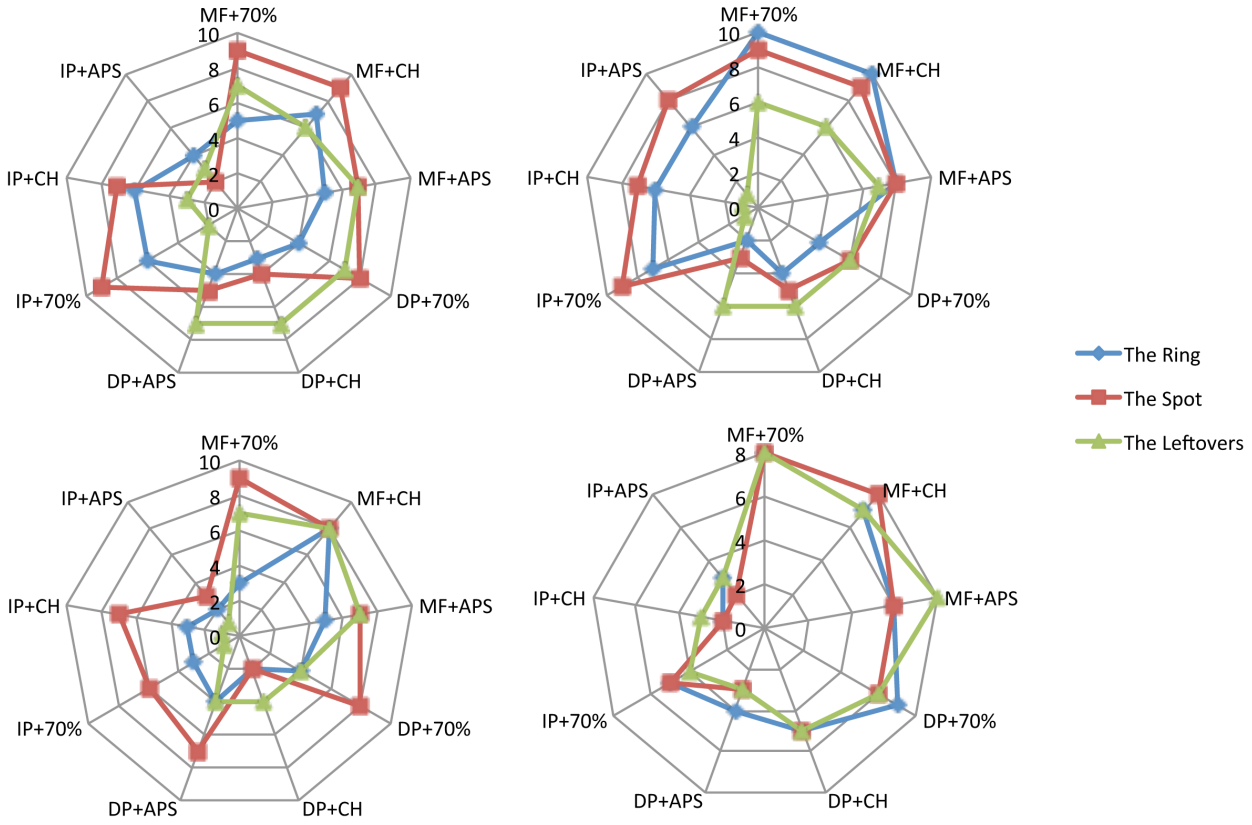

Figure 10: Radar diagrams illustrating the differences in between the factors and the wipe material/solvent of the Spray painted aluminium (top left), Glass (top right), Acrylic plastic (bottom left), and the reference, Stainless steel (bottom right).

The reference material Stainless steel react partly different from the Glass; all combinations of wiper material Industry paper and cleaning agents show both a low dissolving capacity for Ring- and Spot areas as well as a low capacity to absorb the dissolved soil. Combinations of Cleaning agents and the Drying paper are here performing better than the Industry paper but the Microfiber outperform both the paper variants.

4. DISCUSSION

Now, the experience of a visionary product is difficult to concretize, and even more difficult to put a number on to it. Nevertheless, by converting the experience to describing words such as adjectives, it is easier to understand and analyse the outcome of the emotions. Bergman M, et al. (2013)

The main issue in this case study was to find an approach and to evaluate the cleanability, but also finding correlations in between the cleanability, different materials and the emotions (experience) of the domain. Now, we know that the Glass, Spray painted aluminium and Acrylic plastic, in an earlier case study, passed through the focus group discussions about an visionary product and that these materials fulfil the visionary experience of a; *robust, resistant, clean, warm, sleek* and *elegant* product, Bergman M, et al. (2013). However, did they stand up for their good reputation even through this case study?

As shown in the table and figures there were some differences in between the surfaces total score but also between the factors, wipe off materials and solvents. A figure assembled of seven different photos is illustrated below to get an even better picture of how these surfaces could looked like after cleaning, (figure 11).

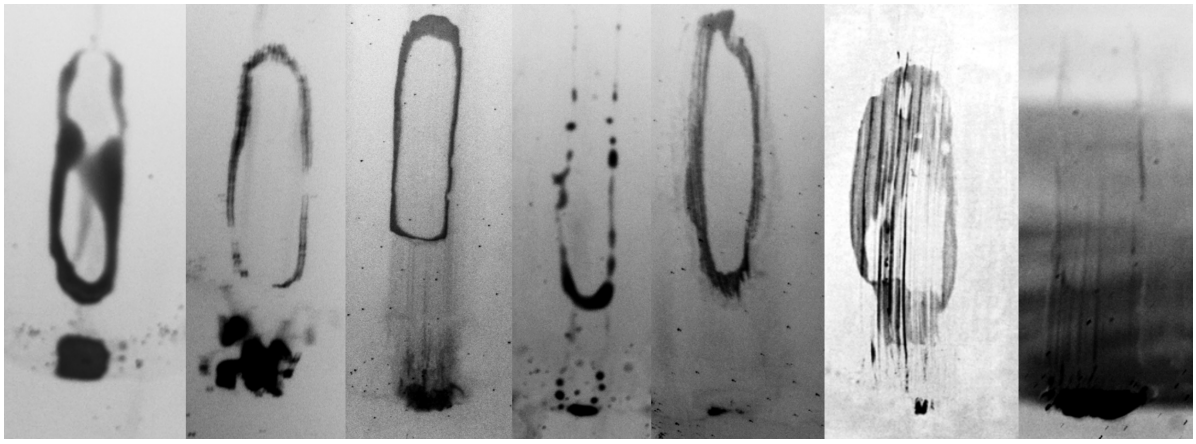

Figure 11: Figure illustrating a selection of seven different results from the wipe off test were the factors; the ring, the spot and the leftovers, have got a variance.

Now, the result of the wipe off test reveals three important things; the choice of wipe material is significant and so is the solvent. Nevertheless, the choice of material is fundamental; in this case study the Microfiber fabric together with the 70% alcohol or the Chlorine on the Glass gave the best result. Yet, the surfaces (all four of them) are good enough in terms of the cleanability in regard to the measurements.

4.1. The design of the microstructure

We can confirm that all of the four materials tested, passed the technical requirement of open contact surfaces, Sa <0.8µm, even though the surface roughness specification using Ra could be challenged separately. Focusing on the three challenging materials (Spray painted Aluminium, Glass and Acrylic plastic) they all are between 2-70 times smoother in terms of the roughness Sa-value. It appears to be correlation between the Sa-value and a cleaner surface (the cleaner surface the lower Sa-value). However, there are more parameters in the ISO 25178:2011 and 4287:1997 that could have an impact on the cleanability. What we do know is that the topical company wants a parameter to specify their own surfaces and to be able to guarantee their polishing process in regard of the surface roughness. From that point of view the Sa-value is clearly a good initial choice of design parameter since the long industrial experience in using the closely related Ra-value for specification and the current common use of Ra when specifying surface topography in publications on cleanability and bacteria growth.

4.2. The total CAA score results

The total CAA score results exposes that the Glass together with the Microfiber fabric wiper and the 70% alcohol or the Chlorine, provides the best result. This result offers the companies a

possibility to create their own surface cleaning and maintenance procedures guaranteeing “cleanest surfaces”.

4.3. The factors – the ring, the spot and the leftovers

The factors affecting the cleanability of the surfaces became an interesting parameter. Soil that are removed quickly (before it is coagulated) is obviously easier to remove, although a spot of coagulated blood residues with variance in thickness for instance could appear the same way as in this case study. It is significant; and it is important to choose a wipe material and a solvent that not only dissolves the soil, but also absorbs it effectively.

4.4. The conceptualization of emotion/experience

So how does the result from the wipe off test correlate with the design of a future product? First of all the material selection has to be proper; form follow function. Using the three “Stainless steel challenging materials” with their proven cleanability properties, one concept design of a future sterilizer challenging the current design (figure 12, left) is illustrated in figure 12 to the right. Here the Glass with its cleanability performance are covering the major area of the domain where the human operators normally interact with the product and create needs of cleaning. The transparent Glass is also providing the opportunity of adding a graphical pattern using a background foil without losing the desired cleanability function materialized by the Glass surface. The semi elastic Acrylic plastic is shock- and scratch resistant; and therefore placed directly under the Glass (grey part in fig. 12 right) where the loading trolley encounters each loading cycle. The lower part (dark blue in fig. 12 right) is covered with cost effective Spray painted aluminium –all surfaces with verified cleanability performance compared to the traditional Stainless steel.

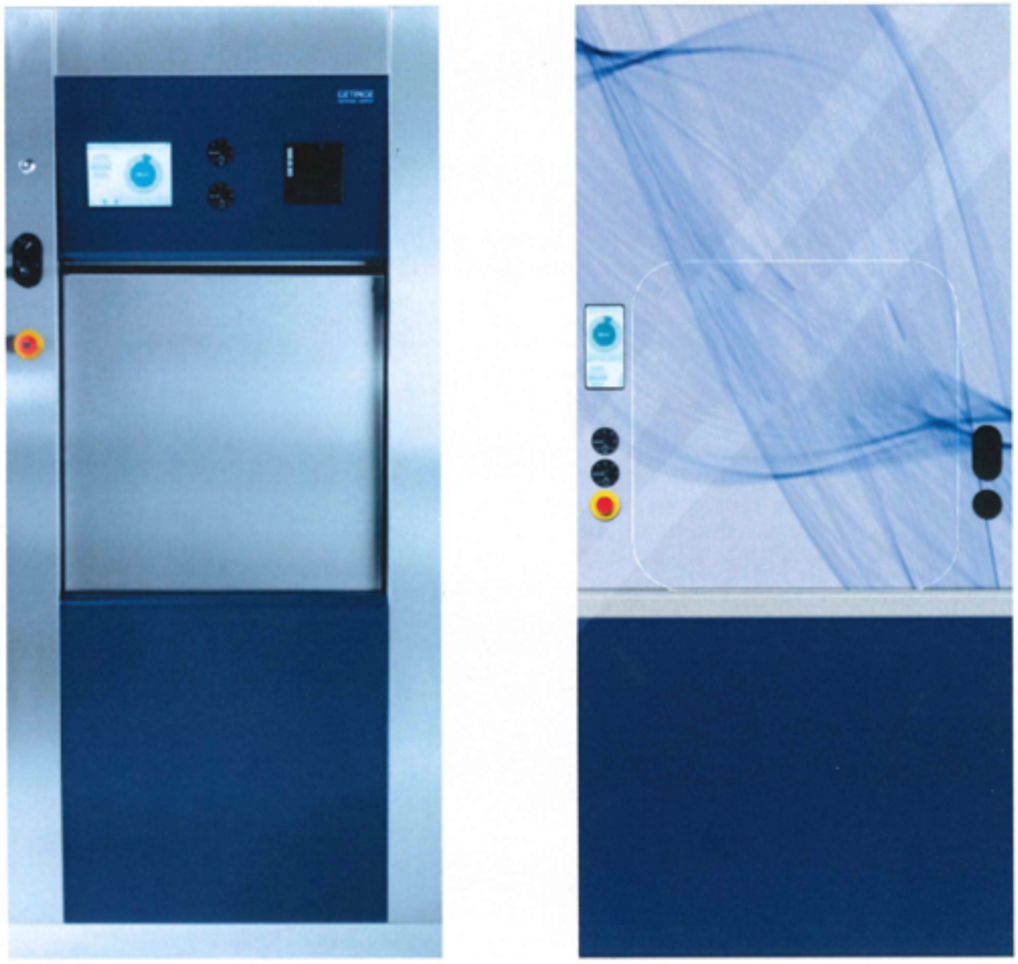

Figure 12: Figure showing the existing domain (left), and a visionary product (right).

The overall experience of healthcare environments could be improved if suppliers understand benefits and capitalize on advanced material and surface selection, not only from an economic viewpoint, but also from a functional and user perspective. If the topical company want a higher level of visual and haptic stimuli of their products the material and surface design is fundamental. The Spray painted aluminium, the Glass and the Acrylic plastic does not only provide a clean surface after maintenance, but also convey a *robust, resistant, clean, warm, sleek* and *elegant* feeling.

4.5. Additional implementations

We know that the design of the microstructure matters regarding the cleanability, and that the Sa-value is the only reference to the roughness in regard of a surface specification for the company so far. Yet, there are parameters that might interfere with the cleanability if focusing on the bacterial growth and the adhesion as well rather than the wipe off effect only. Dürr, H (2007) claims that the contact angle between the soil and the surface matters as well, which could differ depending on the soil, but also the surface roughness. For a deeper understanding on the contact angle and the effects of it, the reader is endorsed to read Woodward R P, (1999).

5. CONCLUSIONS

- For the challenging of traditional Stainless steel materials; Glass, Spray painted alumina and Acrylic plastic all are compete able alternatives with superior or similar cleanability properties.
- For the wiping materials; the Microfiber have got the best properties in terms of getting the cleanest surface.
- For the cleaning agents; the 70% alcohol or the chlorine have got the best properties in terms of getting the cleanest surface
- For the emotion and the experience; stainless steel should and could be challenged using the here introduced Clean ability approach to be able to change, and improve, the user experience of products in healthcare environments.

ACKNOWLEDGEMENT

The functional surface research group at Halmstad University would like to express a special acknowledge to Getinge Infection Control AB Sweden for the financial support, but also for the special interest in this project.

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BIOGRAPHY

Martin Bergman was born 1985 in the middle of Sweden close to the lake “Vänern”, which by the way is the 3rd biggest lake in Europe. He has a background as a technician/engineer in the plastic industry and has a design engineer bachelor. His 2-year master thesis is within industrial design, and was about functional surfaces for the typical sauna environment. Today he is currently a PhD. student in Mechanical Engineering/Industrial Design at the Department of Business and Engineering at Halmstad University (Högskolan i Halmstad) and also Industrial Design Education Manager at Halmstad University. Martin has been into several projects within material design, starting 2010 by traveling to Kansas (US) for a life there doing research at Kansas University in collaboration with architectural company, A Zahner Company. Since that moment, material and surface design has been in focus.

Bengt-Göran Rosén, BG, was born 1962 in Halmstad on the Swedish west-coast. He is currently professor in Mechanical Engineering at the Department of Business and Engineering at Halmstad University (Högskolan i Halmstad) and heads one of the main research areas – Mechanical Engineering and Industrial Design. He has been appointed visiting professor at Lund University in the south of Sweden, at ENISE Ecolé Nationale d’Ingénieurs de Saint-Etienne in France and is currently visiting professor at Chalmers University of Technology in Functional Surfaces and BISTU, Beijing Information Science & Technology University. 2010-2012 BG was the Chairman of the national Swedish Production Academy and is currently vice president for the same organisation. BG is active in international- and national standardisation work within the ISO TC 213, Dimensional and geometrical product specifications and verification, as Swedish expert in the field of surface structure- and previously co-ordinate measuring machine metrology. BG has been working since 1988 with the different Volvo companies and lately also Scania on manufacturing, characterisation and function on drive train components from engines to cam-shafts and gears. BG also have an interest in surfaces for prosthesis applications like dental implants and hip-joints and has lately worked intensively with industrial designers to promote surfaces as a strategic tool for the successful innovative companies.

Lars Eriksson was born 1964 in the Swedish capital city, Stockholm. He has been working as an Industrial designer since 1994 when he was graduated in Umeå with a Master of Fine Art at the

School of Design in Umeå at Umea University. Lars has been working 11 years as Industrial Designer with over 30 industrial clients, in total included research and educational company collaboration over 100 clients. Today he is a professor in industrial design and occupied with education and research with a focus on Industrial design in general and surface properties in specific. For the last five years Lars has been involved in design research with a special focus on surface properties with a functional approach. Lars is at present time co supervisor for 4 PhD students, 3 in surface properties with Licentiate degrees of Engineering and 1 in the properties of lighting and design.

Sensory, semantics and emotional relationship in tactile macrotextures selection of industrial products

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Abstract: The main purpose of this research consists in developing a pragmatic method, allowing the evaluation and selection of tactile macrotextures associated to subjective user interactions. So, this paper introduces an approach to formalize the relation between emotional values and textures, it is applied in the context of kitchen utensils. At this point we emphasize the importance of the identification and application of the subjective values during the product development by designers, guided by Kansei Engineering process [1]. Indeed, with the evolution of the global industrial sector, many alternatives of materials have been developed throughout decades. It is estimated that there are at least 160.000 different materials available in the world [2]. The development of such a variety has been led for the most diverse products, following the evolution of emerging consumer needs. At the strategic level of the production system, the research and industrial development stand out mainly in a functional context to add technical value to the efficacy of innovative products [3] [4]. However, there are still specific gaps in the usual methodological bases for the conception of new "affective products", endowed with emotional value (as fits the consumer demand). We identified in the literature that there are difficulties in weighting subjective attributes [5] [6], such as sensory, semantic and emotional aspects, in association with the identification and selection of materials for the design of industrial products. In the process, these aspects are not handled with a scientific method, but mainly empirically. However, these aspects are crucial to fully meet consumer demands. This limitation led our research to an initial experiment aiming at identifying relationships between 15 different tactile macrotextures present in 4 classes of materials and a selection of 212 descriptors [7] [8] [9], classified in sensory, semantic and emotional dimensions. A protocol was conceived and implemented between two culturally distinct nations, France and Brazil, defining a total population of 60 participants including Designers and Engineers. A descriptive statistical method was adopted to assist in handling the quantitative and qualitative variables at this stage. The preliminary findings enable us to characterize key parameters for the validation of the

descriptors associated with the tactile macro textures. Thus, we considered the relevance of multiple factors, such as sub classifications of the adopted descriptors, the presented materials and textures and sampling profile of the participating groups. The synthesis of these results will be used in the next experiments to analyse the tactile perception.

Keywords: Textures selection, emotion, affective products.

1. INTRODUCTION

A positive affective interaction with a product can avoid a premature disposal. Therefore, products that are emotionally well accepted will remain longer in the user's hands, when satisfaction is fully achieved. Affection is often defined as an emotional state and in psychology it represents three basic aspects: desire, happiness, and sadness [10].

In his study, CSIKSZENTMIHALYI [11] emphasizes the importance of an affective relationship between the user and the object and the relevance of the user involvement in the creation of an object. In other words, it is the recognition of values assigned by the user and translated into the design process by the designer. The "emotional longevity" established with the artifact can still be understood as it allows creating social and environmental durability situations, to the point that they will contribute to control a compulsive buying behavior in society, and consequently, to use the product wisely. In this research, we highlight the perceptive values that include pleasure for the consumer (positive affective state).

The authors understand that perceptual values are qualitative and quantitative attributes of psychological apprehension influenced by technical properties and based on neurophysiological sensations [12].

However, the problem of this research suggests that it is being given little importance by the industry to the exploration of different tactile macrotextures endowed with perceptual values. This encourages the development of new tools to help designers focus on the product surface. Thus, it is necessary to enable the creation of new tactile experiences based on the Kansei Engineering (KE) methodology. In contrast, we must make sure that the textures used in the industry are not repetitive, or even similar, conveying an ordinary concept [13]. Hence, the products with the same type of texture may be perceived similarly by the users.

In the last decades, many polymeric materials have been increasingly used in popular products on the market. This increase can be explained by a consumption phenomenon, which is driven by the necessary reduction of manufacturing costs and greater formal plasticity allowed for this type of materials. Consequently, the effort and the influence derived from the improvement of the visual quality of the product surfaces developed for this segment of materials (kitchen utensils and automotive industry, etc.) has gained attention, but primarily in major industries. Recent cases of material simulation and physical aspects, examples of polymers that mimic steel surfaces, ceramics, composites or timber (for economic benefits) or simply graphic coatings were used to decorate many different materials (e.g. Water Transfer Printing Process). Here, the values are interpreted according to the visual shapes and textures, whose meanings present undefined concepts or are dissociated from the real product (loss of material recognition).

Nevertheless, it is particularly complex to separate these interpretations from each other i.e. to separate the form (Gestalt) and content (semiotics) because there are no pure forms without meaning, or content without forms. The materials that do not allow the productive use of form can

limit the capacity to generate emotions and stimulate sensations [14]. Therefore, form is potentially related to content. An appropriate environment can stimulate the sensory aspects of the user-product interaction, aiming at increasing adhesion and values attributed to them by the users [5]. If the contextual variable of the artifacts is not considered, the intentionally assigned meanings cannot be explained [15].

Hence, we reinforce the importance of pre-establishing contextual relationships with subjective interpretations. In part 3, the case study described in detail discusses the sensory, emotional and semantic correlations with materials and textures, simulating a scenario (descriptive and imaginary) for kitchen utensils.

This article is organized as follows: part 2 describes the main methods of product design and analyses their integration of emotional variables; part 3 presents the activities and results for the experiments involving the "Kansei - Texture" connections; and part 4 concludes with our further study prospects.

2. SUBJECTIVE VARIABLES IN DESIGN METHODS

The design methodology involves the study of principles, practices and procedures. The main objective is to improve its implementation and to focus significantly on the design process [16]. The methodology is still considered a "branch of science that critically analyses structures, rules and methods to design products in the context of artifacts, materials and systems" [17].

These definitions represent the most classic design models that are structured according to the global visions of the ‘60s, when the research in design methodologies started [18], and were based rather on strategic and technical aspects than on those that were specific and human.

The conception methods in the product design field tend to propose numerous different and successive phases that are organized by linear or cyclical, descriptive or prescriptive structures, with or without flexibility between the proposed phases [19]. The key point is to achieve the goals to meet the consumer demands. Consequently, an increasing integration of human factors in the design activities are being more exploited in the recent propositions for the conception of tools, following the emerging consumer needs on the market.

For the designer, KRIPPENDORFF [20], the conception of purely functional products based on the model proposed by the Ulm School of Design is an outdated paradigm. The design focused on the product and its technical aspects is providing more opportunities for a human-centered design. This interaction with the consumers contemplates the way they see, interpret, and behave in relation to the product.

The design process is related to social practices, symbols and preferences [20]. Thus, it can be observed that the users do not react to physical aspects of the artifacts, but to their meaning.

“Individuals are composed of a set of idiosyncrasies[1] that can influence their interaction with a product, forged throughout their existence by the social and cultural experiences found in the environment they live in” [14].

The products should provide not only efficiency and functionality but also pleasant experiences to their users [21]. Therefore, when working on a project, the designer has to balance between aesthetics and functionality [22].

[1] Personal temperament, set of own reactions to each individual.

For a brief analysis of these aspects, we compare ten of the most well - known authors in design methodologies from Europe and South America in the last decades: BONSIEPE [23], QUARANTE [24], PAHL and BEITZ [25], ROOZENBURG and EEKELS [17], ULRICH and EPPINGER [26], BAXTER [27], CROSS [16], LÖBACH [28], BACK [29] and PLATCHECK [30].

However, we have to point out that none of these authors have fully incorporated emotional aspects or even technical aspects linked to the process of analysis or selection of macrotextures into their methodologies. Table 1 shows the impact of these subjective attributes on different methodologies.

Table 1: Comparison between authors and their conception methodologies.

	Authors (Function/ Location)	**Year of publication**	**Impact of emotional attributes in the design methodology**		
			weak	**partial**	**strong**
Authors of Product Design Methodologies	**BONSIEPE, G.** (Designer - Germany)	1984	X		
	QUARANTE, D. (Designer - France)	1984		X	
	PAHL, G. & BEITZ, W. (Engineer - Germany)	1988	X		
	ULRICH, K. T. & EPPINGER, S. D. (Engineer – USA)	1995	X		
	ROOZENBURG, N.F.M. et EEKELS, J. (Designer - Netherlands)	1998		X	
	BAXTER, M. (Neurobiologist - England)	1998	X		
	CROSS, N. (Architect - England)	2000	X		
	LÖBACH, B. (Designer - Germany)	2001	X		
	BACK, N. (Engineer - Brazil)	2008	X		
	PLATCHECK, E. (Designer - Brazil)	2012	X		

This investigation shows that the systematic approach involving subjective values (emotional impact) has not received too much attention in the methodological structures for decades, mostly during the selection of materials and finishes. Some researchers in the context of Kansei Engineering and Emotional Design proposed the incorporation of primarily independent tools into the conception process.

These tools are equipped with variables that allow a systematic assess of emotional values in certain phases of a project (examples listed by the Design & Emotion Society). Some tools have applications on the global analysis of materials (simplified databases), however, most of them are used to assess the final product as a whole (SENSOTACT®, Kansei Engineering Software, TRENDS software, SKIPPI software, etc).

From the engineering point of view, most authors do not incorporate subjective concepts into the selection processes of materials and finishes. Some of these designers tend to include sensory variables from the range of human perception to promote a short and restricted interpretation of subjective values. The CES EduPack 2012 Software® developed by ASHBY [2] for browsing, searching, and selecting materials is a good example of such initiative.

Thus, attempts to transition between subjectivism and pragmatism encouraged us to find, initially, sensory, semantic and emotional relations with materials and finishes by a sequence of experiments. An initial hypothesis comprises the existence of stable relations between technical parameters of textures and a number of emotions evoked in the interaction with materials.

Punctually the study of these technical parameters will be approached at the time of physical tests with samples of textures at a later stage. Therefore, the contribution of this paper is aimed to validate the potential relationships of descriptors from the visual interaction with images of textures. Preliminary results of the experiment are presented in the following chapter.

3. MATERIALS AND METHODS

3.1. Objective

The experiment was carried out to find links between a selected set of descriptors and a selected set of materials represented by different textures in a given context and to identify the relation between materials and sensorial, semantic and emotional descriptors, as established by populations of different ethnicities.

3.2. Method

The method consisted of a sensory interaction of the population, in which only perceptual, cognitive and emotional responses were evoked from images of tactile textures. Following, an interaction network was established between the population, the textures, the descriptors, and the context. The tactile perception was not included at this stage of the study, therefore, this data was not used in the comparative analysis, but it will be included in further studies.

3.2.1. Materials and Population

A total of 1300 descriptors related to materials and textures were first gathered, taken in some theoretical databases (Table 2). Then, a weighted selection resulted in two distinct groups of words (G1A and G1B) for the implementation of the experiment. This division was made to reduce participant task load.

Table 2: Classification of attributes and sources.

	Attribute types	**Total quantity**	**Selected attributes** Test G1A - Test G1B		**Source of attributes**
Sensorial	Visual and tactile perceptual attributes	421 words	49 words	48 words	BASSEREAU and CHARVET-PELLO [7], ASHBY and JOHNSON [31], ZUO et al [32], « Semantic differential scale »
Semantic	Meaning Attributes	687 words	27 words	28 words	KARANA [8].
Emotional	primary and secondary emotion Attributes	212 words	30 words	30 words	Labels describing affective states SCHERER [33]; GALC – SCHERER [9].
Materials	Identification	50 words	15 words		(website LdSM/UFRGS) [34]
Sum of descriptors:		**1370 words**	**212 vs 15 materials**		

The selection method was chosen by consensus of the researchers integrated to research group (the authors of this paper) according to greater relevance to the context of textures and materials. For instance, the group chose to discard some terms because a large number of synonyms were found and didn't contribute to a synthetic representation of the analyzed dimensions (sensory, semantic and emotional) for example : delicate, fragile, graceful and weak. At the end of this

selection phase, a set of 106 words in each group (G1A + G1B = 212 words) was divided into three families (sensory, semantics and emotional).

In parallel, we chose 15 textures associated to 4 classes of materials (metals, polymers, composites and naturals) through discussions with experts in the context of materials from the Laboratory of Design and Materials Selection – LdSM of the Federal University of Rio Grande do Sul – UFRGS [34]. We decided to select the most popular materials in its most simplified structures. (Figure 1: c).

The 15 textures and the 106 words were disposed on a paper panel (size A0) around a square shape (Figure 1: a) with macro photographs of textures in a descriptive context hypothetically indicated (kitchen utensils). The shape of this paper panel was chosen to enable participants to read words and look at textures from one single direction (they didn't have to turn the paper around to read all the words).

A population of Brazilian and French people were selected in the categories of "novices" and "experts" and also divided as "designers" and "engineers". The total number included 60 participants, 36 Brazilians (28 engineers and 8 designers) and 24 Frenchmen (12 designers and 12 engineers).

3.2.2. Protocol

The task was performed in small groups (2 -10 subjects). In this session, 10 minutes were spent for instructions and comprehension of the semantic content related to the list of descriptors and textures. Approximately 35 minutes were spent for the participants to manually draw lines matching each material/texture and its corresponding descriptors in a comfortable and relaxed way (Fig. 1: b).

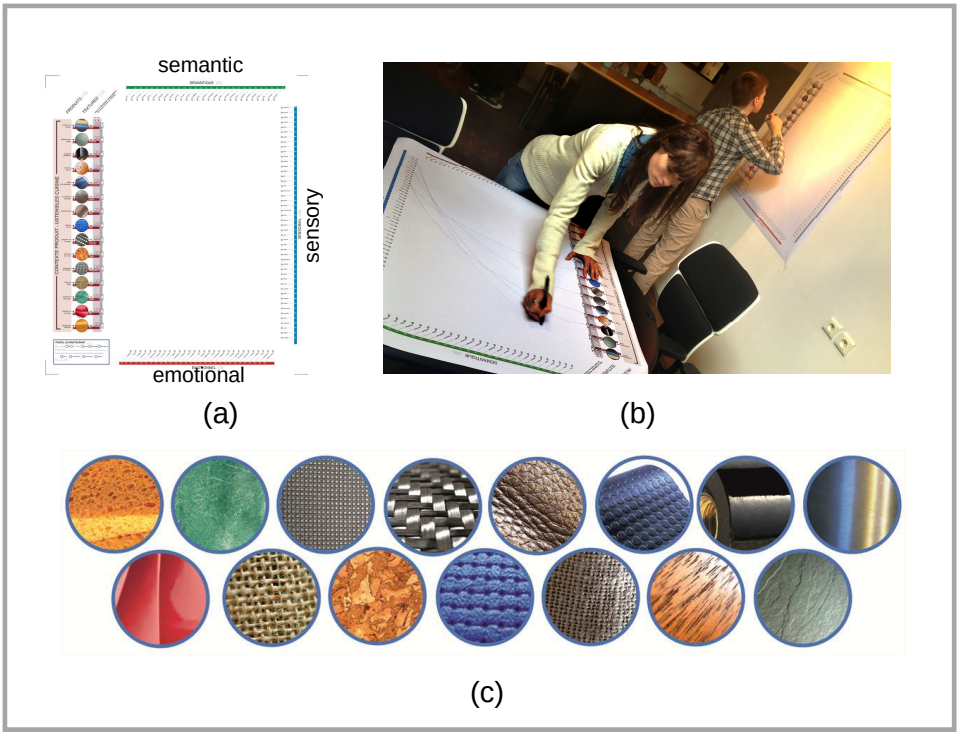


Figure 1: Materials: (a) Panel A0 - Textures vs. Descriptors, (b) Hand draw line – population, (c) 15 selected tactile textures.

They were invited to draw these lines considering that each line drawn would correspond to a relation between a material/texture and a descriptor, such as for instance: Rubber – helpful, artificial

and fun; Wood – pleasure, timeless, aesthetic and ribbed.

The participants were allowed to match several words with a single texture or a single word with several textures.

The integration of context was carried out by giving, in writing, some examples of how each texture is used in cooking utensils (e.g. scissors, pepper grinder, kitchen cloth, cutting board, etc.).

A global schema of the experimental protocol is shown on Figure 2.

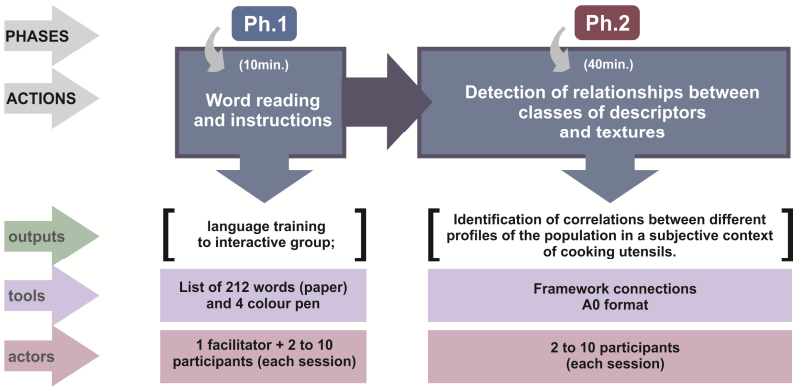


Figure 2: Schema of the experimental protocol.

3.3. Results

The total number of connections achieved by the entire heterogeneous population was 4581 (total of lines in 15 textures) and the maximum variance was set between 36 and 310 connections per participant (globally, the lower values for the novices and the higher for the experts). Some 1791 different connections were added to this number after the inclusion of 60 participants (FR + BR).

All descriptors (212) have been mentioned at least once by the population and most of the results were processed using the software Excel® due to the heterogeneity of the participants.

3.3.1. Visual density analysis

After the data were tabulated, a visual density analysis of the lines drawn on paper was performed under a set of answers in reduced scale (photocopied of the originals – miniature panels). These lines were organized from the less dense to the more dense (Figure 3). This organization took into account the actual values of the amount of lines. The copies were arranged in columns (side by side), corresponding to intervals of 10 lines each (in transition from 36 to 310 lines).

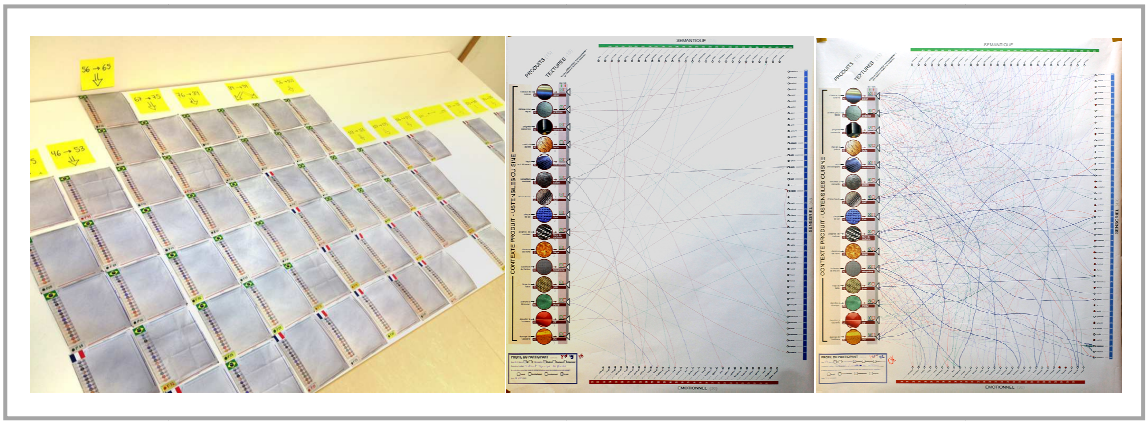


Figure 3: Visual analysis of the line density in the miniature panels on the table.

To have a better overall view, the tags with flags from Brazil and France were attached to the miniature panels in addition to codes, which were used to identify the nationality, occupation and expertise of all 60 participants.

We have determined that the line density was not necessarily homogeneous in relation to the expertise (Novice and Experts), especially for Novice and particularly in France where the standard deviation was higher. In relation to occupation (Designer and Engineer), the line density for the Brazilians was totally heterogeneous, however, the standard deviation for Designers in France was more significant. Globally, it was possible to identify higher density for all Experts.

3.3.2. Data descriptive analysis

The complete measures were initially presented by descriptive statistics from the data interpretation. Firstly, we identified the standard deviations that certain materials/textures present due to the different analyses when data were cross-checked (Figure 4). Secondly, we highlighted certain aspects drawn from Figure 5 (Kansei –texture connections), to compare the connection frequencies per person and also the relations of the number of different connections created by the groups or subgroups, considering the different nations, occupations and expertise of the participants.

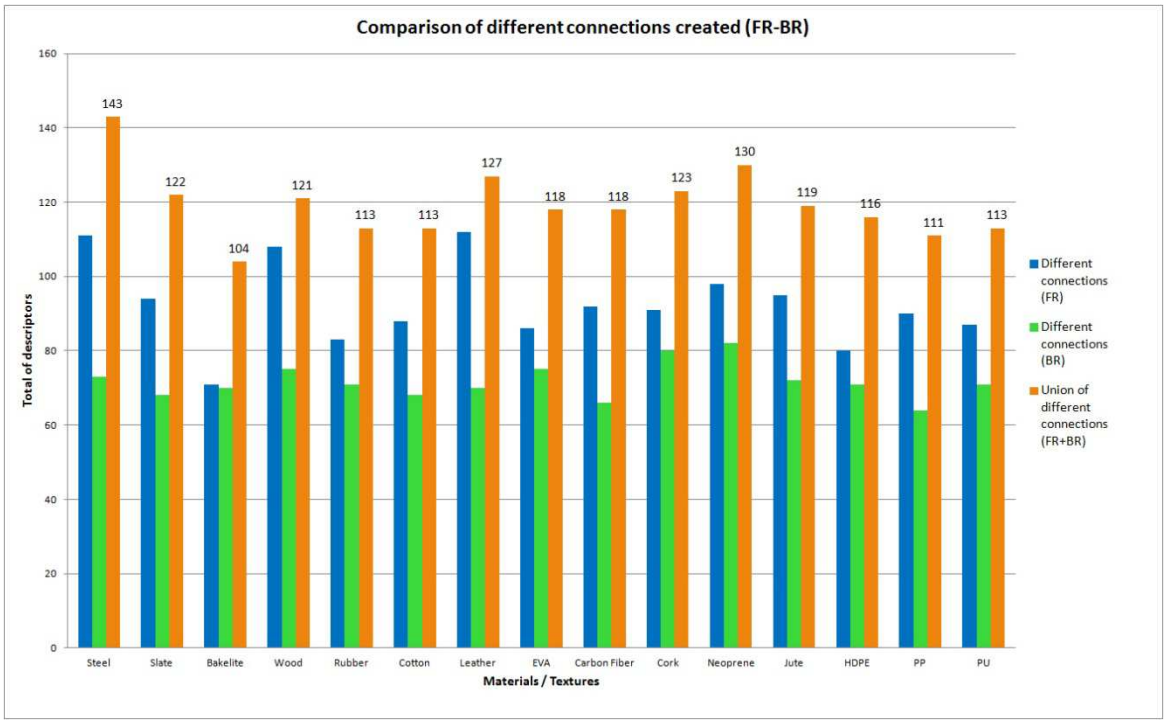


Figure 4: Total number of different connections created for each texture.

When both groups were compared, it was possible to highlight the most relevant standard deviations for the 3 classes of descriptors (sensory, semantic and emotional). This is the case of steel, wood and leather textures (Figure 4). We noticed that these 3 types of materials are among the oldest of this group in the cycle of exploitation and human consumption.

With regards to populations (FR + BR) and the context created, we found that the French participants were sensitive to multiple and various sensory, semantic, and emotional values. In Figure 5, it is possible to visualize the difference between these values by the average connections (AC) established by person (on the axes of central information).

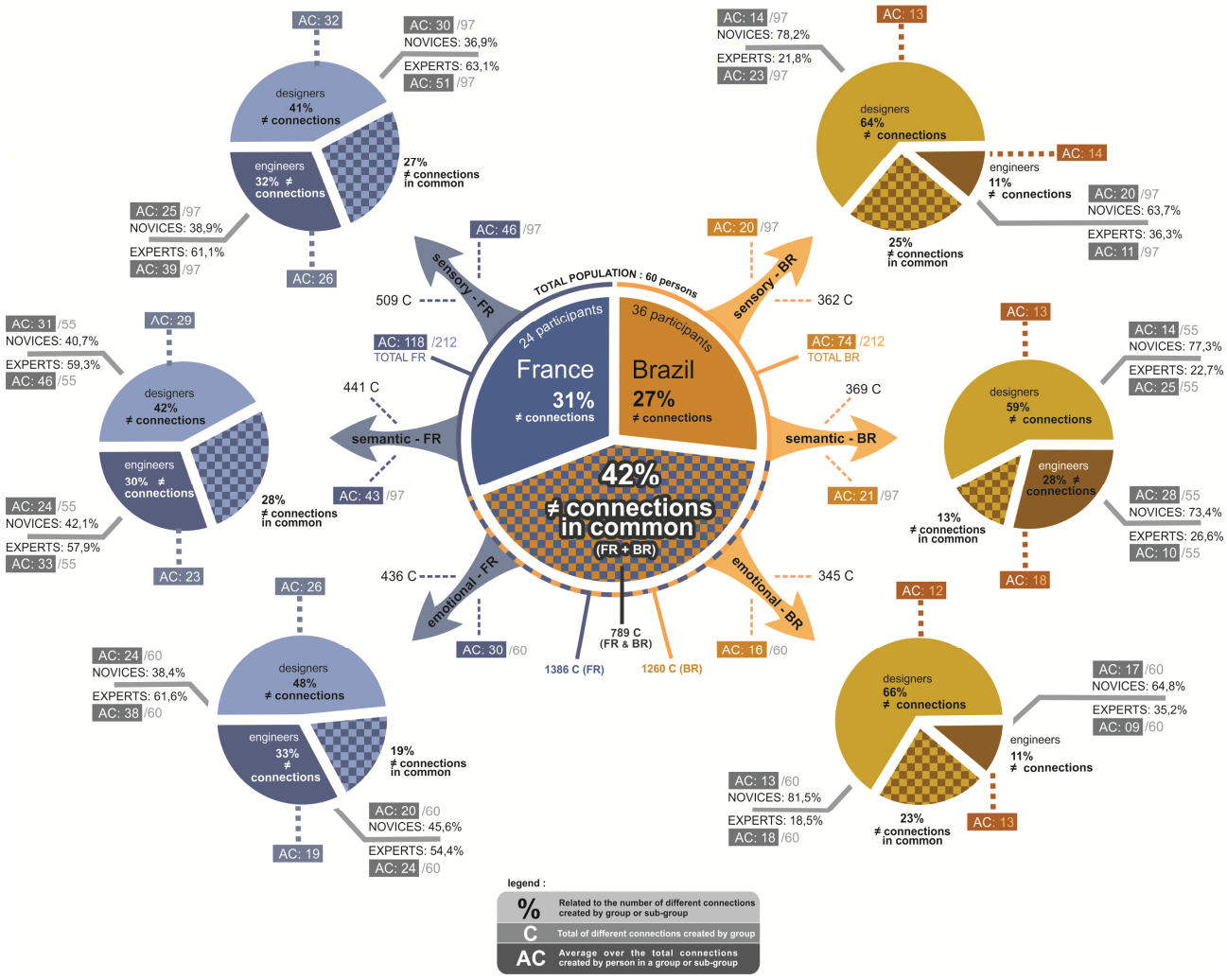


Figure 5: Subjective assessment of Kansei – Texture connections – established due to the occupation and the expertise of a population in a kitchen utensil context.

All values expressed as percentages were based on the number of different connections created by the groups or subgroups.

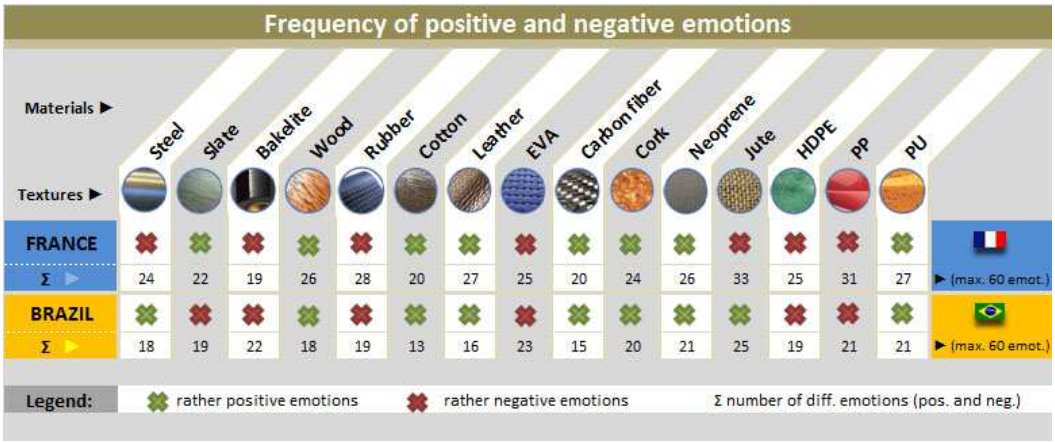
The French participants showed greater cohesion (different connections in common) in sensorial and semantic dimensions, and higher variance (Figure 5, on the left). This means that the French population also connected more divergent attributes when compared with the Brazilian population (Figure 5, on the right side). In the sensory dimension, the contrast was more evident (509 different connections made by the French compared to the 362 different connections by the Brazilians).

There was a significant inversion in average connections (AC) between the expert and novice engineers of each country (Figure 5). The Brazilian novices connected more descriptors than the experts in the same Brazilian Group (sensory, semantic, and emotional) with great variance, as well as the French expert designers.

We have identified which textures present in the context of kitchen utensils evoked primarily positive emotions, as well as those primarily negative, by analyzing the participant groups (Table 3).

Among the participating countries, the materials such as steel, slate and jute revealed opposite emotions (positive or negative). Surely, the number of emotions in all cases does not represent unanimity in every texture, but the largest number of registered emotions (Table 3).

Table 3: Frequency of "Texture – Emotion" connections in the context of kitchen utensils.



We also emphasize that textures such as jute, PP (polypropylene), rubber and PU (polyurethane) represented the largest number of different emotions evoked by the Frenchmen (greater standard deviation). However, in this case, the connotation was primarily negative. Similarly, jute, EVA (Ethylene vinyl acetate) and Bakelite were highly evoked by the Brazilian participants.

4. CONCLUSION

After performing a density visual analysis and a data descriptive analysis, we conclude that our experimentation focused on the interaction between designers and textures can reinforce the integration of a greater number of feelings, meanings, and emotions into the selection of material for the industrial design process.

However, the great "variability" of Kansei – Texture connections can represent certain contradictory conditions e.g. positive and negative emotions attributed to the same texture by the same population, but by different individuals. This could be explained by the influence of social, economic, cultural differences that exist between homogeneous or heterogeneous populations, particularly between different countries.

The synthesis of these results does not yet validate the hypotheses because comparisons must still be performed in different dimensions: sensory (Visual vs. Tactile), contextual (an approach in the automotive context will be held in the next experiment) and ethnic. However, the discussions generated here will be used in subsequent research experiences to analyze the tactile perception.

Therefore, the identification of a context and the variables of the population for the Kansei – Texture connections should always be considered.

ACKNOWLEDGEMENTS

This PhD study has been supported by CNPq - Brazil.

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Experimental Verification for Subjective Sense of Object Weight

Proposed User Category based on the individual Kansei by Subjective Weight

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Abstract: Weight is frequently used in product information and the design process. However, the perceived weight is greatly influenced by individual subjectivity. Guessing the exact weight using only numerical information and visual estimation is not easy. Therefore, this study focused on the relationship between the perceived weight and actual weight, and verified the difference between the subjective and physical senses of weight. In other words, we aimed to explore the error range, and to reveal the characteristics of the subjective sense of weight. We performed two experiments. Experiment A is for the 'subjective sense of weight due to the difference in weigh' using models with differing weights but the same size, and Experiment B is for the 'subjective sense of weight by size' using models with differing sizes but the same weight. In the results, the average subjective weight of the 170 g model was 223 g for an error rate of approximately 31%. On the other hand, the average subjective weight of the 100 g model was 103 g. Therefore, the error between the subjective and physical weights was greatest at 100–170 g in Experiment A. In Experiment B, the average subjective weight of the 170 g model with a diameter of 75 mm was 298 g, which is 75% greater than the physical weight. The error for the 170 g model was smallest at -4% when the diameter was 120 mm. In other words, the error decreased with increasing model size in Experiment B.

Keywords: Kansei Evaluation, Subjective Weight, Perceived Weight, Recognition Model, Sensory Measurement.

1. INTRODUCTION

Weight is a property specific to the physical system of an object. It is frequently used in product information and the product design process. In recent years, weight saving of products has become an important issue in manufacturing. Especially in the field of aviation and automotive, they are aiming the weight saving of the machine for energy conservation. And, it is necessary to reduce the weight of the product in order to increase the portability of Electronics.

However, the perceived weight is greatly influenced by individual subjectivity. For example, exactly the same design might be feeling lighter or heavier by a personal impression. Guessing the exact weight using only numerical information and visual estimation is not easy, and individuals can interpret the information differently. Therefore, this study focused on the relationship between the perceived weight (subjective sense of weight) and actual weight (physical weight).

There have been few studies on the perception of weight, and these were limited to particular products. In this study, we therefore limited the shape to a sphere small enough to fit in one hand to serve as basic research that is applicable to various product designs.

In other words, this study verified the difference between the subjective and physical senses of weight. We aimed to explore the error range, and to reveal the characteristics of the subjective sense of weight. It could relate subjective sense of weight to Kansei.

2. OVERVIEW OF RESEARCH

For this study, we performed two experiments. Experiment A is examined for the ‘subjective sense of weight due to the difference in weigh’ using models with differing weights but the same size. And, Experiment B is examined for the ‘subjective sense of weight by size’ using models with differing sizes but the same weight.

In Experiment A, the weights of the 100 mm diameter plastic balls were changed. Five different weights of 100–600 g were used to represent electronic products used in daily life. In Experiment B, the plastic balls had diameters of 75, 100, and 120 mm, and two weights of 170 and 460 g were used. Table 1 shows the contents for the experimental models. Figure 1 and figure 2 show the image of the experimental models.

Table 1: Experimental contents

	Shape	Size (Diameter)	Weight
Experiment A	Sphere	Same	Difference
Experiment B	Sphere	Difference	Same



Figure 1: Models for Experiment A



Figure 2: 170 g Models (left) and 460 g models (right) for Experiment B

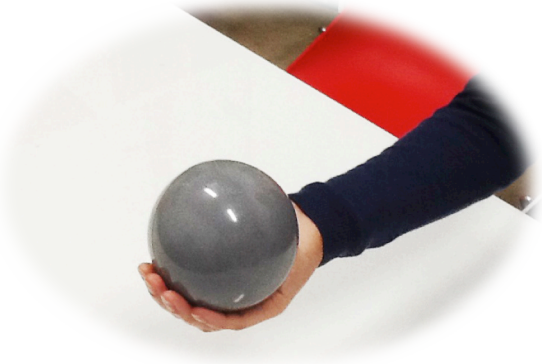

Figure 3: Condition of the experiment

For the experiments, the subjects were asked to weigh a 500 ml PET bottle for 10 s to prepare for this experiment. They were then asked to weigh the nine models of Experiments A and B, which were presented at random. The 50 subjects were all male college students with an average age of 23.5 years; they were all right-handed. Figure 3 shows how to perform the actual experiment.

3. RESULTS AND ANAYSES

3.1. Experiment A

Table 2 shows the overall results of Experiment A. In the table 2, the average subjective weight of the 100 g model (A-1) was 91.2 g for an error rate of -9%. And, 170 g model (A-2) was 222.2 g for an error rate of +31%. Subsequently, 280 g model (A-3) was 326.8 g (+17%), 460 g model (A-4) was 652.6 g (+42%), and 600 g model (A-5) was 761.1 g (+27%). In the results, the average subjective weight of the 170 g model was 222.2 g for an error rate of approximately 31%.

On the other hand, the average subjective weight of the 100 g model was 91.2 g. This produced the smallest error of about -9%. Therefore, the error between the subjective and physical weights was greatest at 100–170 g in Experiment A. In figure 4, we could fine that the subjective weight was judged heavier than the actual weight on below 600 g models. However, individual differences appeared large in all models.

Figure 5 is the graph of user category by error rate. In Experiment A, the group with error rate of less than 20% is 48%. The group with error rate of less than 50% is 36%, and the group with error rate of 50% or more is 16%. According to the personal weight senses, they could be divided into the accurately judging group, judging the objects to be lighter group, and the group that believed the objects to be heavier than the actual weights.

Table 2: Result of Experiment A

Models	A-1	A-2	A-3	A-4	A-5
physical weight (g)	100	170	280	460	600
subjective weight (g)	**91.2**	**222.2**	**326.8**	**652.6**	**761.1**
sd	54.2	111.8	133.0	243.1	224.9
error	-8.8	52.2	46.8	192.6	161.1
error rate (%)	**-9%**	**+31%**	**+17%**	**+42%**	**+27%**

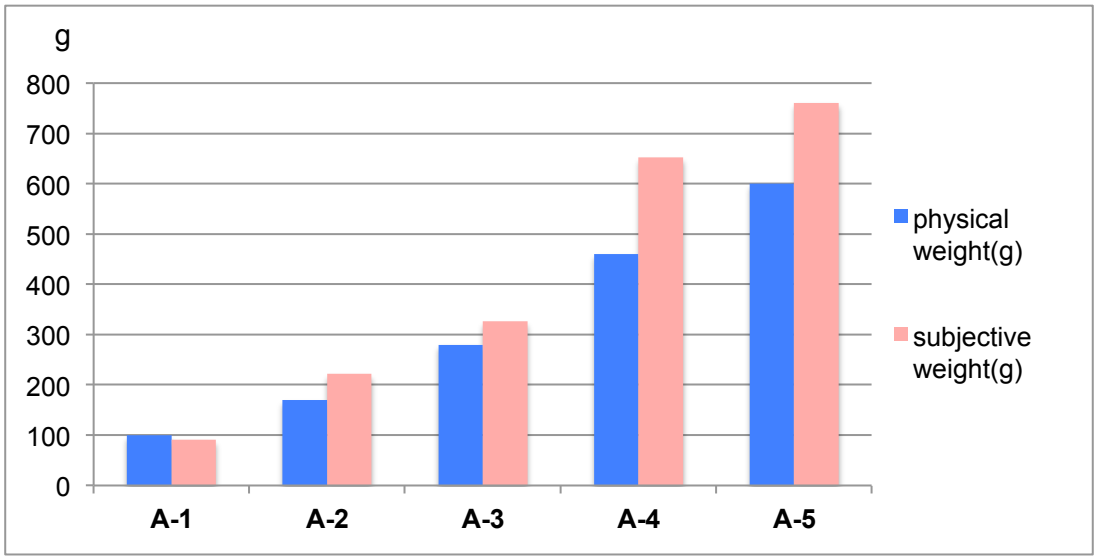

Figure 4: Comparison of subjective weight with physical weight for Experiment A

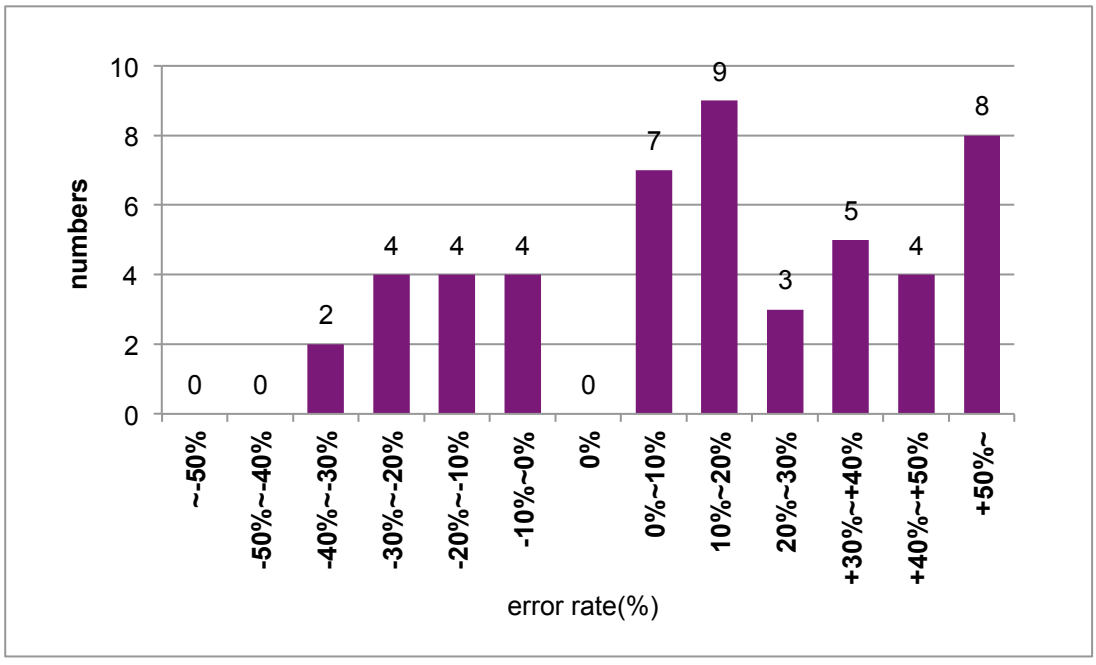

Figure 5: Error rate of Experiment A

3.2. Experiment B

Table 3 shows the overall results of Experiment B. In the table 3, the average subjective weight of the 170 g model with a diameter of 75 mm (B-1) was 305.7 g, which is 80% greater than the physical weight. The 170 g model with a diameter of 100 mm (B-2) was 226.4 g (+33%), and the 170 g model with a diameter of 120 mm (B-3) was 157.8 g (-7%). In this result, the error for the 170 g model was smallest at -7% when the diameter was 120mm.

On the other hand, the average subjective weight of the 460 g model with a diameter of 75 mm was 719.8 g, which is 56% greater than the physical weight. The 460 g model with a diameter of 100 mm was 643 g (+40%), and the 460 g model with a diameter of 120 mm was 539.9 g (+17%). In this result, the error for the 460 g model was smallest at +17% when the diameter was 120mm. Therefore, the error decreased with increasing model size in Experiment B (Figure 6).

Figure 7 and Figure 8 are the graph of user category by error rate for Experiment B. In Figure 7, the group with error rate of less than 20% is 28%. The group with error rate of less than 50% is 32%, and the group with error rate of 50% or more is 40%. In Figure 8, the group with error rate of less than 20% is 32%. The group with error rate of less than 50% is 36%, and the group with error rate of 50% or more is 32%.

Table 3: Result of Experiment B

models	B-1	B-2	B-3	B-4	B-5	B-6
Diameter (mm)	75	100	120	75	100	120
physical weight (g)	170	170	170	460	460	460
subjective weight (g)	**305.7**	**226.4**	**157.8**	**719.8**	**643**	**539.9**
sd	136.2	114.7	93.3	245.2	203.3	221.2
error	135.7	56.4	-12.2	259.8	183	79.9
error rate (%)	**+80%**	**+33%**	**-7%**	**+56%**	**+40%**	**+17%**

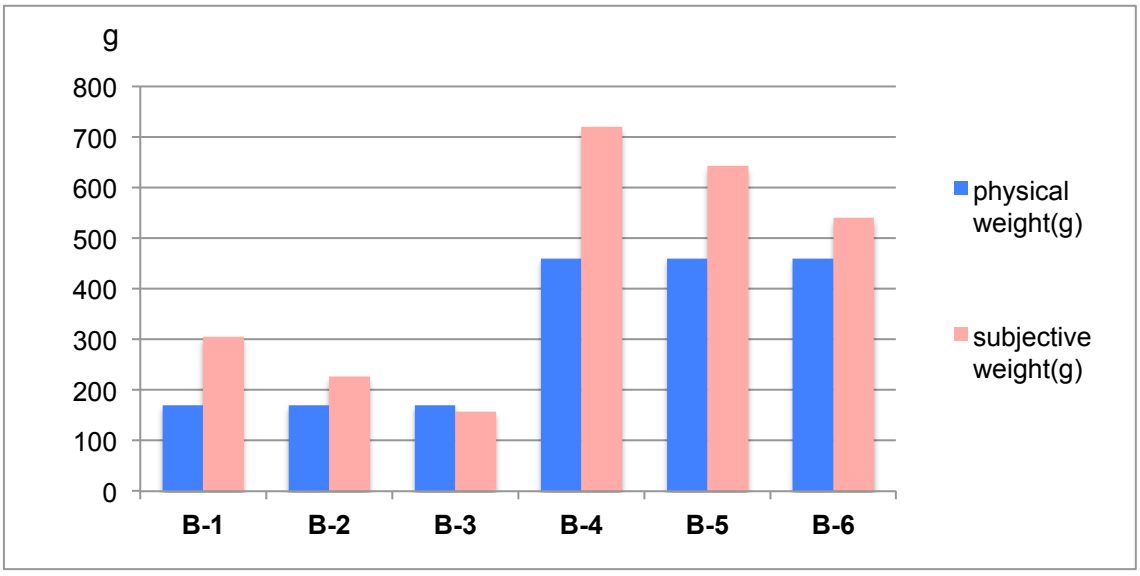

Figure 6: Comparison of subjective weight with physical weight for Experiment B

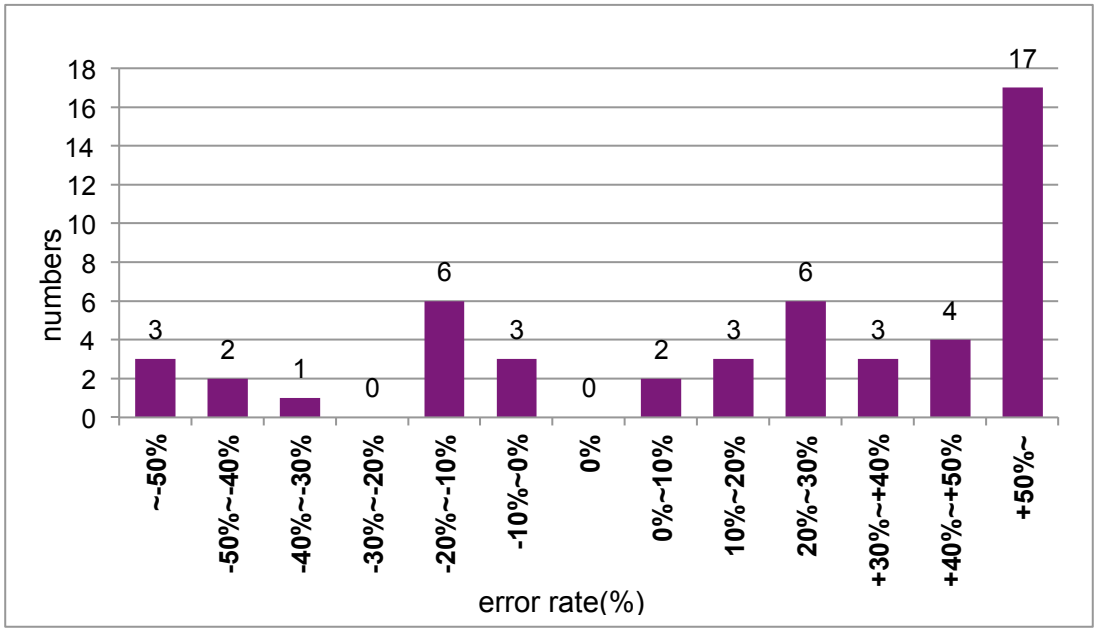

Figure 7: Error rate for 170 g models of Experiment B

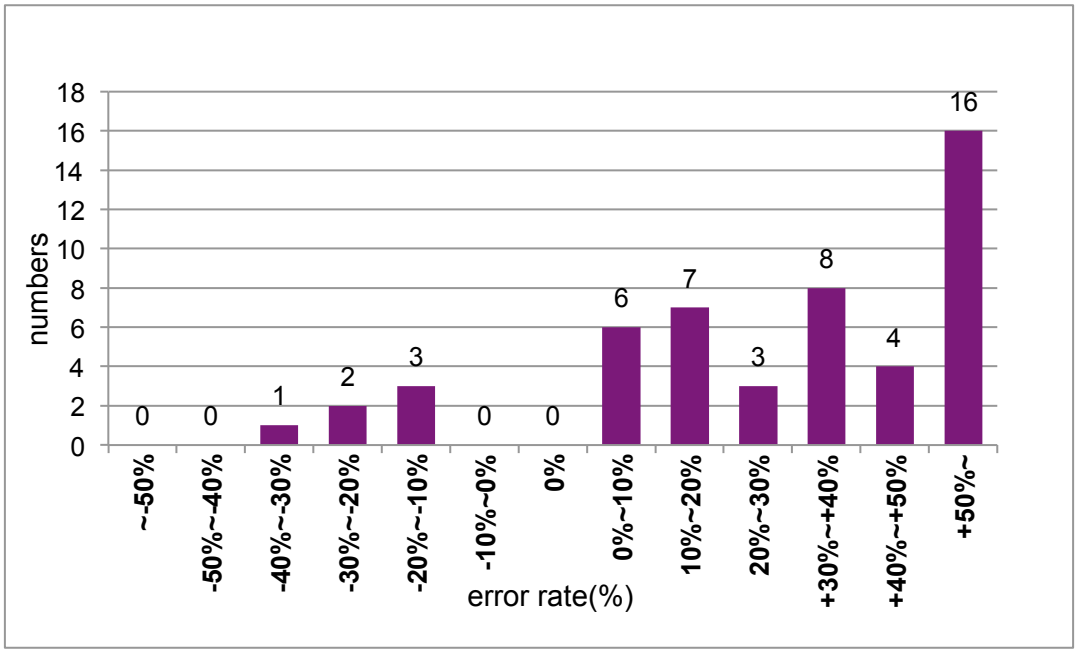

Figure 8: Error rate for 460 g models of Experiment B

4. DISCUSSIONS

This study revealed that there is a large error between the perceived weight (subjective sense of weight) and actual weight (physical weight). Based on these results, we have divided the groups by cluster analysis and subjective weight. Figure 9 is the graph of distribution of user by subjective weigh. The group that feels heavy more than 20% below the actual weight is 50%. The group that feels heavy more than 65% is 26%. The group that feels very heavy more than 120% is 12%. At the end, the group that feels lightly is only 12%.

By figure 9, we found that estimated 90% of people are feeling heavier than the actual weight for the recognition of the object weight. Further, 40% of people feel heavier than 65% than the weight

of the actual weight. This means that it is difficult to accurately recognize the user numerical information is used as the product information.

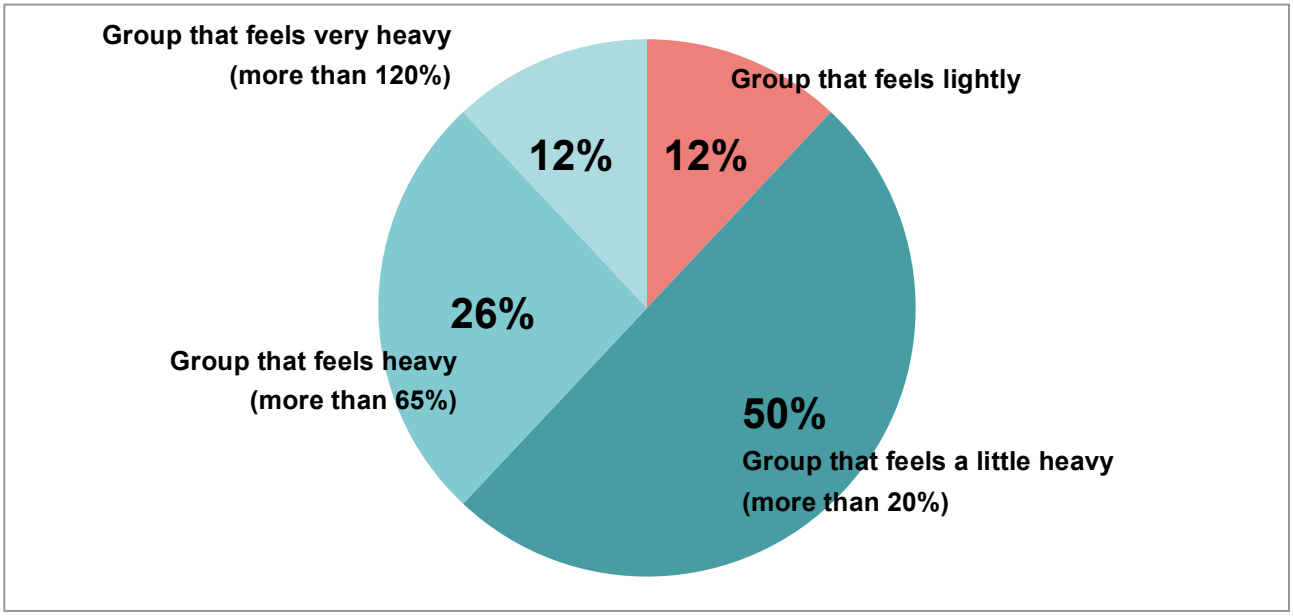

Figure 9: Distribution of user by subjective weight

5. CONCLUSION

From this study, we revealed the following;

- In average, the subjective weight was judged 24% heavier than the actual weight on below 600 g models.

- The greatest difference, between the actual weight and the subjective weight, was on the models that were between 100 and 170 g. When the actual weights were equal but the sizes were different, the bigger objects were considered lighter in their subjective weights.

- In 170 g objects, the size 75 mm model was judged as two times heavier than the 120 mm model. According to the personal weight senses, they could be divided into user groups.

- We think this study could relate subjective sense of weight to individual *Kansei.* Through the analyses of the error range and the characteristics of the subjective sense of weight, we expect the support of design sensibility that made use of the sense of human nature.

In the future, we aim to explore the shape characteristics that affect the perception of weight by creating models of various shapes around the weight range with the greatest error.

ACKNOWLEDGMENTS

This work was supported by JSPS KAKENHI Grant Number 25870016. (Grant-in-Aid for Young Scientists B)

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BIOGRAPHY

Short biography of author 1

Miyong Lee received her Ph. D. in Kansei Science of Tsukuba University. Theme of the doctoral thesis is “Recognition Characteristics of Shapes based on Kansei Evaluation: for an Effective Visual Communication in Design” (2009). She is now engaged in Kansei evaluation using a new evaluation method and in the user category based on the recognition of the individual characteristics for various stimuli. She is an assistant professor of research group of micromechanical systems, Division of Human Mechanical Systems and Design, Graduate School of Engineering, Hokkaido University since 2010.

Short biography of author 2

Kazuhiro Nishida was in the master course program of Mechanical Engineering of Graduate School of Engineering, Hokkaido University, when he was engaged in the present research. He was interested in studying “textile feeling” and “sense of weight” for universal design. He completed the master program in 2013, and is now working for aftermarket division in DENSO Corporation.

Short biography of author 3

Yoshihiro Narita is Professor of Mechanical Engineering of Hokkaido University, and he obtained Doctor of Engineering in 1980 from Hokkaido University. His research interests cover Dynamics of machines, System engineering, Composite materials, Optimization, Engineering education and Kansei engineering. He was Executive board director, Division chair and Branch chair of JSME. He is an Executive chairman of the Spring Kansei Conference, March 2014 in Sapporo.

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Impact of Curvature of Product Shape on Aesthetic Judgments

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Abstract: Competing products in the market are not widely different in terms of technical levels. Instead, their major difference lies in aesthetics and design, which are also the decisive factors of purchase decisions. Therefore, understanding consumers' aesthetic appreciation of industrial products is an important issue in the field of aesthetics and its application to consumption-related affairs. Former research indicated that people choose to stay away from sharp products and prefer curvilinear products. But what if the products under comparison are all curvilinear? Will people's preference for the same product vary with different curvatures? Do individual differences exist between people? Through this study, it has been discovered that people indeed have a preference for curvilinear products. However, regarding preference for a product with different curvatures, it does not follow that preference increases with the continued increase of curvature. At the peak, the rising trend will start to fall down. In addition, after the peak of preference appears, there is a significant difference in the major curvature between the participants with a design background and the ordinary participants. While the ordinary participants' preference for curvilinear products does decline, preference of the participants with a design background declines sharply. The above finding may serve as a reference for designers who may consider the application and timing of curves in designing product shapes in the future.

Keywords: curvilinear preference, aesthetics appreciation, product design

1. INSTRUCTION

Earlier research showed that products can evoke strong emotional responses (Girard & Johnson, 2009). People's feelings about products are apt to be affected by the external features, i.e., size, shape, color, and texture. In addition, relevant research on product experience indicated that among all senses, vision receives the largest amount of perceived information conveyed by the external characteristic elements of a product, and the information is the most intense (Schifferstein & Desmet, 2007). Therefore, people's feelings about a product largely come from the initial visual impression. As for the experience of product-purchasing, vision is the most important of all senses

(Fenko, Schifferstein, & Hekkert, 2010). Whether consumers want to buy is decided as soon as products are seen. In other words, nowadays to increase the chance of selling a product to customers, how to enhance its visual appeal is an important task. However, under such a physical condition as product appearance, what visual elements will affect people's feelings, arousing love or hate in them? Competing products in the market differ little from each other concerning function and production quality. Actually, their major difference lies in overall aesthetics, which also plays a decisive role in a purchase decision (Demirbilek & Sener, 2003). Therefore, in the fields of aesthetics and consumption-related affairs, it is an important issue to understand what is emphasized by people's aesthetic appreciation of industrial products (Liu, 2003).

People often give rapid evaluation to a product encountered by them. Such evaluation is usually a judgment based on the physical characteristics of the product (Bar & Neta, 2006). People's aesthetic judgments will be influenced by a lot of visual features. Through these visual features, designers lead people to perceive the emotions arising from expectations. In product design, it is common to use semantic techniques so that visual features of a product will generate some associations. Common practices include the use of texture, shape, color, and so on to evoke people's emotional responses. For example, a rounded and smoothed shape can cause warm feelings while a sharp shape can provoke alarming feelings (Demirbilek & Sener, 2003). In order to ascertain these feelings, empirical aesthetics often focuses on variables of external characteristics and investigates those well-defined and artificial stimuli systematically (Liu, 2003). In that way, the visual features affecting aesthetics in the process of design can be clearly understood. Furthermore, as for people's experience with the size and shape of an object, vision plays a more important role than touch (Miller, 1972; Rock & Victor, 1964). Therefore, researchers are concerned about what formal (concerned with outward form) features of a product will receive more visual preference. Then, the potentially advantageous features will be manipulated, and principles of formal preference will be deduced, such as symmetry (Jacobsen & Höfel, 2002; Tinio & Leder, 2009), prototypicality, oblique effect (Latto, Brain, & Kelly, 2000), complexity (Imamoglu, 2000), and perceptual fluency (Reber, Schwarz, & Winkielman, 2004). Since people's preference mostly results from the process of visual evaluation, visual features function like a clue, giving much inspiration. People are able to anticipate whether a certain aspect is dangerous or safe (Carbon, 2010). For example, the shape of an acute angle is a clue which can help us to detect danger and can also increase our attention (Berlyne, 1974), thus keeping us away from danger. This phenomenon is also found in interpersonal interaction. Specifically, when two people meet for the first time, one will observe the other's external features, such as shoulders, elbows, and knees. If acute angles are found in those parts, the person involved will be thought to be aggressive (Guthrie & Wiener, 1966), arousing the other's vigilance. Other previous studies explored facial experiences and interpreted their tendencies. According to the studies, if the basic external elements of a face amount to a V-shaped corner, it will generate a threatening feeling. On the contrary, the face with a rounded shape will produce a warm feeling (Aronoff, Woike, & Hyman, 1992).

Such a phenomenon not only exists in interpersonal interaction but also in people's reactions to a product. In everyday life, among the formal features of products, the sharp appearance or otherwise provides clues for people when they determine their preference quickly. To be exact, an object with the sharp appearance will increase people's attention, because they will instinctively feel threatened or endangered (Bar & Neta, 2007). Therefore, people prefer to stay away from sharp-shaped objects associated with danger and select rounded-shaped objects associated with safety. That is, people would prefer rounded-looking products over other products. Bar and Neta (2006) indicated that whether it is a real product or a meaningless pattern, the angle of a shape or the sharpness of a

comer will affect people's feelings about the object. People will prefer a curved-shaped object or one with round corners. Gordon (1909) mentioned in Esthetics, regarded as a textbook for psychological aesthetics, that curves are usually felt to be more beautiful than straight lines. Hsiao and Chen (2006) also suggested that there are four fundamental dimensions regarding people's emotional reactions to product forms. Among them, the emotion factor is concerned with the curvature of a product in relation to aesthetic preference (Hung & Chen, 2012). Products with a high emotional value tend to have a curvilinear, curved, or organic shape. Moreover, this perceptual phenomenon is applied to the interior design of automobiles. Thus, the curvilinear shape of automobiles holds a greater appeal for consumers than the linear shape. Meanwhile, curves can arouse people's positive emotional reactions more effectively (Leder & Carbon, 2005). The same applies to design of furniture in the living room (Dazkir & Read, 2012).

However, Bar and Neta (2006) indicated that this case of preference does not apply to all products but to those products used in daily life, and that the shape of the product itself has no special meaning, namely, the product with a neutral image, such as a watch or sofa. But this preference does not apply to a product like a knife, because it connotes sharpness and danger. In that case, the negative image exerts a greater influence on preference than a curvilinear shape. Leder, Tinio, and Bar (2011) performed further research into the image of a product perceived by people. Their study suggested that only the product that presents a positive or neutral image to people can increase people's preference through the increase of formal curvature. On the other hand, a product that presents a negative image to people cannot increase people's preference through the above method. The emotional attributes conveyed by the product itself will affect people's preference for curvilinear products. Besides, people's aesthetic experience will affect their judgment. Experienced people refer to those who are interested in a specific issue or have received some training in the related field. Experienced people have more knowledge of the related field to make judgment, while inexperienced people can mostly describe the outward characteristics as well as their own perceived emotions (Augustin & Leder, 2006). Inexperienced people are more susceptible to the effect of the sharp shape while experienced people are uniformly free from its influence (Silvia & Barona, 2009).

Nevertheless, most of the previous studies on the product shape explored curvilinear preference in the following way. The stimuli were divided into two types, i.e., sharp and rounded products, and the participants had to choose one from the two. But if the same product has different levels of curvature, will people's preference change accordingly? In other words, will people's preference also increase with formal curvature? Seen from the standpoint of design experience, preference can never increase continuously. But is there an optimum ratio of curvature to aesthetic beauty? According to the results of a pilot study conducted by the authors, as the formal curvature of a handheld device becomes larger, people do have a higher preference for it. Yet, it is not always true, for there is a peak for curvature and preference (Lu & Ho, 2013). When the curvature is greater than a critical value, preference tends to take a reverse turn; that is, people will start to dislike a more rounded product. But the pilot study was conducted only on handheld devices with a single size. Then, if handheld devices of different sizes are tested, will levels of preference change differently? In view of that, the primary purpose of the study is to investigate how the curvature and length-width ratio of a product affect preference.

2. METHOD

2.1. Subjects

The participants gave informed consent and received NT$ 100 NT (approximately 3 USD) for their participation. The participants had not smoked cigarettes or drunk caffeinated beverages for two hours before the testing session. Additionally, none of them reported any injuries, diseases, or previous eye surgery. All reported normal or corrected-to-normal vision.

2.2. Participants

32 participants (16 men and 16 women) were involved in this study, with their ages ranging from 19 to 33 years (M = 24.09, SD = 4.08). 15 of the participants had a design background while 17 didn't. The participants gave written consent and received NT$100 (approximately $3) for their participation. The participants had not smoked cigarettes or drunk caffeinated beverages for two hours before the testing session. Additionally, none of them reported any injuries, diseases, or previous eye surgery. All of them reported normal or corrected-to-normal vision.

2.3. Apparatus and stimuli

The basic forms of the stimuli were selected from the top 50 cellphones and tablets on a website, ePrice (http://www.eprice.com.tw/mobile/billboard/?top=50), and their average length and width were taken as the bases. The average length and width of cellphones were 130.3 x 66.9 mm, and those of tablets were 238 x 158.2 mm. In addition, the length and width (38 x 38 mm) of watches were added. Namely, three different products with different length-width ratios were selected to draw the front views of the profile lines, with their brands or the elements possibly associated with brands removed. The angular changes of the products ranged from the right angle to the round angle (curve), divided into ten levels, i.e., 0 mm, 1.5 mm, 3.5 mm, 5.5 mm, 7.5 mm, 9.5 mm, 11.5 mm, 13.5 mm, 15.5 mm, and 17.5 mm. In other words, there were 30 stimuli employed in the experiment (10 curvatures × 3 length-width ratios = 30), with some examples shown in Figure 1.

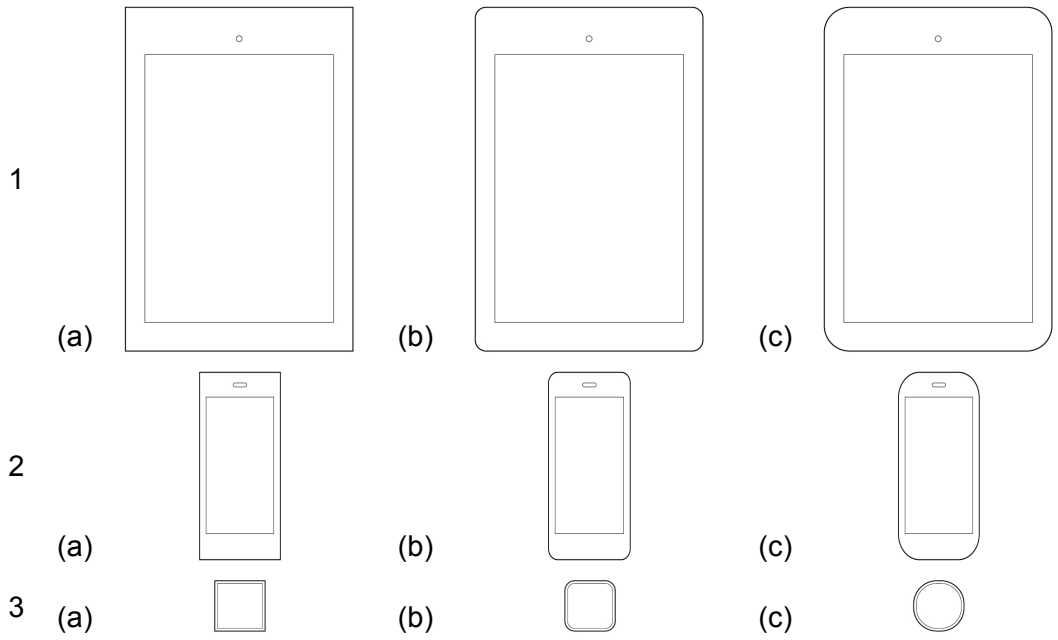

Figure 1: Different curvatures on the corners of the stimuli, scaled in proportion to their actual sizes: (a) 0 mm, (b) 7.5 mm, (c) 17.5 mm (1. Tablet, 2. Cellphone, 3. Watch)

2.4. Procedure

MacBook Pro was used in the experiment to display the experimental stimuli on a 13.3-inch screen. Its screen resolution was 1,280 x 800 pixels, and its update frequency was 60 Hz. Besides, all the experimental stimuli were controlled through the software E-prime 2 (Schneider, Eschman, & Zuccolotto, 2002). The 30 experimental stimuli were displayed in a random manner, and the pictures of the stimuli were scaled to 75% of their actual sizes in order to be easily presented on the screen

The participants were asked to give two scores as soon as possible after watching one stimulus. One of the scores was for preference, and the other was for curvature. The adopted scale was a seven-point Likert scale, in which 1 means the weakest degree while 7 means the strongest degree, with the flow chart shown in Figure 2. As the main concern of this study, the score for preference was obtained first (Carbon, 2010).

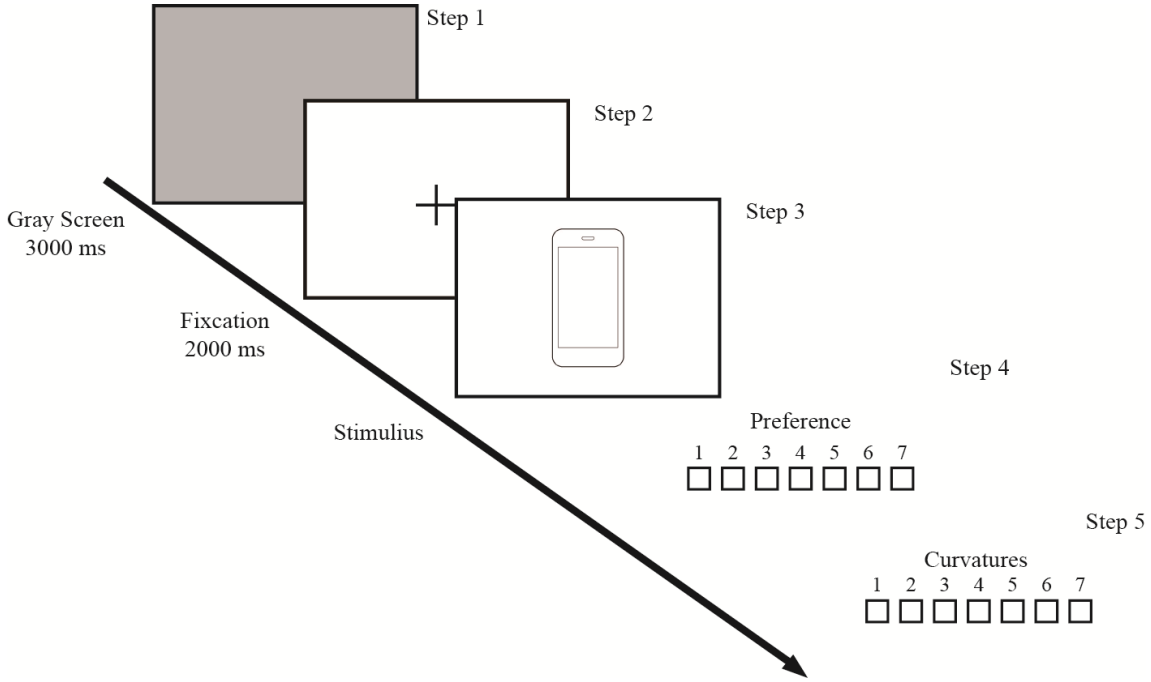

Figure 2: The flow chart of the experiment

3. RESULTS AND DISCUSSION

This study aimed to explore the relationship between people's preference and two variables, different formal curvatures and length-width ratios of products. A three-way repeated measurement analysis of variance (ANOVA) was conducted on three variables. Namely, between-group variables (subjects with or without a design background), formal curvatures and length-width ratios were analyzed in a mixed matrix. As indicated by the main effects of the participants, preferences for products with different length-width ratios showed no significant difference, with $F(2, 60) = 0.60$, $p = .55 > .05$. But there was a significant difference between different curvatures, with $F(9, 270) = 26.56$, $p < .01$. Moreover, the two variables, i.e., curvature and product type, interacted with each other, with $F(18, 540) = 5.74$, $p < .001$. In other words, products with different length-width ratios looked the same to the participants. In addition, the participants had a higher preference for the stimuli with the fifth level of curvature (M = 4.88) than those with the first level of curvature, or the rectangular shape (M = 2.42), as shown in Figure 3. From the figure, it could be discovered that the participants had a higher preference for curvilinear shapes with varying degrees than a rectangular

shape. Furthermore, as the formal curvature of a product was greater, it would receive a higher level of preference. This result is consistent with the findings of previous studies (Bar & Neta, 2006; Leder et al., 2011). In addition, the participants' scores for the ten levels of curvature of the stimuli were positively related to their scores for psychological feelings about the curvilinear shapes, with $R^2 = 0.92$. That is to say, as the physical property (curvature) of a stimulus changed, the participants' psychological feeling about curvilinear levels increased as well. But their preference for the stimulus did not increase. However, when its curvature exceeded the fifth level, a greater curvature received a lower level of preference, which was never found in any previous study.

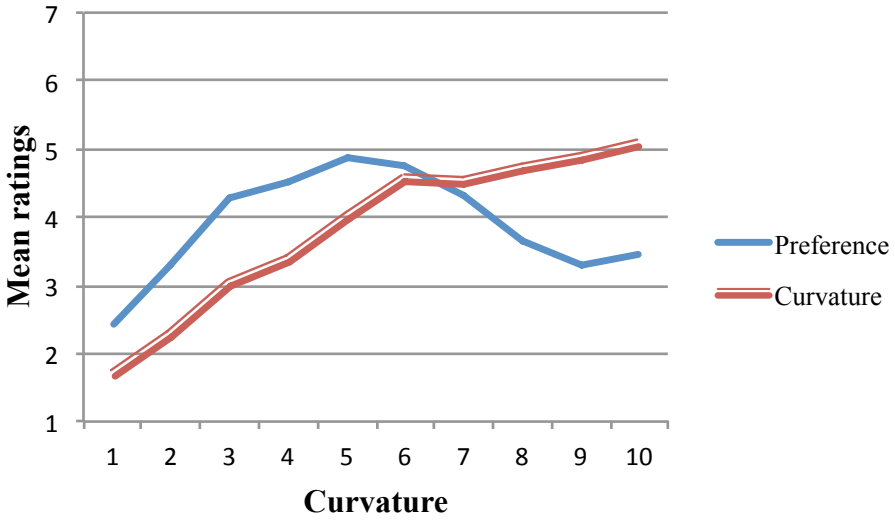

Figure 3: Mean ratings for preference and curvature in comparison

In addition, the result showed that the length-width ratio and curvature interacted with each other. Figure 4 illustrates the relationship between curvature and preference for a product with different length-width ratios. As indicated by an analysis of the simple main effect, on the third level of curvature (3.5mm), the participants' preferences for cellphones and watches were higher than that for tablets, with $F(2, 26) = 4.65$, $p < .05$. As for the products with a smaller size, i.e., cellphones and watches, there was no significant difference except on the eighth level of curvature (13.5mm), with $F(2, 26) = 8.28$, $p < .01$. Meanwhile, post-hoc analyses showed that the preferences for cellphones and tablets were higher than that for watches. The possible reason was that on the eighth level of curvature or above, the prototype of watches was already changed into a round shape. When matched with the ten levels of curvature, products with a small size (cellphones and watches) and products with a large size (tablets) underwent different trends. On the first five levels of curvature (0-7.5mm), the participants had a lower preference for tablets than for cellphones and watches, with $F(2, 26) = 3.71$, $p < .05$. Besides, post-hoc analyses showed that the participants' preference for cellphones was higher than that for tablets. On the sixth level of curvature (9.5mm), there was almost no difference. However, the situation was reversed on the ninth level of curvature (15.5mm). Namely, the participants' preference for tablets was higher than that for cellphones and watches, with $F(2, 26) = 5.63$, $p < .01$. Also, post-hoc analyses showed that the participants' preference for cellphones was higher than that for tablets.

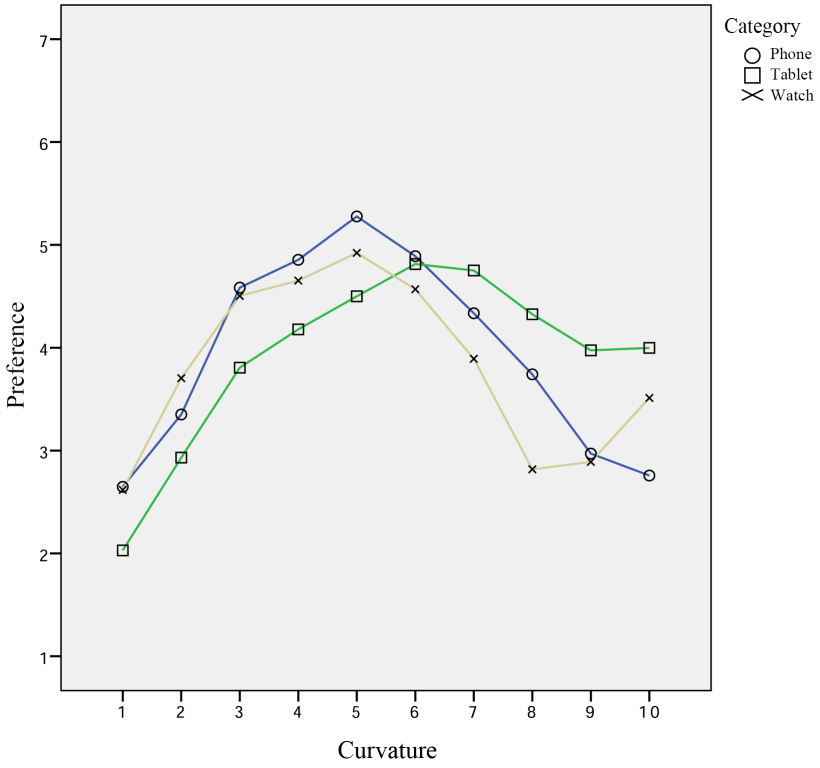

Figure 4: The participants' preference for the three types of products with different curvature

The trend in Figure 4 reveals that a large-sized product can match a larger rounded corner without causing people's dislike. Even though preference for it declines slightly, it still receives a higher preference than a small-sized product. This phenomenon may be due to the fact that there is a proper ratio of the corner radius to the side length. Namely, if the ratio of the corner radius to the side length exceeds the balance point, people will have a lower preference. As a result, the curvature of a large-sized product (a tablet) was larger that that of a small-sized product (a watch) when the highest preference appeared. In this study, for example, the participants' preference declined for the stimuli on the seventh level of curvature or above when the products had a larger size (tablets). Yet, compared with small-sized products (cellphones and watches), products with a larger size received a higher preference. Neutral products like watches were investigated by previous studies. As indicated by the findings of previous studies, more people preferred rounded-shaped watches to rectangular-shaped ones, as shown in Figure 5. Likewise, as indicated by the results of this study, the participants' preference for watches on the tenth level of curvature ($M_{watch}10$ = 3.53, *SD* = 1.69) was higher than that for watches on the first level of curvature ($M_{watch}1$ = 2.59, *SD* = 1.16), t (31) = 2.65, *p* = .012. But, more importantly, it is discovered that before the rectangular-shaped stimulus changes into a rounded shape, people's preference for the external shape of a product does not increase persistently, but that a peak appears. In other words, after preference reaches the peak in this process, a higher level of curvature produces a lower preference.



Figure 5: An example excerpted from previous research (Bar & Neta, 2006)

Would the participants with a design background have different reactions? With the design background taken as a between-group variable, the study made an analysis. It was discovered that there was no significant difference in product preference between the participants with a design background and those without it, with $F(1, 30) = 1.97$, $p = .17 > .05$. Also, the participants with different backgrounds showed no significant difference in preference for different types of products, with $F(2, 60) = 2.54$, $p = .09 > .05$. But the participants with different backgrounds showed a significant difference in preference for different curvatures, with $F(9, 270) = 7.43$, $p < .001$. In addition, there was an interaction between different backgrounds and two variables, corner curvature and product type, with $F(18, 540) = 2.36$, $p < .001$.

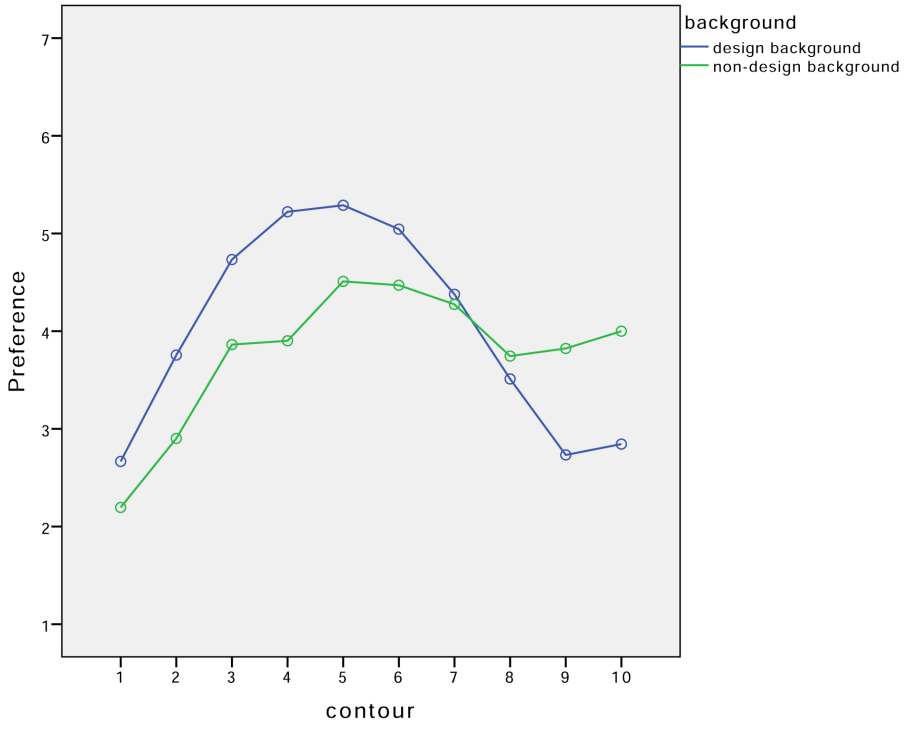

Figure 6: Preference for the stimuli displayed by the participants with or without a design background

As shown in Figure 6, there exists an interesting phenomenon; that is, regardless of whether the participant has a design background or not, the peak of preference occurs. It was proved that a

downward turn is a common phenomenon in this process. In addition, the participants with different backgrounds showed no significant difference in preference for the stimuli. However, after the stimuli were set on the seventh level of curvature, the trend of preference for curvilinear products started to differ between those with a design background and those without it. The results indicated an interaction between curvature and participants' background. As shown by the findings, regarding preference for the products on the seventh level of curvature or above, the participants with a design background are different from those without it. The former participants' preference declined abruptly while the latter participants' preference just declined slightly. Besides, compared to the former, the latter showed a higher preference for the form on the seventh level of curvature. That is to say, people with no knowledge of design are easily affected by curvilinear preference, showing a higher preference for curvilinear forms. This result may be due to the fact that experts, or people with design-related knowledge, have received training in the related fields, so they are less affected by the straight or curved shape when making preference judgments (Silvia & Barona, 2009). Experts interested in art are more sensitive to product changes, putting more emphasis on high-level design concepts (Leder & Carbon, 2005). When appreciating a piece of art, experts are more concerned about its style, while ordinary people focus on its external description (Augustin & Leder, 2006). Perhaps individual differences in focus lead to different preferences for curvature. When curvature is large, people with a design background feel the style unsuitable. Though their preference declines slightly, ordinary people still have a higher preference than those with a design background.

This study is different previous studies in terms of research settings. In addition to the respective basic forms, the three stimuli were matched with 10 different levels of curvature. As a result, it was discovered that people have a higher level of preference for curvilinear objects. Besides, it was discovered that when the basic forms of the stimuli gradually changes from a right angle to a curve, preference for them is sure to turn downward, regardless of the length-width ratio. This study suggests that preference for curvilinear forms have been well known; namely, people prefer rounded-shaped products to rectangular-shaped ones. In addition, two phenomena are noteworthy: i.e., the appearance of a peak and the match of a larger size with a greater curvature. It thus follows that there is a balance point between size and curvature. The discovery corresponds with the experience of design. To be exact, angle R in the product form cannot be increased infinitely. On the contrary, there should be a balance point between preference and the level of curvature. This discovery has never been made by previous research on curvilinear forms.

4. CONCLUSIONS

In the fiercely competitive market nowadays, consumers' feelings about a particular product and aesthetic scores for it are the main decisive factors. According to a phenomenon discovered by Bar and Neta (2006, 2007), people generally prefer curvilinear products to sharp ones. However, products on the market are not only limited to highly sharp or rounded shapes. Contrarily, there are many products with intermediate curvature. Then, what is people's preference for those products? In view of that, this study investigated product shapes with different levels of curvature. Besides, how the participants with different backgrounds liked different levels of curvature was explored, with the findings listed below.

1. People do have a higher preference for products with curvilinear shapes, which is consistent with the findings achieved by Bar and Neta (2006, 2007).

In addition to curvilinear preference concerning product shape design, there is an optimum

balance point between the side length and curvature. People have the highest preference for a product shape when its curvature reaches this balance point. Then, the preference takes a downward turn.

3. There is a difference between individuals. Specifically, most people with no design background experience the reversal of preference, but they still have a higher preference for product shapes with greater curvature than for those with rectangular shapes.

As for design practice, this study aimed to explore the effect of different curvilinear shapes on preference. Unlike previous studies, this study focused on three types of handheld devices, i.e., tablets, cellphones, and watches throughout the experiment. The results of this study can help designers get a better understanding of consumers' preference for handheld devices. By changing the shape of a handheld device and increasing the curvilinear touch of the shape, designers may enhance consumers' preference. In addition, handheld devices with a large size should be matched with a larger curvature so that products consistent with consumers' aesthetics and preference may be designed. During the experiment, all the products were scaled to 75% of their actual sizes, and their profile lines were displayed on the screen. Perhaps this might fail to completely present the consumer's feelings aroused by products in the real world. Because of that, related studies in the future can consider testing other types of products. Or 3-D effects can be used to replace the profile lines. It may be explored whether the same phenomenon still exists. Alternatively, with products excluded, only the correlation between size and curvature will be analyzed so that it may be applied to the interface design or packaging. These aspects are well worthy of being studied in the future.

Acknowledgment

The authors would like to thank the National Science Council of the Republic of China, Taiwan for financially supporting this research under Contract No. NSC102-2410-H-006-102-.

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KEER2014, LINKÖPING | JUNE 11-13 2014
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An associate model between interface color design, user's emotion and operation

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Abstract: Color information is one of influential factors which affects human behaviors. Relationships between coloration of interface and operational performance are well known, and many previous researches have shown evidences of relationships between coloration and users' emotion. Consequently, it is expected that there are important effects between interface color design, emotion and operation. Nevertheless, almost of the previous researches were done in which impact of color on emotion or task performances were investigated independently. In this paper, a novel model which represents relationships between color design, emotion and operation is proposed. Structural Equation Modeling (SEM) has been employed as the method for generating representative models. Users' performance and their impression for the interfaces are used for the data to generate SEM models. To obtain users' performance data, experiments have been conducted with simple computer software of arithmetical calculation in which touch panel interface is used. Furthermore, questionnaire approach has been used to obtain users' impressions for interfaces. By using the proposed scheme, we can verify the effects of touch panel coloration on operator's feeling, and clarify how the feelings affect the operations. To verify the efficiency of the proposed scheme, two representation models, one is based on the proposed scheme and the other is based on the traditional scheme, have been generated and analyzed. As a result, the former model can illustrate the relationships between color design and the operational performances better than the latter one.

Keywords: Interface color design, touch panel, usability

1. INTRODUCTION

Color information is one of the most influential factors which affects users' perceptions, physiological reactions and emotional reactions (Valdez & Mehrabian, 1994). Thus, appropriately using of colors in an interface can lead to better performance of the operators. Conversely, poor use of color might lead to decrease in performance and increase the ability of visual fatigue (Ling & Schaik, 2002).

There are many studies which inquired into relationships between color interfaces design and the operations. The results revealed that color affects users' working performances. However, users' perceptions for a coloration are difference depend on the individual. Consequently, it can be assumed that the difference might cause differences of users' feelings.

Several studies have provided evidences of relationships between colors and emotions. They have found that each different color has an individual impact on human. According to Pastoor (1990), subjective measure can be more sensitive to distinguish a difference in color display on monitors than measures with instruments. In addition, many previous researches have used emotional evaluation rather than physiological evaluation (Tsunetsugu et al, 2005). Therefore, it is expected that colors which decorate an interface design, the users' emotions and the task performances are related each other. Unfortunately, almost of the previous researches were done in which impacts of colors on emotions or task performances were investigated independently. Thus, in this paper, a novel representation model of relationship between interface color design and operation is proposed. The authors aim to demonstrate advantage of the model which is generated based on the proposed scheme in comparison with a model based on the traditional one. In order to achieve the research goal, correlations between colorations and users' emotions have been investigated. Moreover, the relationship between users' emotions and operational performances are also verified. In order to obtain data, two method approaches, user experiments and questionnaires, are conducted.

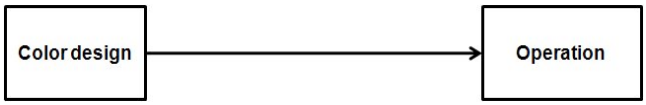

Figure 1(A): Traditional scheme

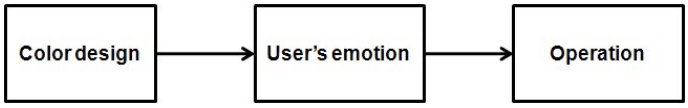

Figure 1 (B): Proposed scheme

2. LITERATURE REVIEWS AND RESEARCH MODEL

When designing a human-machine interface, the designer should consider both of usability and emotional appealing because users' feelings could influence operational performance (Sonderegger & Sauer, 2010). Thus, many studies have been conducted in order to find the factors which impact on user affections. The results revealed that each different color has an individual impact on human feelings [6]. Besides, people respond to colors differently based on some variables such as age, sex and culture (Elliot & Maier, 2007). For instance, Suto and Sakamoto

(2012) clarified the relationships between the effects of colorations used in an interface design and the operators' age. They have found that the relationships among contrast of background decorations, accuracy of operations and the operator's age. They have also concluded that the relationship between contrast of background decorations and operation speed was not affected by aging. However, Jalil et al. (2012) pointed out, the previous studies on the effect of color show conflicting and inconclusive. Thus, further research is required to clarify the issues.

With regard to interface design, effects on users' behavior also have been discussed. Cyr et al. (2010) found that website color appearance is a determining factor for websites' trust and satisfaction. Bonnardel et al. (2011) sought effects of colors used in web sites on users' cognitive processes, and the impact of the color on the users' revisit rate was found. The results showed that users spent longer time on web sites which have warm colors than which have cool colors. Similarly, Sakamoto et al. (2010) conducted experiments to find relationships between impressions of touch panel interfaces of electronic devices and the operations. As a result, it is concluded that the colors which are cool-casual scheme (i.e. mild green and mild yellow) have positive effects on users' performances. Moreover, Cai and Lin (2011) developed emotion-performance model in a context of vehicle driving. They have argued that emotion affects human performance through influencing individuals' judgments and behaviors. The above mentioned studies support the emotional of the operator are strongly related to performance of the operation.

All of above mentioned interface studies, relationships between design and users' behaviors were investigated. This scheme can be represented by a diagram shown in Figure 1 (A). However, design cognition might vary from a person to a person and the relationships also may change depend on an individual. Thus, the authors have proposed another scheme represented in Figure 1 (B) as a diagram. In this scheme, an interface design is recognized by an operator, and he/she has some feelings about the design. Then, his/her operations are influenced by the feelings. This scheme is expected to represent the effects of interface design on the user more clearly.

3. RESEARCH METHODOLOGY

In order to comprehend how design affects users' cognitions and behaviors, novel scheme of association between design and operation performance has been proposed as described in the previous section. In order to verify the validity of the proposed scheme, a representative model is generated by using Structural Equation Modeling method based on the scheme and the model is analyzed. Eventually, the result of proposed scheme is compared and discussed with the model based on the traditional one.

The outline of the process of this research is shown in Figure 2. The first step is the designing of experiments. In this step, an experimental equipments and tasks are designed. Next, the experiments are conducted in order to obtain data for generating models. In the experiments, participants are asked to do simple tasks and answer questionnaires. Afterward, a proposed scheme and a traditional scheme are applied to generate two models, i.e. a proposed model and a traditional model, with the results of the experiments. Structural Equation Modeling is utilized for the generating model process. Finally, correlation results are compared in the models which generated based on the traditional scheme and the proposed scheme.

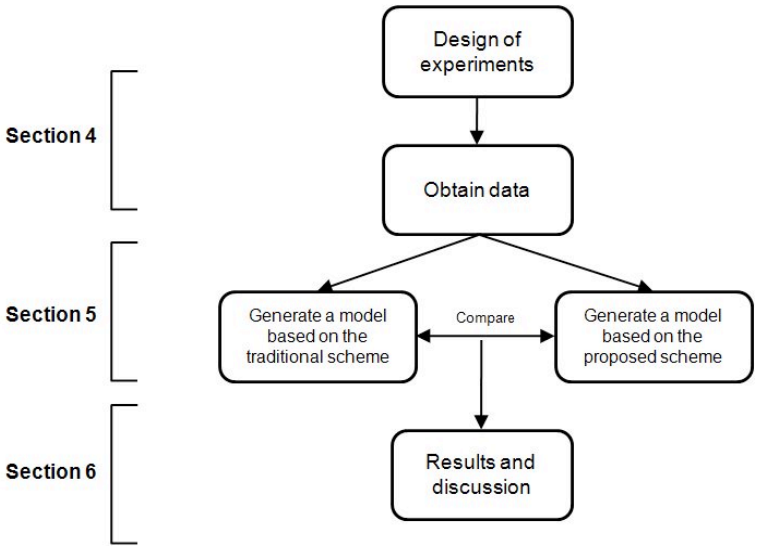

Figure 2: Outline of research methodology

4. DESIGN OF EXPERIMENTS

4.1. Target device

Recently, the demand of using electronic appliances with touch panel interface has been rising more and more. Touch screen technology is widely used for ATMs (Automated Teller Machines), ticket vending machines, interactive kiosks and so forth. Many personal devices such as smart phones, tablets PC, also use this technology. These devices are used in several fields e.g., service and health care (Shervin et al, 2011). Touch panel interfaces enable a user to interact directly with a device by using his/her fingers. Users can retrieve target information by touching the screen (Lundstrom & Weiss, 2008). Many researches claim that operation time of touch screen usage is significantly less than physical input devices such as keyboard and mouse on a same task (Karat et al, 1986; Sear & Shneiderman, 1991). Furthermore, touch interfaces are easy to adjust the interface design; size, color, and location of items on a screen (Colle & Hiszen, 2004). Due to the above advantages, i.e., easy use, flexible design, and better performance, touch screens have became popular, and user-friendly touch panel interfaces are required. Thus, a touch panel device was used in the experiments.

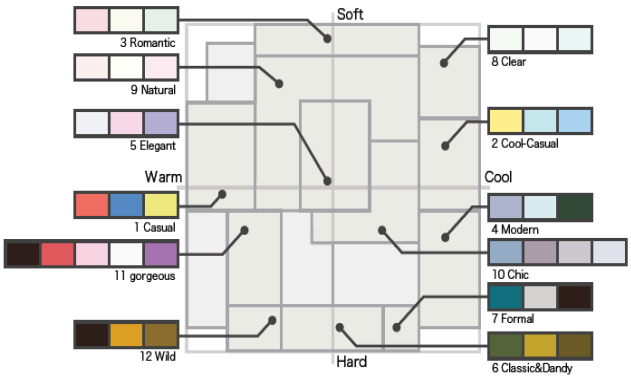

Figure 3: The twelve color schemes which were used in the experiments

4.2. Outline of experiment

Two methods are adopted to obtain data: observing task performances and questionnaires. Relationship between users' feelings and operation are investigated through the experiment. The participants were asked to work arithmetical tests (single digit ones). Then, questionnaires were prepared in order to examine users' feelings on each screen. Afterward, experiments data and questionnaires data were fit in order to generate proposed model. The participants were males and females students in their twenties to thirties.

4.3. Equipment

To get performance data, a simple computer application which quizzes addition questions was used. The bottom of the screen of this application is decorated by a color schemes. This color scheme can be chosen from the color sets on the mix color image scale (Kobayashi, 1987). The mix color image scale is an image map which transforms color schemata into impressions. This scale has two axes, "soft-hard" and "cool-warm." Twelve major descriptive phrases were selected as representative color schemes; "casual," "cool-casual," "romantic," "modern," "elegant," "classic and dandy," "formal," "clear," "natural," "chic," "gorgeous," and "wild." Each color scheme consists of three to five different colors. The representative color schemes are shown in Figure 3. The components colors used in each color scheme are shown in Table 1 by using Munsell color system.

Table 1: Colors which are used in the experiments

Image word	Color 1	Color 2	Color 3	Color 4	Color 5
01.casual	5R 5/12	5PB 4/10	10Y 8/12	—	—
02.cool-casual	6Y 8/10	5B 7/6	5PB 6/8	—	—
03.romantic	7.5R 8/4	7.5Y 9/6	2.5G 8.5/2	—	—
04.modern	6.25PB 5.6/6	5B 8/4	5BG 3/2	—	—
05.elegant	10PB 8/4	2.5RP 8/4	2.5P 6/6	—	—
06.classic&dandy	10GY 3/2	2.5Y 6/8	2.5Y 3/2	—	—
07.formal	5B 4/4	7.5PB 8/2	5PB 2/2	—	—
08.clear	10BG 9/2	10Y 9/0.5	10BG 7/4	—	—
09.natural	3RP 8/4	5Y 9.2/1	5P 8/4	—	—
10.chic	5PB 6/4	5P 6/2	5P 7.5/0.5	5PB 8/1	—
11.gorgeous	5P 2/1	3R 4/12	5RP 8/4	7R 9.2/1	2.5P 4/10
12.wild	N1	8YR 5/8	10YR 4/4	—	—

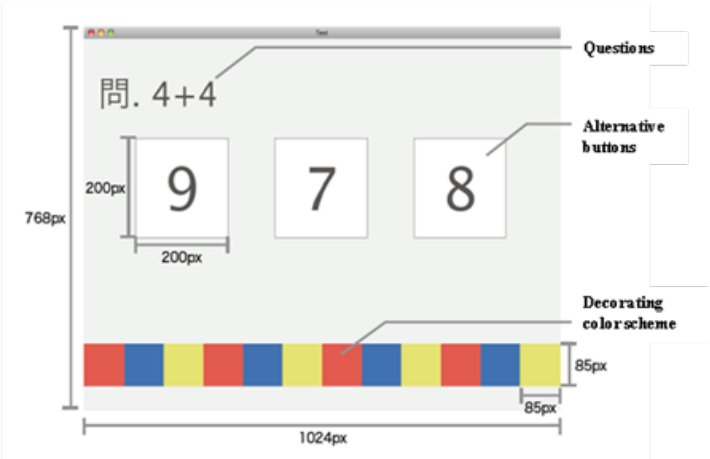

Figure 4: An example of screen which used in the experiments

An example of screen which is used in this research is shown in Figure 4. The background of the screens are colored by pale gray (N8), and the push panels' color are white (N9.5). The color of characters are dark gray (N3). The colors of these components were chosen by considering visibility of characters in the screen. The three alternatives are placed for each problem.

In the experiments, the decoration color scheme was chosen from representative color schemata which mentioned above. Each screen was displayed with a different color scheme without changing other components. Thus, the experiments have been conducted under twelve different conditions.

4.4. Tasks

In the experiments, the participants tried single-digit mental arithmetic tests. The participants were requested to select one correct answer from three choices by touching one of three push panels. If a participant does not touch any buttons within 1.5 seconds, the system moved on the next problem automatically. Thirty different problems were contained in each condition. The spending time and the accuracy rate were chosen as indicators to measure working performances, and recorded.

4.5. Evaluation of users' feelings

Questionnaires have been conducted to obtain participants' feelings data for each screen. Questionnaire comprised fifth-teen sensations query; eleven emotional indicators: preference, understandability, visibility, hesitation, familiarity, eye strain, readability, beauty, comfortableness, impressive, safety, were chosen from 59 indicators which are used to evaluate the web usability in Japan (Nakagawa et al., 2001) and four emotional indicators: number of tasks, enables concentration, volition, trouble, were developed by intense brainstorming session. Rating linear measurement method was utilized for the scoring. A part of questionnaire is shown in Figure 5.

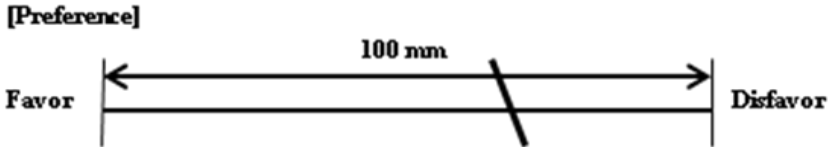

Figure 5: Rating linear measurement method which used in the experiments

4.6. Procedures

The experiments ran under the twelve different conditions as described above. In each condition, each participant was requested to do calculation tasks and ask the questionnaire. On the beginning, each participant got the instructions and trialed a training task. Secondary, the training task was conducted on a screen that had no color decoration. Following a practice step, the participant tried the tasks on the twelve screens. Afterward, the participants had to answer the questionnaires to evaluate their feeling with each decorated color scheme. A two minutes break was given between each condition for resting and decreasing the effect by previous screen. Figure 6 illustrates the procedures of the experiments.

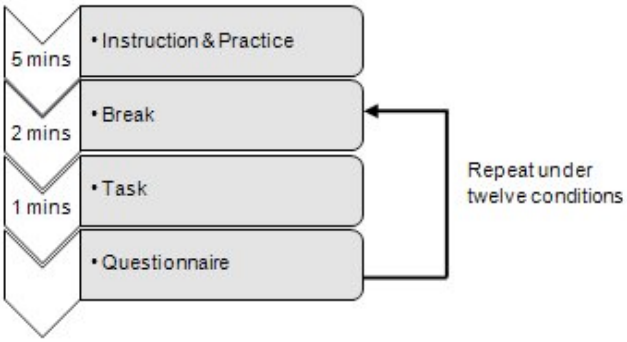

Figure 6: Procedure of the experiments

5. GENERATING REPRESENTATIVE MODEL

After the experiment process, the structural equation modeling (SEM) approach is adopted to generate representative models. SEM is a technique to express a complicated statistical model by a path diagram which expresses causation between variables with an arrowed line clearly. A SEM model can be represented as a diagram by using squares and arrows. A square represents variable and an arrow means causation between two variables. A numerical value added to an arrow expresses a degree of effect (Takaya, 2003). Two types of scheme, traditional scheme which is shown in Figure 1 (A) and proposed scheme which is shown in Figure 1 (B), have been generated by using the SEM method. The results from SEM method were shown by using comprehensible graphic. Sample models were generated from data which obtained from the experiments and the questionnaires which mentioned in the previous section. In order to improve the fit of the models, input data was prepared by using Discretization method and Pruning method. Figure 7 shows a diagram of generated model which based on the traditional scheme.

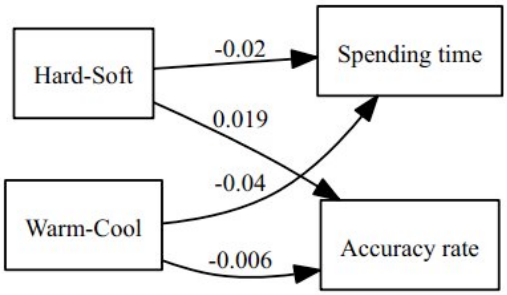

Figure 7: A SEM diagram based on the traditional scheme

The model which is generated based on the proposed scheme showed that there are five emotions which linked up operations; hesitation, number of tasks, safety, beauty, and understandability. Thus, the emotion nodes which are not connected with operation nodes were eliminated and the model has been re-generated. The re-generated model is exhibited in Figure 8.

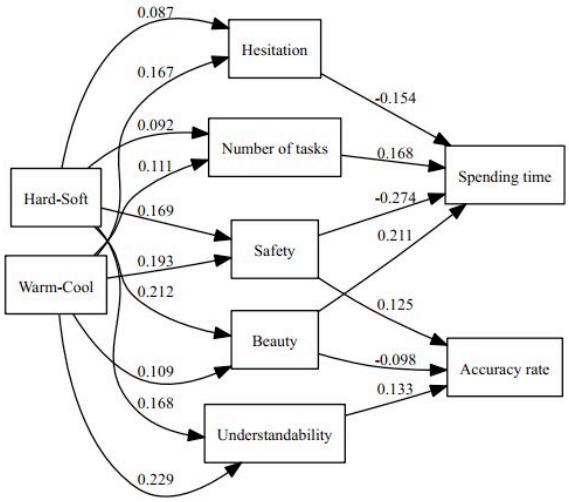

Figure 8: A SEM diagram based on the proposed scheme

6. RESULTS AND DISCUSSION

In this section, the efficiency of the proposed scheme is clarified and discussed by comparing two models, generated based on the proposed scheme and based on the traditional scheme. In the case of the model based on the traditional scheme, the result shows that the soft-hard value has negative effect on working time, whereas has positive effect on accuracy of operation. Meanwhile, both of operation indicators were affected negatively by the warm-cool value. However, coefficient of each path is quite low as shown in Figure 7. Thus, we cannot find any significant effects of the interface design on working performance indicators when investigating through the model which is generated based on the traditional scheme. This is to say, the analysis with this model cannot clear up effects of the interface color design on the users' operation.

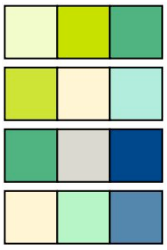

Figure 9(A): The color schemes which have safety image



Figure 9 (B): The color schemes which have beauty image

As shown in Figure 8, in the model based on the proposed scheme, there are fifth emotions connected with working performances. Hesitation enhances spending time to complete work whereas sensation of number of tasks effect negatively on the spending time index. For the accuracy rate indicator, understandability tends to increase number of correct answers in the tasks. Moreover, there are positive correlations with both of working performance and safety. On the other hand, there are negative correlations between the performances and beauty. Therefore, it can be confirmed that the operational performances and the users' feelings have a causal association. The color schemata which have safety image and beauty image are shown in Figure 9 (A) and (B) respectively. Following, the hard-soft node and the warm-cool node are connected with all nodes of emotions positively.

From the results of correlation analysis, we can notice that the model based on the traditional scheme is hard to explain that how colorations take an effect on users' working behaviors. While the model based on the proposed scheme can assist us to better understand about how colors decoration of interface design influence operational performance through users' emotion perspective. The results show how colorations have effects on users' feelings and how operational performance was affected by users' feelings. Furthermore, the proposed scheme can illustrate the effect of colors interface design on users' operation more precisely than the traditional scheme.

7. CONCLUSION

Many researches were done to investigate effects of coloration on operational performance. Many of them considered relationships between colors and operations. This scheme is called as traditional scheme in this research. However, users' perceptions for the interface are difference depend on the individual. Thus, a new scheme has been proposed for better understanding how colors interface design influence users' operational performances. The new scheme represents relationship between design, user's feeling and operation. The experiments and the questionnaires have been conducted to generate example models based on the proposed model and traditional model in order to demonstrate advantage of the proposed scheme in comparison with the traditional one. It has been revealed that the proposed scheme can illustrate the relationship between interface color design and the operations more accurately than traditional scheme as a result of analysis of the models. Therefore, we can understand the mechanisms in which how an operator feels about an interface design, and how the operations get effects from the feelings with the proposed scheme.

The results of this study have shown that there are causal relationships between interface colors design, users' feelings and operational performances. When the scheme is introduced into a practical system, the relationship between coloration and each operator should become clear. However, it is difficult to know how coloration effects on each person. An efficient method to find the relation is expected to develop a design support system based on the proposed scheme.

ACKNOWLEADGEMENT

This work was supported by Grants-in-Aid for Scienctific Research from Japan Society for the Promotion of Science (NO. 23653260, 21360191, 23611025)

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4B - Textile 2

Cloth Model Handling by The Combination of Some Manipulations for Draping

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Abstract: In this study, manipulation of a cloth model for virtual draping in real-time is performed using hand gesture. The manipulations are holding, releasing, attaching and mapping. And, the cloth model is manipulated by using the manipulations in combination. A cloth model and an object model consist of particles. The holding is performed by fixing the particle nearest to the hand in the loth model to the hand. This manipulation is started if a distance between the particle and the hand is shorter than a threshold. The releasing is demonstrated by releasing a fixed particle. The attaching is performed after the cloth model is held, and the held particle is fixed to the particle nearest to hand in the object model. These manipulations except the holding are performed by pressing keys on the keyboard. The manipulations are combined by pressing the execution keys. As the results, we succeeded in performing each manipulation and using the manipulations in combination. The results suggest the possibility of performing virtual draping by using this algorithm.

Keywords: virtual draping, real-time, hand gesture, cloth manipulation, combination of manipulation.

1. INTRODUCTION

Draping is one of making pattern for garments. In draping, a designer attaches cloth to dummy and makes garment form to make the pattern. The draping has advantages, such as it can make a garment which is a perfect fit. However, it takes cost and time. Virtual draping methods are suggested in order to reduce cost and time. Especially real-time draping can demonstrate more realistic draping.

The studies including virtual draping for making customized virtual garment and garment simulation have been conducted. Interactive system and simulation for garments have been developed to make fitted garments. Yasseen Z. et al. create a garment reflected a user's image by drawing line on the dummy body in virtual space (Yasseen et al., 2013). And, dynamic behavior of

the garment is simulated in moving the body. Wibowo, A. et al. develop a method which makes garment pattern by drawing garment outline with special tools on mannequin (Wibowo et al., 2012). In addition, they make actual garments from the obtained garment patterns. A cloth model and mesh manipulation are important for interactive virtual draping. The study, which the cloth model attached to an object model is moved by mouse, has already been conducted (Igarashi and Hughes, 2003). In these studies, the cloth model is often manipulated by using mouse.

However, virtual cloth manipulation using gesture is more realistic than the mouse manipulation. Therefore, we suggested method of cloth manipulations for the virtual draping according to hand gesture in the real world (Inui et al., 2012; Mesuda et al., 2013). However, the method needs other manipulations for draping because the method can performed only two type manipulation: moving and cutting. In addition, some manipulations have to be used in combination. In this study, we suggest four manipulation methods: hold, release, attaching and mapping. And we demonstrate some manipulations in combination.

2. THE MODEL AND THE DEVICE

In this study, a cloth model is particle model, and an object model such as dummy body is also represented by particles. And, cloth mechanical characteristic and the reaction of collisions between cloth model and object model are defined. A sensor is used to get hands motion. The model, the calculations and the sensor are discussed in the following.

2.1. The cloth model and the object model

The cloth model consists of particles and springs. Particles arranged on grid are connected by springs. The springs connect nearest particles and next-nearest particles (Figure 1).

The object model also consists of particles. However, the particles are not connected by springs. In dummy model, it consists of 80 cross-sections and 32 particles are arranged evenly in a circumference of the cross-sections. A radius and a height of the cross-section in which a particle is arranged are obtained from data of dummy model. The data are used in mapping. Other manipulations are performed by using three dimensional coordinates of each particle.

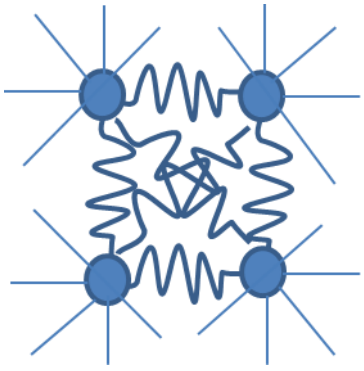

Figure 1: The cloth model

2.2. Dynamic calculation

In this study, dynamic behavior of cloth model is demonstrated by integrating forces acting on the particle (Harada T. & Koshizuka S., 2007). Forces of spring, collision reaction and gravity act on each particle. These forces are summed and position of each particle in the next step is calculated

by integrating the total force. In the integration, leap-frog method is used.

2.3. Collision reaction and collision detection

Collision detection and collision reaction are also defined (Harada & Koshizuka, 2007; Fuhmann, 2003; Fuhmann, 2003; Zhao, 2004). In collision detection, if a distance between the cloth model and the object model is shorter than a threshold, this algorithm judges that the cloth model touches the object model. If the cloth model collides, a repulsive force acts on the collided particle in the cloth model. The repulsive force does not act on the object model because the form of the object model does not change. This repulsive force is calculated by distance between collided particles. The distance is extended to the threshold by the repulsive force. Therefore, there are spaces between the cloth model and the object model.

A part of the cloth model often cuts into the object model. In this case, the particle cutting into the object model is moved to nearest particle in the object model, and then the collision reaction is performed.

2.4. Kinet

Kinect, it is sensor, is used to obtain hands motion in the real world in real-time. Kinect can get part positions of user's body by sensor and camera. Each part is obtained as three dimensional coordinate. The positions are updated every 1/30 seconds. User's motion is obtained by this update.

3. MANIPULATIONS OF THE CLOTH MODEL

In this study, the cloth model is manipulated according to hand gesture. User watches a screen on which the cloth model, the object model and hands position are displayed and manipulates the cloth model. We demonstrate four manipulations: holding, releasing, attaching and mapping. And, these manipulations are used in combination.

3.1. Holding and releasing

The holding is performed by moving a hand in fixing the particle of the cloth model to the hand. The user can watch the closest particle in different color to the hand. And when a distance between the hand and the particle is shorter than a threshold, the particle is fixed to the hand. This is, the user moves their hand to change the color of the particle in which they want to hold. And then they move their hand close to Kinect if the particle color changes.

The releasing is performed by releasing a fixed particle. The releasing particle is decided in the preparatory stages. This manipulation is started by pressing a key on a keyboard.

3.2. Attaching method

The attaching is performed after the cloth model is held because the particle fixed to the hand is attached to the object model. The particle in the cloth model fixed to the hand is fixed to the particle of the object mode nearest to the hand by pressing the key. The place, which the particle is fixed, changes from the hand to the nearest particle in the object model. The color of the nearest particle changes because the user can check the attaching position. The color of a particle in which they want to attach changes by moving their hand. And then they press the key to attach the cloth model. When the cloth model is attached, collision reaction has to be considered. Because there are spaces between the cloth model and the object model by collision reaction. Thus, collision detection and reaction are performed after the particle in the cloth model is moved to the particle in the object model. And then the cloth mode particle is fixed.

3.3. Mapping and stabilizing method

In draping, grain is often attached to guideline of the dummy such as center line. Attaching by mapping and stabilizing the cloth model to the object model is performed to attach exactly. The cloth model is mapped along the dummy model and stabilized by the dynamic calculation and collision reaction. In the calculations, parts of the cloth model are fixed. Thus, the attaching form is made. The mapping method is detailed below.

First, a height of the dummy model mapping the particle of the cloth model is calculated. Top of the cloth model is attached to the highest position of the dummy model mapping the particle, the height is decided in advance, and a height mapping each particle is calculated based in the highest position. At this time, top and bottom cross-sections of the height are calculated.

Next, lateral position mapping of the particle is calculated. Length of the cloth model particle in lateral direction is compared with arc length from the centerline in the top cross-section obtained in the previous step. And, right and left particle of the dummy model of the mapped particle on the circle are calculated. And then, angle and radius of the particles in the dummy model is obtained. Angle and radius in which the particle is mapped in the cross-section is calculated by interpolating the angle and the radii. The calculated radius is extended to the threshold because there are spaces between the cloth model and the dummy model by collision reaction.

After mapping, top and left of the cloth model are fixed and then dynamic calculation and collision calculation are performed.

3.4. Combination manipulation

These manipulations are used in combination. Each manipulation is switched by pressing a key. However, the holding is performed by the distance between the hand and the particle in the cloth model. And, the attaching can be performed after the holding manipulation. The mapping cannot be used in combination. However, the mapping is started by pressing the key because it will be used in combination in future study. Each manipulation can be used once.

4. RESULT AND DISCUSSION

In the holding, the releasing and the combination manipulation, their initial state is that both or one of upper edge of the cloth model are fixed. Table 1 shows a combination of the manipulations. Figure 2-6 show results of each manipulation. Figure 7-9 show results of combination manipulation.

From Figure 2, we succeeded in holding any positions in the cloth model. This algorithm can keep fixing the position in the cloth model after holding. In the Figure 3, in either two positions or a position are fixed, the fixed particle can be released. This algorithm can simulate how the fixed area of the cloth model falls. From Figure 4, the cloth model can be attached to the object model. The spaces between the cloth model and the object model are considered. However, the attached point is often a little different. This cause is calculation time in dynamic calculation and collision reaction. The particle is moved to a position stabilizing the particle by calculating these calculations several times. Therefore, the particle can be attached to a closer position by increasing the calculation time. Figure 5 shows the result of increasing the calculation time. As the result, this problem is improved.

In the mapping, left side and top of the loth model are attached to center line and above the level of the waist of the dummy model. From Figure 6, we succeeded in mapping along the center line. The cloth model is wavy a little in the first time after mapping. The cloth model is stabilized and its form changes along form of the dummy body by repeating the calculations. However, a part of the cloth mode does not change along the dummy model form. This cause is the influence which the

top and the left side of the wavy cloth model are fixed and it affects other areas of the cloth model. This problem is solved by increasing particle number of the cloth model and dummy model.

As shown Figure 7-9, the cloth model can be manipulated by some manipulations in combination. In both of combination 1 and combination 2, the cloth model can be held and released. However, in combination 1, the form of the cloth model is unstable if the particle fixed to the hand is released. This cause is that the calculated result vibrates. In combination 3, we can confirm clearly the cloth model is attached to the object model. In combination 4, the cloth model often vibrates faintly and is attached to different point a little, but this algorithm can demonstrate the cloth model colliding and attached to the object model. This faintly vibration is also generated by the calculated result vibrating. This problem is solved by changing this integration method.

This combination manipulation has some problem, but this algorithm can manipulate the cloth model in combination regardless of sequence and type of the manipulations. Therefore, it is fully possible to perform the draping by using the manipulations in combination in this algorithm using the hand motion in the real world.

Table 1: Combination of the manipulations

Combination name	Manipulations
Combination 1	Holding -> Releasing
Combination 2	Releasing -> Holding
Combination 3	Holding -> Attaching -> Releasing
Combination 4	Holding -> Releasing -> Attaching

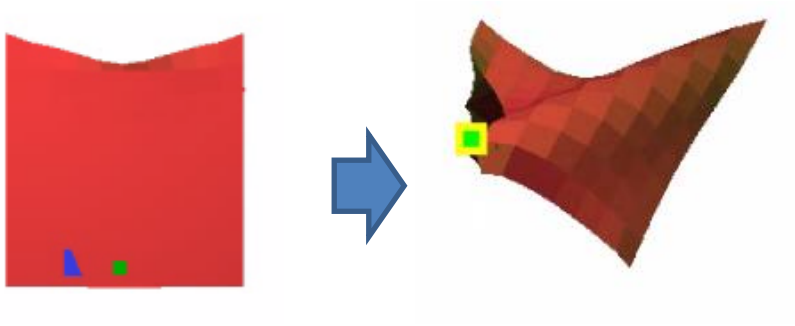

Figure 2: Result of the holding the cloth model. The initial state is that two particles in the top of the cloth model are fixed.

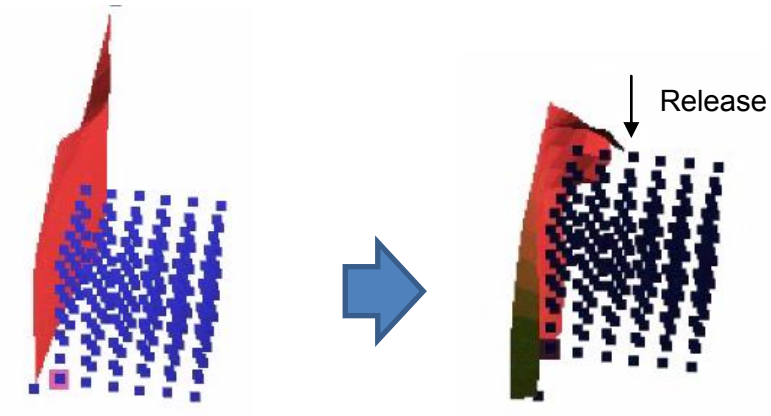

Figure 3: Result of the releasing. The initial state is that two particles in the top of the cloth model are fixed. The right of the fixed position is released.



Figure 4: Result of attaching. The initial state is that one particle in the top of the cloth model is fixed.

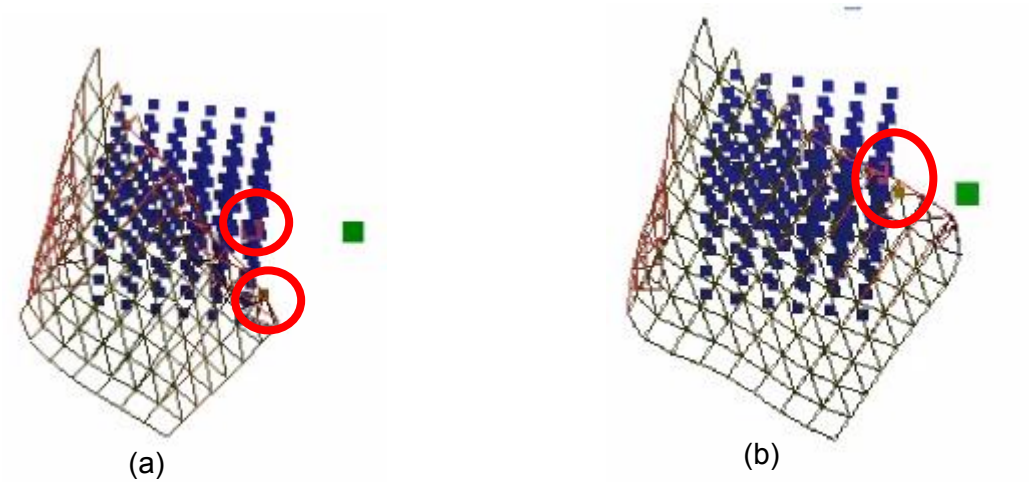

Figure 5: Figure 5: Comparison of different calculation time. The circles in this figure are at attaching point and the nearest object particle. (a): The calculation time is 50. (b): The calculation time is 100.

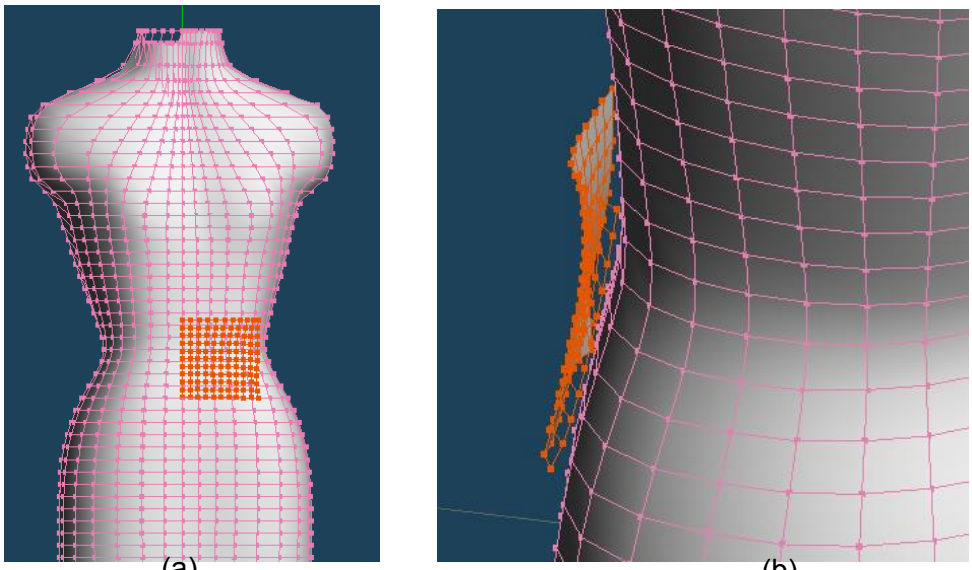

Figure 6: Result of mapping. (a): The front view of dummy model. (b): The side view of the dummy model.



Figure 7: Result of Combination 1. The initial state is that one particle in the top of the cloth model is fixed.

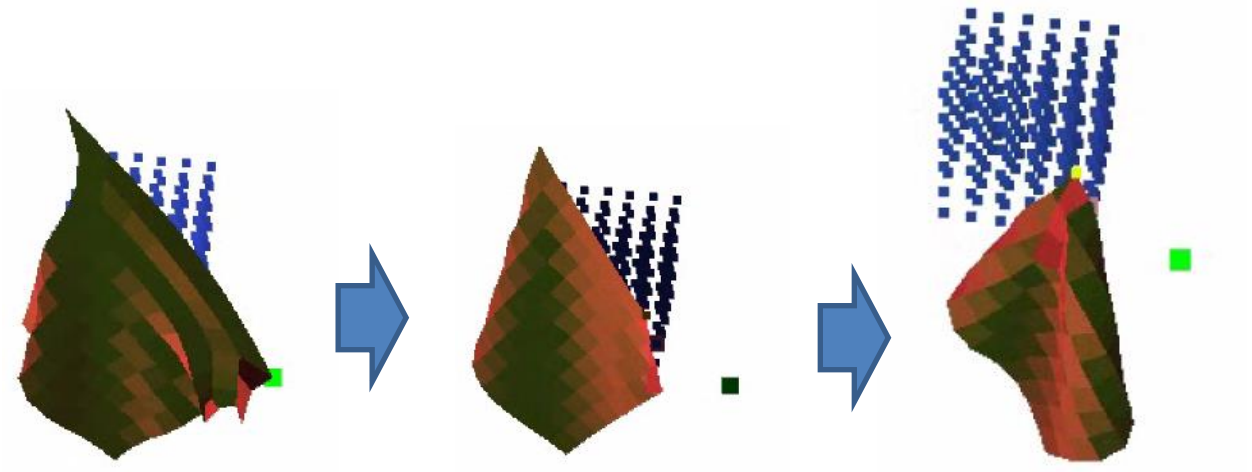

Figure 8: Result of combination 3. The initial state is that one particle in the top of the cloth model is fixed.

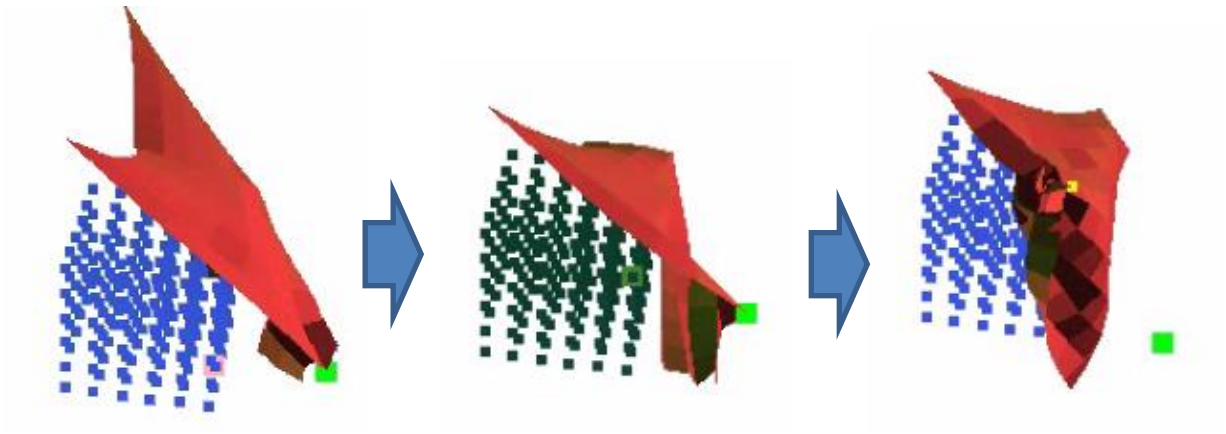

Figure 9: Result of Combination 4. The initial state is that two particles in the top of the cloth model are fixed.

5. CONCLUSION

In this study, cloth model manipulations, holding, releasing, attaching and mapping, are performed by using a hand motion in the real world in real-time. And, the cloth model is manipulated by using some manipulations in combination. The hand motion in the real world is obtained by using Kinect. The cloth model is particle model and the object model also consists of particles. Dynamic calculation, collision detection and collision reaction are defined.

The holding is performed by fixing the particle nearest to the hand to the hand position. This manipulation can be performed if the distance between the hand and the particle shorter than a threshold. The releasing is demonstrated by releasing the fixed particle. The attaching can be performed after the cloth model is held. The holding particle is moved to the particle of the object model nearest to the hand, and then dynamic calculation and collision reaction are performed. Next, the particle in the cloth model is fixed to the position where it moved by these calculations and released from the hand position. In the mapping, the particles in the cloth model are arranged based on the guideline of the dummy model. And then left side and top of the cloth model are fixed and dynamic calculation and collision reaction are performed. These manipulations except the holding are performed by pressing keys on the keyboard. In combination of the manipulations, the manipulations are performed by pressing their supporting keys

As the results, this algorithm can perform the manipulations and the combination of the manipulations can be also performed. Therefore, manipulations which user has intended are performed according to the hand motion in the real world. The results suggest the possibility of performing virtual draping by using this algorithm.

ACKNOWLEDGMENTS

This work was partly supported by Grants-in-Aid for Scientific Research (No. 23240100, 24220012) from the Ministry of Education, Science, Sports and Culture and Grants for Excellent Graduate Schools, MEXT, Japan.

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Relationship between jacket comfort and stiffness of adhesive interlining

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Abstract: We investigated the effects of adhesive interlining on wearing and moving comfort and garment pressure exerted on the body. Scheffe's paired comparison test was performed for sensory evaluation of four jackets of the same pattern: one without interlining and three with different adhesive interlinings (soft, normal, hard). The bonded fabrics have different shear and bending rigidities. Nineteen subjects performed a series of postures and movements while wearing the jackets: (1) standing, (2) moving arms forward, (3) raising arms overhead, and (4) moving arms horizontally to the side. They compared wearing and moving comfort, and the feeling of garment pressure on designated parts of the body on a seven-point scale. Analysis of variance revealed significant differences in preference scores between jacket types. A jacket with lower stiffness was evaluated as more comfortable and as placing less pressure on the body. There were significant differences in wearing comfort between jackets even when subjects were standing. We conclude that adhesive interlinings affect wearing and moving comfort of jackets and the pressure exerted by a jacket on the body, especially in the shoulder, back, forearm, under the arm and bust areas. The use of lower-rigidity interlining, especially for the shoulder, back, under the arm and bust, will result in a more comfortable jacket, although the interlining must be sufficiently rigid to maintain the desired shape and appearance of the jacket.

Keywords: Jacket, Comfort, Stiffness, Adhesive, Interlining

1. INTRODUCTION

Adhesive interlining is generally used in parts such as the front, side, upper shoulder and

hemline of jackets to increase textile rigidity. Studies have investigated the changes in bending rigidity and shear stiffness associated with bonding adhesive interlining [Kim K. et al, 2011-2013]. The effect of adhesive interlining on jacket appearance was investigated by Kim et al. [2013], who found that the surface smoothness and waist line and thus the appearance of a jacket were affected by bonding adhesive interlining.

Although the effects of adhesive interlining on garment appearance have been investigated, the effect on clothing comfort has not. Along with garment appearance, wearing comfort is considered as an important factor of clothing. Changes to bending rigidity and shear stiffness could affect jacket comfort. There are many studies on the relationship between pressure and garment comfort of tight fit garment giving high pressure such as underwear, socks and stockings [Jeong, Y. et al. 2006 Liu, H. et al. 2013, Ishimaru, S. et al. 2011]. However, researches on the effect of compression on the outer garment such as a jacket are less.

There are some studies on the jacket comfort taking account with garment pressure caused by different both patterns and materials [Kanai, H. et al 2007]. Satoh and Ikeda et al. [1994, 1995] investigated the wearing comfort of several commercial jackets on market considering garment pressure. Chen et al. [2003] investigated the relationship between clothing pressure and the textile mechanical properties of a men's jacket employing grey incidence analysis theory. Even though, they showed that tensile and compression properties, shear stiffness and weight per unit area are related to the above clothing pressure of a men's jacket, the influence of partially different rigidity of a jacket on wearing comfort has not been investigated. In practice, the stiffness of clothing material is controlled by bonding interlinings. Sometimes, depending on the jacket parts, interlinings of different rigidities are used for the appearance. Even jackets made with the same face fabric, the comfort will be different depending on the interlining kinds. The partially different rigidity will affect comfort of the entire and part of jacket. Thus, the comfort changes caused by bonding interlining need to be investigated.

Using the jacket that was made using different interlining with varied rigidity, we investigated the effects of adhesive interlining on wearing and moving comfort and on garment pressure exerted on the body. We also considered the different comfort depending on different movement of different body parts.

2. EXPERIMENTAL

We carried out sensory tests to investigate the effects of adhesive interlining on wearing and moving comfort and on garment pressure exerted on the body. Scheffe's paired comparison test (Nakaya variation, which neglects sample order) was used for the sensory evaluation.

Four jackets of the same pattern and material (100% wool) without a lining were made for this evaluation. Figure 1 shows the jacket pattern and the interlining parts. The jacket size is JIS (Japanese Industrial Standards) 9AR (height 158 cm, bust 83 cm and hip 91 cm). One (no interlining) was made without interlining and the others were made with three different adhesive interlinings (soft, normal and hard) having different shear and bending rigidities. Pictures of jacket samples are shown in Figure 2. The masses of the jackets and the shear stiffnesses and bending rigidities of the fabric bonded by interlining measured with a KES-FB system [Kawabata, 1980] are given in Table 1. The mass of jacket, shear stiffness and bending rigidity of fabric bonded interlining used in jacket samples increased in the order of no, soft, normal and hard interlining.

Nineteen subjects, whose fitting sizes were 9AR, volunteered to participate in the test. Subjects

wore the same T-shirt and skirt for the test. They performed a series of postures and movements while wearing the jackets: (1) standing, (2) moving arms forward, (3) raising arms overhead, and (4) moving arms horizontally to the side as shown in Figure 3. They compared the feeling of weight, feeling of hardness, wearing comfort, moving comfort, and feeling of garment pressure on designated parts (neck, shoulder, bust, front of the upper arm under the arm, part around the bust and button, back, back of the upper arm, front side and back side) of the body for the entire jacket as shown in Figure 4. They scored the results on a seven-point scale. The test was carried out in a chamber with standard conditions of 20 ± 1 °C and 65% ± 5% relative humidity.

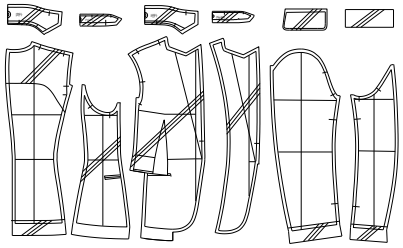


Figure 1: Jacket pattern with interlining parts (diagonal lines)

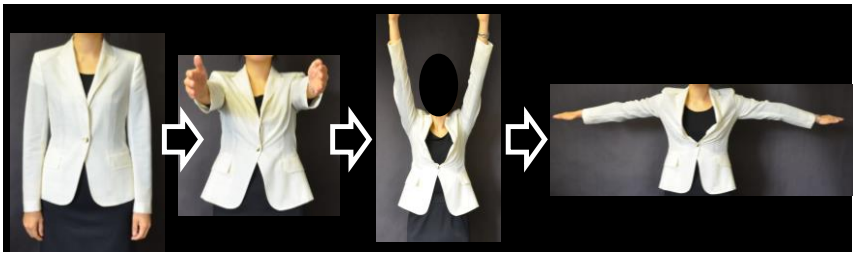


(a) no interlining (b) soft interlining (c) normal interlining (d) hard interlining

Figure 2: Jacket samples with different interlining

Table 1: Mass, shear stiffness and bending rigidity of fabric bonded by interlining

Property \ Fabric bonded by interlining	No interlining		Soft interlining		Normal interlining		Hard interlining	
	warp	weft	warp	weft	warp	weft	warp	weft
Mass (g)	201.6		212.3		234.8		263.7	
Shear stiffness ($gf \cdot cm^{-1} \cdot degree^{-1}$)	0.668	0.664	0.886	0.834	2.256	2.204	5.934	6.082
Bending rigidity ($gf \cdot cm^{2} \cdot cm^{-1}$)	0.062	0.050	0.108	0.101	0.214	0.208	0.453	0.456



(1) (2) (3) (4)

Figure 3: Movement in the sensory test; (1) standing; (2) moving arms forward; (3) raising arms overhead; and (4) moving arms horizontally to the side

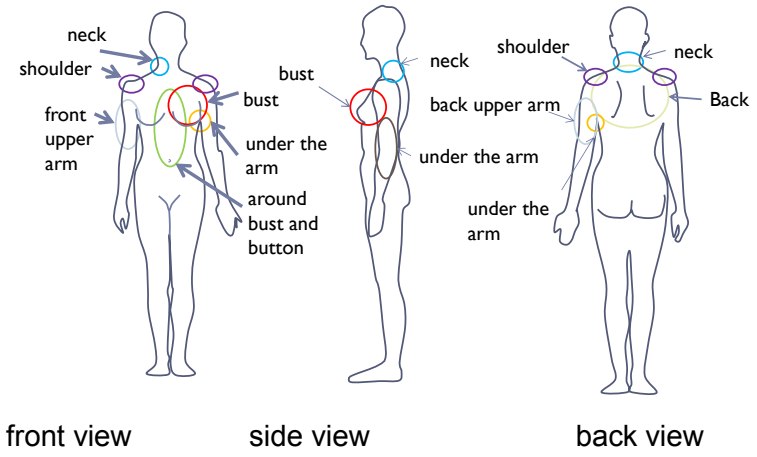


Figure 4: Designated body parts in the sensory test

3. RESULTS AND DISCUSSION

Significant differences in preference scores between jacket types were revealed using analysis of variance. Table 2 shows the significant differences between sample pairs in terms of feeling of weight, feeling of hardness and feeling of pressure for each movement. There were significant differences in feeling of weight between all samples except between the jackets with no interlining and soft interlining. It was thus revealed that the subjects felt differences in jacket weight.

There were significant differences between all sample pairs in the evaluation of the feeling of hardness for the entire jacket. Even when standing, subjects felt the difference in the feeling of hardness. For all movements, subjects felt differences on the neck, bust and under the arm between the two jackets of all sample pairs except for the pair having no interlining and soft interlining. This means that the differences in weight, bending rigidity and shear stiffness between the jackets having no interlining and soft interlining were too small for subjects to feel. The results reveal that the subject felt the weight and hardness of jackets differently for different interlinings except in the comparison of jackets with no interlining and soft interlining.

Table 2: Significant differences between jackets of sample pairs in feeling of weight, feeling of hardness and feeling of pressure for each movement (*: 5% significant difference, **: 1% significant difference)

Evaluation condition \ Jacket sample pair		no interlining –soft interlining	no interlining –normal interlining	no interlining –hard interlining	soft interlining –normal interlining	soft interlining –hard interlining	normal interlining –hard interlining
Standing	Feeling of weight		**	**	**	**	**
	Feeling of hardness—entire	**	**	**	**	**	**
	Feeling of hardness—neck		**	**	*	**	**
	Feeling of hardness —bust		**	**	**	**	**
	Feeling of hardness—under the arm		**	**		**	**
	Feeling of pressure—entire		**	**	**	**	**
Front	Feeling of hardness —entire		**	**	**	**	**
Horizontal	Feeling of hardness —entire	*	**	**	**	**	**
Up	Feeling of hardness—entire		**	**	**	**	**

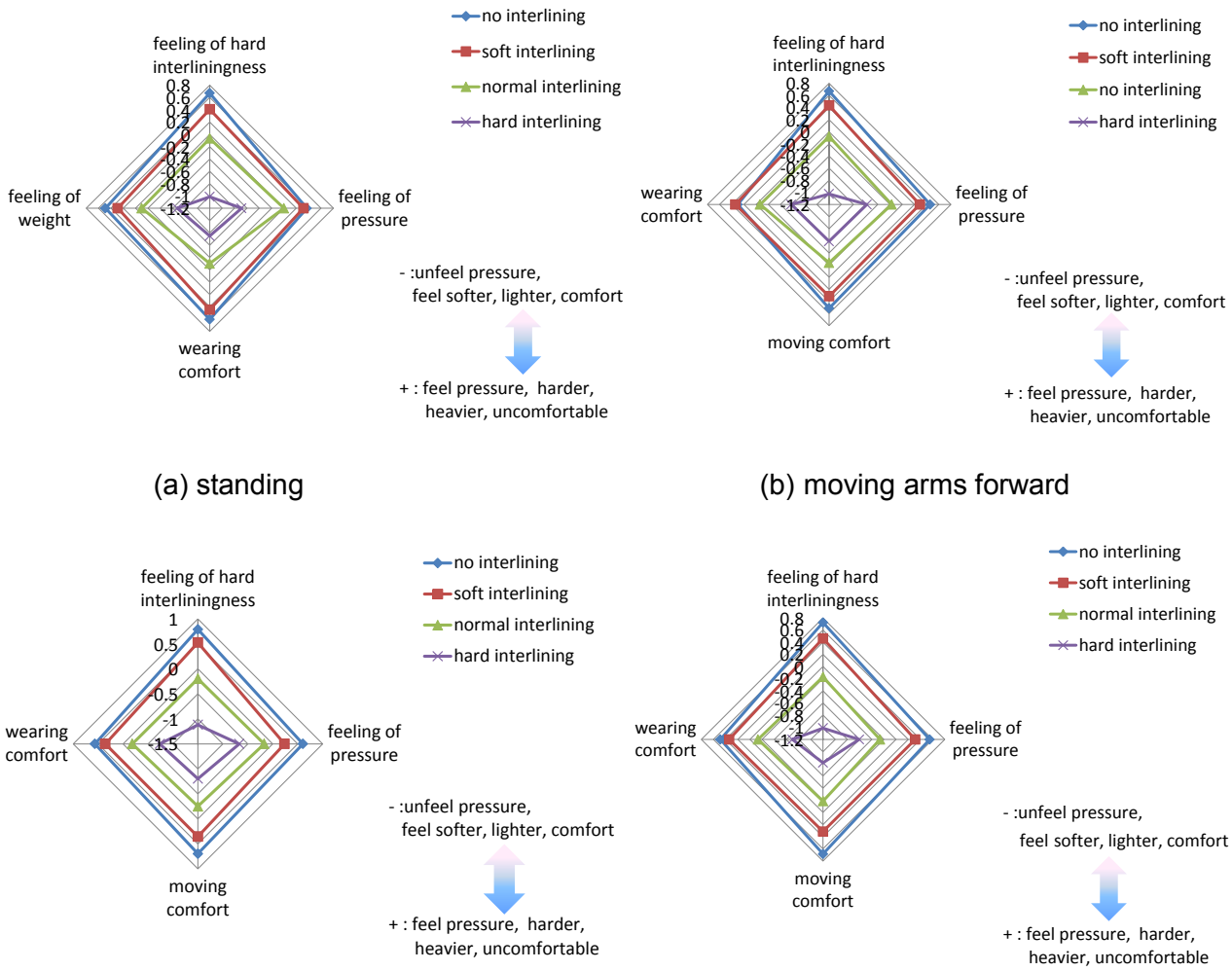
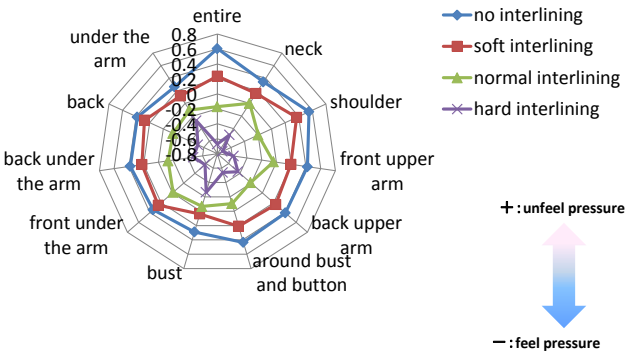


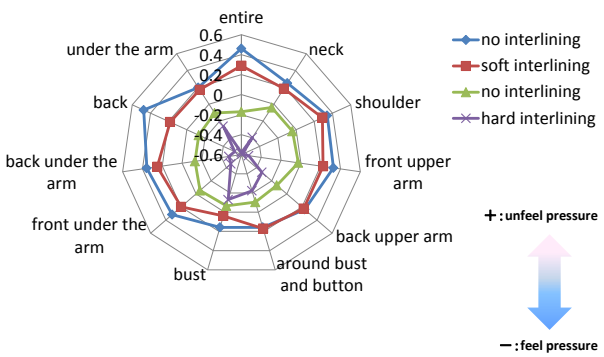
Figure 5: Preference scores for feeling of hardness, feeling of weight, wearing comfort, feeling of pressure, and moving comfort of the entire jacket in each movement

Preference scores of feeling of hardness, feeling of weight, wearing comfort, feeling of pressure, and moving comfort of entire jacket for each movement are shown in Figure 5. The jacket without interlining was evaluated as the softest and lightest. The subjects evaluated the jackets as being increasingly harder and heavier in the order of jacket with no, soft, normal and hard interlining. In terms of moving comfort, feeling of pressure and wearing comfort for the entire jackets, subjects again evaluated jacket without interlining is the most comfortable, the easiest to move in and having the lowest pressure for the entire jacket. The results were the same as the results for the feeling of hardness.

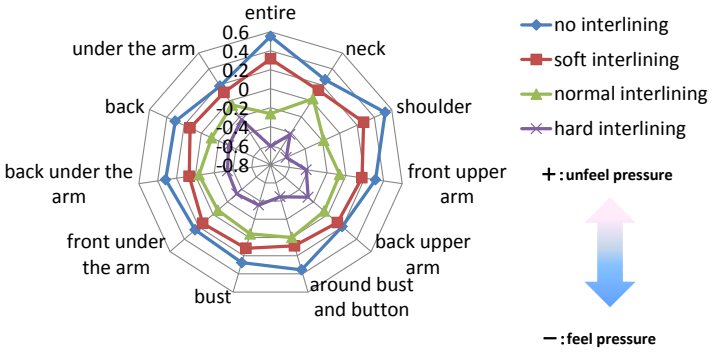
Preference scores of feeling of pressure for each part and each movement are shown in Figure 6. The feeling of pressure increased in the order of no, soft, normal and hard interlining. This was the same order as for bending rigidity and shear stiffness of the bonded fabric. However, the areas where subjects felt pressure varied depending on movement. There were significant differences between the two jackets of most sample pairs except for the pair of jackets having no and soft interlining. This result is the same as that for feelings of hardness and weight. However, there were significant differences for the back, under the arm during horizontal arm movement, and bust during upward arm movement for all sample pairs. It was thus found that subjects largely felt differences in pressure for the back, under the arm and bust in those movements. This is explained



(a) raising arms overhead

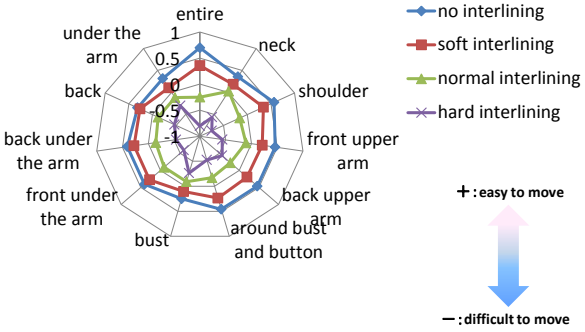


(b) moving arms forward

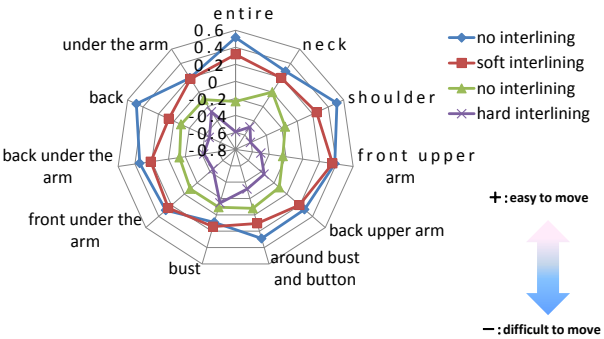


(c) moving arms horizontally to the side

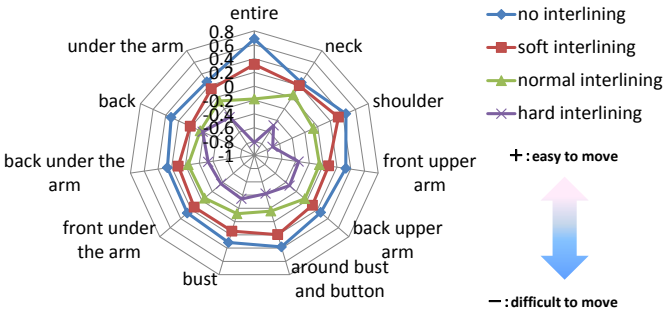
Figure 6: Preference scores of feeling of pressure in each area for each movement



(a) raising arms overhead



(b) moving arms forward



(c) moving arms horizontally to the side

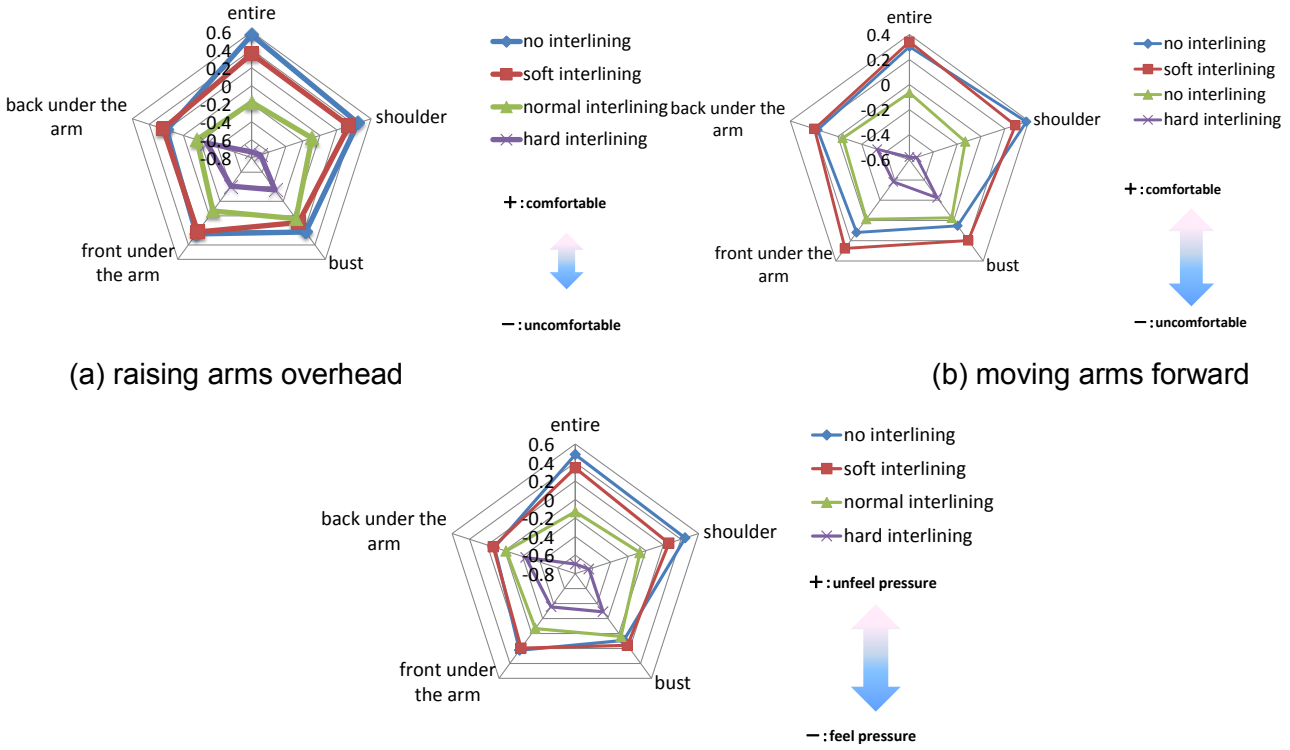
Figure 7: Preference scores of moving comfort in each area for each arm movement

by the large difference in pressures. The pressures were generated by the restriction of fabric deformation on the body parts in the movements that require large deformations of fabric.

Preference scores of moving comfort in each area for each movement are shown in Figure 7. In terms of moving comfort, the jacket without interlining, followed by the jackets with soft, normal and hard interlining, was evaluated as the easiest to move in. There were significant differences between the two jackets of almost all sample pairs except for some areas for the jackets with no and soft interlining. There were significant differences between jackets with no and soft interlining in the shoulder and back for the forward arm movement, in the front of the forearm and back for the horizontal arm movement, and in the front and back of the forearm and under the arm for the upward arm movement. It was thus found that subjects felt moving comfort at the shoulder, back, front and back of the forearm, and under the arm more strongly. The reason is the same as that explaining the results for the feeling of pressure. However, subjects felt the differences in moving comfort more sensitively than those in the feeling of pressure.

Subjects particularly felt pressure and moving comfort in the forearm, where interlining was not used. The reason was that the deformation of clothing was affected by other connected parts. Forearm parts of sleeves were drawn out with the side and shoulder parts where interlining was used. It was thus found that interlining affected parts where interlining was not used.

Preference scores of wearing comfort in each area for each movement are shown in Figure 8. There were significant differences in wearing comfort between the two jackets of almost all jacket pairs for the standing posture and other movements except for the pair of jackets with no and soft interlining. The jackets with no and soft interlining were evaluated as being comfortable, the jacket with normal interlining as having medium comfort, and the jacket with hard interlining as being the most uncomfortable.



(a) raising arms overhead

(b) moving arms forward

(c) moving arms horizontally to the side

Figure 8: Preference scores of wearing comfort in each area for each arm movement

The above results reveal that the jackets felt different to the subjects because of their different stiffnesses of fabric due to different bonding interlining. Preferences of feeling of weight, feeling of hardness, feeling of pressure, moving comfort and wearing comfort had the same tendency. Softness, comfort and absence of pressure were judged to decrease in the order of the jackets with no, soft, normal and hard interlining. It was thus revealed that the different stiffness of bonded fabric resulting from the interlining affected the wearing comfort of the jackets.

4. CONCLUSION

A jacket with lower stiffness of fabric was evaluated as more comfortable and as placing less pressure on the body. We conclude that the stiffness of bonded fabric affects the wearing comfort of jackets and the moving comfort and pressure exerted by a jacket on the body, especially in the shoulder, back, forearm, under the arm and bust areas. This is due to the restriction of fabric deformation in areas that require large deformations of fabric during movements. These areas are the shoulder, back, under the arm and bust. A lower stiffness of bonded fabric with interlining in these areas will result in a more comfortable jacket, although the interlining must give sufficient stiffness to maintain the desired shape and appearance of the jacket. In this study, it was found that the effect of the fabric rigidity on the jacket comfort taking into account the arm movements and jacket parts. The quantitative evaluation will be our next subject.

ACKNOWLEDGMENTS

This work was supported by JSPS (Japan Society for the Promotion of Science) fellows and JSPS KAKENHI Grant number 24220012 and 23240100.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Influence of Fiber's Surface Morphology Change on Anti-pilling Performance of Woolen Knitted Fabric

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Abstract: Although the main factor controlling pill generation at the time of wearing wool knitted articles is the knitting structure of the raw material; the strength of yarn, the number of twist of yarn, the fabric design, the gauge number and so on, it is influenced ~~also~~ by the dyeing / finishing method of the knitted fabric after knitting as well.
In this paper, the influence of change in surface morphology of raw material fiber on pill generation is investigated (along with mechanical and physical properties of fabrics). Fabric samples are treated with several physicochemical processing. The difference in condition of scales and the relation with pill generation were discussed and clarified. The plain knit wear is widely used for sportswear and child's underwear subjected to high activity. Such clothing necessitates comfortable and soft touch and besides the surface of the clothing must be kept smooth and anti-pilling condition. These requirements are hopeful for comfortable clothing life. Thus, the present paper is believed to be a suitable topic relevant to Kansei Engineering.

Keywords: Pilling, Surface morphology, Wool-Knit, Physicochemical treat.

1. INTRODUCTION

The generation of the pill at the time of wearing wool knitted fabrics mainly originates from properties of the raw material, the number of twist of the yarn, the fabric design and the gauge number, and others. But sometimes such a design is unwillingly employed because of aesthetic necessity and soft handle. For child clothes and sportswear subjected to high activity, anti-pilling fabric are required. The pilling phenomenon is largely developed when the yarn as the raw material is long and tough, and the structure of knit composed of yarns with low twist density is coarse. The generation of the pill on the wool knitted fabrics is also influenced by the post processing of dyeing and finishing. In our preceding work [(Mori et al 2013), we discussed about the influence of dyeing

and finishing processes on the performance of woolen and worsted fabrics. And it was confirmed that handling and feeling of the fabrics could be modified by physicochemical finishing processes. In the present work, first the generation of the pill was investigated for wool knitted fabrics subjected to 4 kinds of post physicochemical processing such as Chlorination (Breck et al ,1989), NARS shrink-proof (Cadamone et al,2004), Argon low temperature plasma(Mori et al.2006) , and Polyuretane resin treatment and so on in which anti-pilling function is expected to be endowed. Next, the relation of the unevenness on the fiber surface, i.e. the state of scale height to the pilling nature was investigated in that the generation of pilling was ascribed to entanglement of fluffs on fabric surface. The state of the pilling was comparatively evaluated from 3 kinds of information that the number of pills on a prescribed area of the test fabric after pilling test, the number of pills dropped out and the size of the pill. The 3 kinds of information here are (ⅰ) Five-rank evaluation based on JIS-1076-1992, (ⅱ) Average number of pills generating on a area of 12×10 cm2 of the test fabric, and (ⅲ) number of pills dropped out into the box of tester. AS a result, high correlativity of the scale height with number of Pills (R2=0,71)was found out. This means that the generation of pilling is easily brought about by large difference between low and high scales. To further confirm this correlation, the scale height must be measured, and the measurement by AFM(Atomic Force Microscope)is now under consideration.

2. EXPERIMENT

2.1. Materials

The sample used is composed of merino wool yarns of 20.1～21.0 μm in diameter 2/60 (33.3 dtex) . The structure is plain weave. As to the count of twist, lower twist is set 685Z, while upper twist is set 685S. Coarse density is 153/10cm and wale density is 134/10cm, respectively, and weigh is 178g/cm^2. The physical properties of materials are summarized in Table 1.

Table 1: Physical properties of materials

Materials	Yarn		Knitted Fabric		
	Count	Twist	Density(/10cm)		Weight(g/cm^2)
			Coarse	Wales	
100%Merino wool(20.1-21.0μm)	**33.3dtex**	**685Z/685S**	153	134	178

2.2. Details of finishing processes

Samples are classified into 5 fabrics. 4 kinds of physicochemical treatments were subjected to grey fabric.

- Sample 1: Grey fabric; Knit wool fabric described in 2.1
- Sample 2 in which chlorination treatment was practiced on sample 1 and scales on the surface of wool were removed.
- Sample 3 in which surface modification by NARS processing was subjected to sample 1.
- Sample 4 in which aqueous emulsion type resin processing was practiced on sample 1.
- Sample 5 in which Argon Low Temperature Plasma exposure was subjected to sample 1.

2.2.1. Chlorination treatment

Fabric samples placed in a dyeing bath were dipped in water at 20 to 25 ℃ under a liquor to wool ratio of 20 : 1, and the amount corresponding to 0.05% non-ionic surfactant was added as a penetrating agent to the dyeing bath. The dyeing bath was stirred until the fabric samples were perfectly soaked in it. Then, solutions of 3.0% (o.w.f. as active chlorine) DCCA and 5.0% (o.w.f.) sodium pyrophosphate ($Na_2P_2O_7 \cdot 10H_2O$) were added, further acetic acid was added to adjust pH within the range of 5.5 to 6.0, and the resultant solution was maintained for a period of 20 min at this temperature. The temperature of the solution was then raised to 35 ℃ in 10 min, and maintained for 20 min. 6% (o.w.f.) sodium hydrogen sulfite ($NaHSO_3$) was further added, and after the temperature of solution had been raised to 60 ℃, the solution was maintained at this temperature for 10 min. The treated fabrics were rinsed and dried by air. The fabric samples treated with such chlorination processing were subjected to property measurements.

2.2.2. NARS shrink-proof processing

According to a modified method of the procedure described in U.S. Agricultural Research Service (Wyndmoor, PA 19038), treatments to wool fabric were carried out at conditions of pH 10.2, 30 ℃, period of 30 min and liquor to wool ratio of 20 :1 using a laboratory dyeing machine containing 1 g/L Ttriton X-114, 3 g/L NaOH, 1 g/L gluconic acid, 3 g/L dicyandiamide, and 12 g/L H_2O_2 (35%). After such treatment, the fabrics were rinsed until reaching neutral pH. Successively the treatment by enzyme was carried out at 50 ℃ and pH 6.0 for 40 min in a bath dissolving 1.5g/L triethanolamine (TEA), 1g/L Triton X-114, 1.5% (o.w.f.) Na_2SO_3 and Esperase 8.0LTM (Novoenzymes, North America, Flaklington, NC). After the treatment, the enzyme was deactivated at the conditions of 80 ℃ and period of 10 min. The fabrics were rinsed and dried by air.

2.2.3. Water soluble polyurethane resin treatment

As for sample, aqueous emulsion type resin Supeperflex R 5002 is in a state of 5 % solution. Pad was extracted, and it was cured during 1 min at 130 ℃ after the drying process.

2.2.4. Argon low temperature plasma treatment

Plasma reactor used is a type DSSO-422 (Daia Sinku Co., Ltd.). The discharge frequency was fixed at 13.56 MHz. Plasma treatment was carried out by the following procedures. The sample was placed in the reactor, and the reactor was evacuated to 0.001 Torr (0.13 Pa). Then argon (Ar) was fed into it at a volumetric flow rate of 10 mL/min. The electric power for plasma discharge was fixed at 100 W. The internal pressure of the reactor was maintained at 0.1 Torr (13.3 Pa) during a plasma-treatment time of 300 s. The treated fabric samples were finally rinsed with water and dried by air, and then they were subjected to property measurements.

2.3. Pilling test method

Pilling conditions for treated and untreated sample fabrics are based on the JIS L-1076-1992 (ISO 12945-1) method. The measurements for the treated fabrics were compared with the measurement for the untreated fabric. According to the method, the ranking from the first to the fifth rank is determined. To determine more accurate ranking of the fabric, in this study, the information on both the number of pills in the 12×10cm area and the number of the pills dropped out was employed.

2.4. Breaking strength

Items of breaking strength, elongation for an untreated fabric and 4 kinds of treated knit fabrics were measured based on JIS L-1095 by means of tension tester AG-IS 10KN (Shimadzu Manufacturing Co. Ltd., Japan). The average breaking strength (N) and elasticity (%) were

determined under the conditions of number of samples = 50, sample length and width = 200 mm and 50 mm, respectively, initial load = 0.05N, and pulling speed = 200 mm/min.

2.5. Bursting strength

The bursting test was executed by means of constant elongation method based on JIS-L1096-8.16. First, five test pieces of 8 cm diameter are cut out and then the test piece with the backside upward is smoothly fastened to the clamp of internal diameter 4.4 cm without wrinkling and loosing. The force N when the test piece is broken down by a pushing rod at a pressing speed of 10 cm/min is measured. The pushing rod has the diameter of 2.5 cm and the tip of the pushing rod has the radius of curvature of 1.25 cm. The value of force N is averaged by 5 measurements, and is expressed by tenth's place.

2.6. Observation of fiber surface morphology

A 3D profile microscope (Keyence VK 8500) was used on the direct magnification of 1000 at a plane special resolution of 0.13 μm and at the repetition accuracy of 0.02 μm. The unevenness on the surface of each sample; unevenness in μm on 7 to 8 sheets of scale was observed by means of this microscope, the unevenness of scale was compared with each other for samples with and without treatment.

2.7. Dyeing method

The dyeing property was discussed to compare chemical changes of worsted wool caused by a variety of physicochemical treatments in terms of color intensity, and the relation to fabric handling was confirmed. In the present work, also treated and untreated wool fabric samples were dyed using a dyeing machine Colorpet 12LMP-E (Nissen Co.). The samples were immersed in a 0.1% solution of surfactant acting as penetrating agent under the liquor to wool ratio of 20:1 for 10 min. The dyestuff was added to the surfactant solution at a temperature of 50 ℃, then the temperature was raised to 100 ℃ at a rate of 1.5 ℃/min and maintained at this temperature for 20 min under a gentle stirring. The dyeing process was further continued for 40 min at 100 ℃ in the presence of 2.0% (o.r.f.) acetic acid (99%) for adjusting pH at 4.0 to 4.5. The dyed samples were thoroughly washed and dried. The dyestuff used was 5.0% (o.r.f.) Lanasol Black CE-R.

2.8. Dyeing intensity

Color of sample was measured by means of spectro-colorimeter Minolta CM-3600D. Power source was D65, visual angle was set 10°, and the sample size was 5 cm×5 cm. Dyeing yield was measured from reflection ratio at the maximum wavelength of absorption, and K/S was calculated using Kubelka-Munk equation. L*, a* and b* on CIELAB system were obtained for the dyed samples and L* was used for the reference value of dyeing yield. Reflectance of the treated wool was measured, and L* was calculated according to Kubelka-Munk equation.

2.9. Objective evaluation of fabric handling by KES

Mechanical properties and fabric handling were evaluated by objective evaluation method using KES (Kawabata Evaluation System) procedure(Textile Machinery Society Japan,1998,Kawabata,1980) for untreated and treated wool fabrics. Tensile, bending and shearing were measured for course and wales directions, and both compression and surface properties were measured together with thickness and weight of fabric. Total Hand Value(THV) was calculated using KES and measurements of mechanical properties outlined above. According to

five-rank evaluation,THV=1 means poor and THV=5 means excellent The size of fabric was exactly 20 cm×20 cm, and kept at 20℃ and 65% RH. For a period longer than 24h.

3. RESULTS AND DISCUSSION

3.1. Test results on pilling

3.1.1. Ranking of pilling and its evaluation data

The rank of pilling based on the JIS L-1076-1992 (ISO 12945-1) method, and the numbers of the pills and the pills dropped out are listed for grey fabric and the fabrics treated by 4 kinds of finish processing in Table 2. In the same table, the total (comprehensive) ranking judged from both the rank based on the above JIS method and the information on the numbers of pills and the number of pills dropped out is also shown. It is apparent in Table 2 that NARS processing brings about the least generation of the pill, and according to JIS L-1076-1992 the 5th rank is attained and in chlorination processing the 4th rank is realized. For untreated (grey) fabric the rank is 4. By finish processing, the ranking can be improved by 1 to 2 ranks.

Table 2: Rank of pilling and state of pilling generation

Process Name		JIS L-1076-1992	Pills /12×10cm^2 [1)]	Dropped Pills[2)]	Comprehensive ranking[3)]
0	Untreated	3	94,74,70,84/4 =80.8	25	4
1	Chlorination	4	18,15,12,16 =15.3	8	2
2	NARS	5	1,0,2.3/4 = 1.5	0	1
3	Polyurethane	3-4	49,30,48,38 =41.3	11	3
4	LTP Plasma	3-4	50,54,28,44/4 =44	13	3

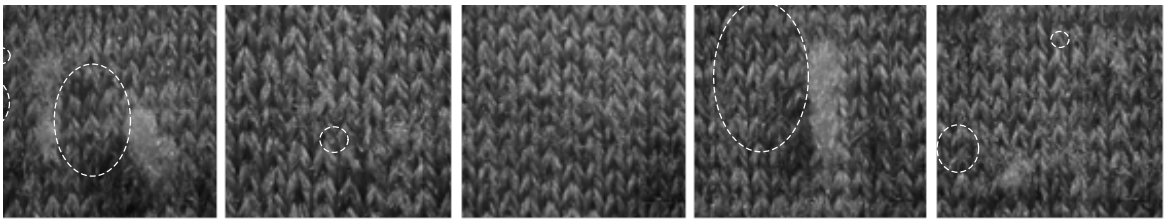
1) The average number of the pills generating in an area of 12×10 cm2 on two sets of cloths in warp and weft directions, i.e. 4 sheets, was employed in the evaluation by JIS L-1076-1992.

2) The number of the pills dropped out during test.

3) Comprehensive ranking judged from both the rank based on JIS method and the information on the numbers of pills.

3.1.2. Generation situation of the pill

Figure 1 shows the magnified photographs of untreated (grey) knit fabric and knit fabrics treated by 4 kinds of physicochemical processing. Some pills are seen on the surfaces of grey fabric, and the fabrics treated by resin and plasma, whereas no pill is seen on the surface of the fabric treated by NARS. Only some indication of generation of the pill appears on the surface of the fabric treated by chlorination processing.



∗ White dotted circle s represent shows the position and the size of Pill.

∗ The number of Pills fixed within the limits is referred to Table 2.

Figure 1: Photographs (in 35% of magnification) of fabric surfaces and the numbers of the Pills dropped out on the based of the basis of JIS method.

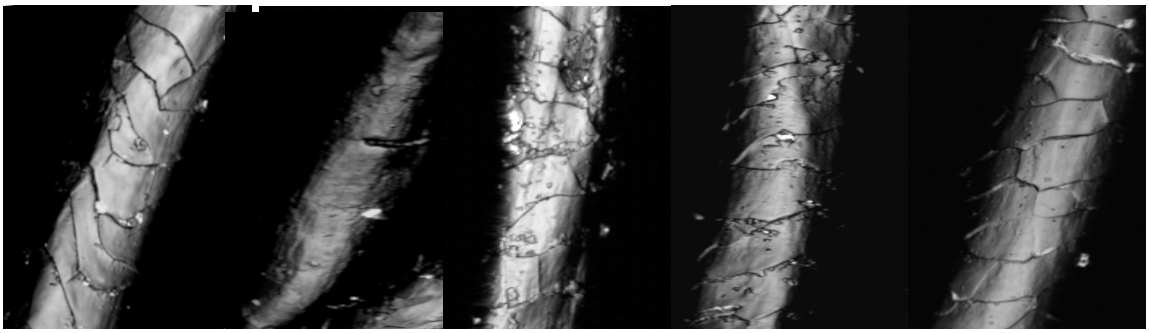


Figure 2: Photographs of the surfaces of the wool fibers without and with treated physicochemical processing.

Figure 2 reveals photographs of a single fiber taken by a 3D laser microscope equipped with extremely deep focus Keyence VK-8500. The single fiber was taken out of untreated (grey) fabric and the fabrics treated by 4 kinds of physicochemical processing. Scales on the surface of the fiber subjected to chlorination treatment are found to be completely removed, and only some trace of the scales is observed. There is almost no appreciable difference on the surfaces of the fabrics treated by resin and plasma, and the untreated fabric. On the other hand a little bit of scale remains on the surface of the fiber subjected to NARS treatment. But the scale is thinly worn away, and appears to make the scale and the fiber axis come closely into contact.

3.2. Unevenness of fabric surface, scale height and the number of the pill

Figure 3 shows the unevenness existing in between about 7 to 8 scales on the fiber surface or within about 100 μm in the longitudinal direction, namely, opening of the scale. The fibers subjected to observation were extracted from a grey fabric and the fabrics treated by 4 kinds of physicochemical processing. The unevenness was measured by means of a 3D laser microscope equipped with extremely deep focus, Keyence VK-8500. With chlorination treatment, scales are removed, and unevenness clearly lessens. NARS treatment lessens unevenness more, and the tip of the scale is found to be worn away.

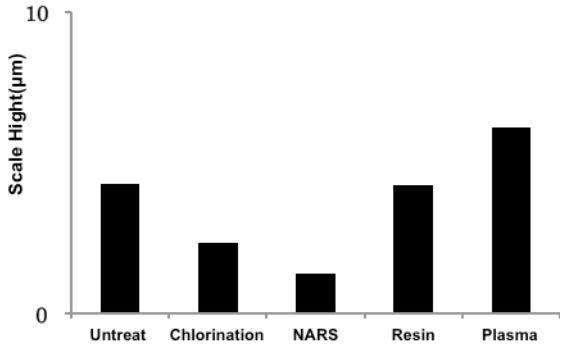


Figure 3: Scale height on the surface of the fiber subjected to each processing.

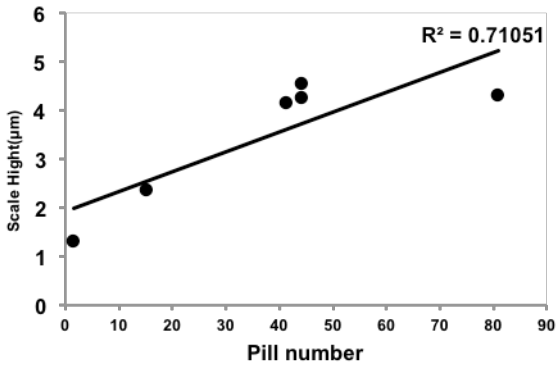


Figure 4: Correlation of scale height on the surface of fiber with the number of pills.

Next the relation of the number of pills on the surface of knit fabrics generating after pilling test executed, to the unevenness of scales on the fiber surface, namely, the state of opening of the scale was examined. Figure 4 indicates the relationship between these two factors obtained. The correlativity of the scale height with the number of pills is found to be high in that R2＝0.7105.

3.3. Tensile (Breaking) and bursting strength

Figure 5 shows tensile and bursting strength of the knit fabric. The knit fabrics used for evaluation of tensile and bursting strength were untreated knit fabric and 4 kinds of treated knits fabrics. This figure shows that the decrease in strength is the maximum in NARS-treated fabrics, and besides both kinds of strength in NARS-treated fabrics become lower than in untreated (grey) fabric.

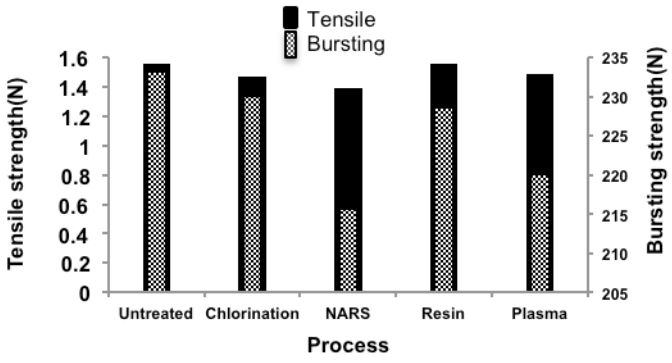


Figure 5: Tensile and bursting strength of the fabrics subjected to anti-pilling processing.

3.4. Handling

Total Hand Value(THV) was calculated from the basic physical properties on the basis of KES procedure for knitted fabrics treated with four sort of finishing processes. Calculated values of THV are shown in Figure 6. It is apparent that THV after NARS finishing amounts to 4.9 and the NARS finishing is superior in fabric handle.

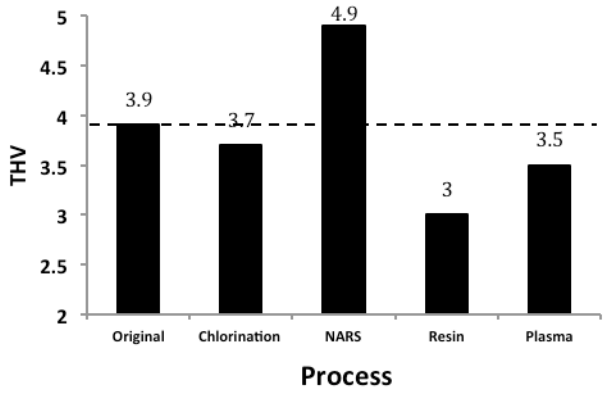


Figure 6: Comparison of THV each processed fabric.

4. CONCLUSION

It was confirmed that the anti-pilling nature for pure wool knit fabric could be improved by about 2 ranks by NARS finishing process. The feature of NARS treatment to wool knit fabric lies in low scale height, namely, close scale opening on the surface of the fabric, and the depression of the fabric strength. The depression of felt-shrinkage after hand-washing, and the dyeing nature, namely, dyeing intensity and iridescence of the treated fabric by NARS treatment can be markedly improved as compared to those of untreated fabric. Besides, the NARS finishing process is non-chlorine treatment and accordingly, the treated fabric still keeps a handling of the essential wool, as compared to the chlorination finishing process. Theoretically and clearly, there seems a close relationship between the generation of pills and the scale. If so, the chlorination treatment should be the best processing method from anti-pilling points of view. But actually NARS treatment was the best one instead of the chlorination in this work. Then, a special attention was paid to unevenness on the fiber surface after each processing. Now the unevenness on fiber surface is observed by means of Atomic Force Microscope (AFM), and is compared with each other. Besides, the selection of treatment agents and reinforcement agents to minimize the depression of the strength and to maximize the anti-filling nature is also the subject for a future study.

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BIOGRAPHY

Short biography of author 1

1. Born in 1929
2. Retired from a dyeing and finishing company in 1996 after 45 year's service
3. Established Mori Consultant Engineering Office just after retired
4. Got a Doctor Degree from Shizuoka University in 2006, Title of doctor thesis: Shrink-proofing of wool by low temperature plasma treatment
5. Now consultation service in and outside Japan

Hobby

Creation of original and novel fabrics for garments and picture appreciation

Short biography of author 2.

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Dr. Takako Fujimoto belonged to 1)Niigata University (1977-1981), and then has belonged to 2) Hokkaido University of Education (1992- at present) and has been professor since 1992. She has been i) Head, Japan Section of The Textile Institute of UK (2005-), ii) a member of council of TI, iii) a council member of Japan Research Association for Textile End-uses, iv) a visiting professor, University of University of New South Wales, Australia (1996.9-1997.3). Her major research areas in scientific achievement are a) theory of heat transfer of fibrous materials, b) mechanical properties and handle estimation of clothing fabrics, c) objective evaluation of clothing materials, d) durability of clothing materials. The number of her published original books is 5, of her published original papers and articles is around 130. She received three prizes and awards related to the above scientific achievements.

Objective Evaluation of the Sharpness and Stability of Deliberate Crease Lines and Pleats in Apparel Products

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Abstract: This paper describes the behaviour of deliberate creasing or pleating of apparel fabrics formed, for example, in skirts and trousers. In this study, woven fabric samples of two fibre groups were prepared. One is pure wool and woolblend-based group, and the other is vegetable and protein fibre-based fabric group (cotton, ramie etc.). The beauty or quality as measured in terms of the sharpness of creases of different fabric groups was evaluated.

Keywords: quality of creases and pleats, mechanical properties, sensory test, wool

1. INTRODUCTION

From ancient times people put on good appearance garments that have pleats or creases. The beautiful form of crease lines and pleats has been regarded as an essential appearance feature of trousers and pleated skirts. It is important for designers, textile manufactures and consumers to know the quality of creases and pleats, i.e. how sharp and stable the pleats or crease lines are going to be. In general the neat front and back crease lines of a pair of trousers and folding lines along the pleated skirts add elegance to people who like to dress well. Nowadays people have many kinds of clothing made from a range of fabric constructions and fibre types. Various aspects of creases and pleats have been studied for a long time; for example, crease recovery , crease sharpness with crease height and angle and washing stability.

The purpose of this study is to evaluate crease sharpness and beauty based on crease shape for a range of woven fabrics in different fibre types such as pure wool, wool blend, cotton, ramie, silk, polyester and nylon. A sensory test was carried out for the subjective evaluation of crease quality of these fabrics. Their low-stress mechanical properties such as bending and compression characteristics were measured on the KES-F system. Besides a

cross-section of their crease shape and recovery was observed by a light microscope and then angles and curvatures measured at the apex point of the creases.

2. EXPERIMENTAL

2.1 Subjective Crease Evaluation

Three samples of size 3 cm long (warpways) x 6 cm wide (weftways) were cut from each fabric. The weftways length contained 1 cm margin for a seam at each end (Figure 1). These samples were cut weftways to the margins into three test samples 1cm wide warpways. The weftways edges were joined together and sewn. At this stage, each sample of dimensions 1 cm warpways x 2 cm weftways was folded.

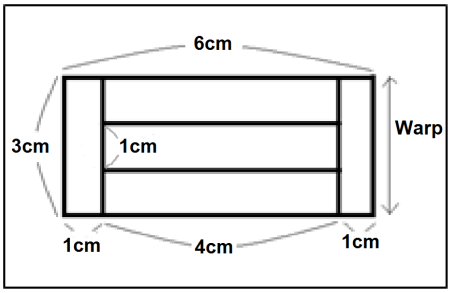

Fig 1: Sample size

These test samples were folded and pressed on a domestic steam iron for experiment A and also on a Hoffman steam press for experiment B. A domestic steam iron used was Sunbeam Model SR5400 type424 (1650-1800W, 230-240V, ~50Hz). Pressing temperature was about 200 degree and each sample was pressed for 20 sec. On Hoffman steam press, the test samples were pressed under steam pressure of 80 lb/in^2 for 10 sec which was followed by vacuuming for 10 sec. For observing crease stability, these samples were also open-steamed for 10 sec. After pressing and steaming, these samples were cut through the margins lines. Each of these pressed samples, with its crease-line placed on a thin stainless steel wire (diameter 0.45 mm), was let to recover for 5min under the standard conditions of 20-22 ^{o}C and 60-64% RH.

To take a photo of the cross section of samples, samples were suspended about their crease-lines on the wire for 5 min before taking their photographs. The camera used was Nikon D100 with Nikon Macro Speed Light SB-21. The sample used for this purpose was the middle of the three folded samples, 1 cm warpways x 2 cm weftways. Photographs of outlines of cross-sections of folded samples were then digitised using an image analysis method based on Coral Paint Shop Pro Photo (graphics software of Coral Corporation) and Open Source Computer Vision Library developed by Intel/Willow Garage. The outline is converted into numerals as (x,y) data by Graph Click (a digitizer shareware of Arizona Corporation).

To estimate the curvature of a crease cross-section outline, a quadratic equation was fitted to the line using the least square method. The curvature at the top of the crease, K, represents the curvature of the crease line.

2.2 Sensory Test

For subjective evaluation of various aspects of fabric crease, human *Kansei*, two human sensory tests were carried out. For Test A, five undyed, white fabric samples were used. These were fabrics of different fibre types such as wool, cotton, silk, ramie and polyester. For Test B, six samples were used, which were wool and wool/polyester types. Each sample was 10 cm x 10 cm.

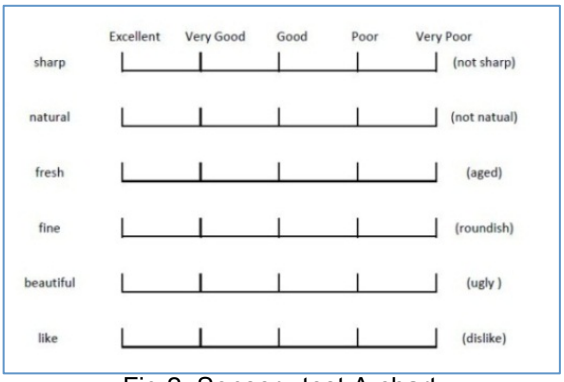

Fig 2: Sensory test A chart

To make a crease or folded line along the middle line of the sample, each sample was pressed by the domestic iron at 200 ^{o}C for 20 sec.

The evaluation method only allows assessors to observe, not allowed to touch the fabric samples. Eleven assessors or judges were used to grade the various fabrics for their different crease aspects in a standard conditioned laboratory (20-22 ^{o}C and 60-64% RH). Judges were not allowed to handle the fabrics. Evaluation charts used are shown in Figures 2 and 3. Figure 2 is a chart for Test A and Figure 3 is a chart for Test B.



Fig 3: Sensory test B chart

This is evaluated on a scale of 1 to 5. Grade 5 means that the sample has excellent sharp/ natural/ fresh/ fine/ beautiful/ formal look crease and is the most favourite. On the contrary, Grade 1 means that the sample has very poor crease, namely having not sharp/not natural/aged/roundish/ugly/casual look/dislike crease. Judges graded each fabric sample on these charts. Samples were presented in a tubular form, with its top edge in line with the eyes. After pressing, the top edge of each sample, with its crease-line running in the vertical direction, was wrapped and mounted on the top surface of a cylinder, leaving the bottom 80% of its length under zero or low tension.

2.3 Mechanical Properties

The low-stress mechanical properties were measured on the Kawabata Evaluation system for Fabrics, KES-FB. Samples were 20 cm x 20 cm size and conditioned under standard conditions, 20 ± 2 ^{o}C and 65% RH. Each sample was measured three times and the mean values of their mechanical parameters were calculated. The mechanical and physical properties considered in this study are summarized in Table 1.

Table 1. KES mechanical properties of fabric

Property	Parameter	Parameter	Unit
Bending	B2	Bending rigidity (weftways)	gf·cm^2/cm
	2HB2	Bending hysteresis (weftways)	gf·cm/cm
Compression	LC	Compressional linearity	-
	WC	Compressional energy	gf·cm/cm^2
	RC	Compressional resilience	%
	To	Thickness under 0.5 gf/cm^2	mm
	Tm	Thickness under 50 gf/cm^2	mm
Weight	W	Weight per unit area	mg/cm^2

2.4 Fabric Samples

Constructional details of experimental fabric samples are provided in Table 2.

Table 2. Fabric constructional details

Fabric	Fibre	Weave	Thickness (mm)	Fabric	Fibre	Weave	*Thickness (mm)
R1	100% ramie	Plain	0.575	W1	100% wool	Plain	0.370
R2	100% ramie	Plain	0.462	W2	100% wool	Plain	0.462
Rc	Ramie/cotton (weft: 100% ramie)	Plain	0.505	W3	100% wool	Plain	0.398
Rs	Ramie/silk (weft: 100% ramie)	Plain	0.447	W4	100% wool	2/1Twill	0.556
C1	100% cotton	Plain	0.422	W5	100% wool	Plain	0.496
C2	100% cotton	Plain	0.672	W6	100% wool	Plain	0.499
C3	100% cotton	Plain	0.540	W7	100% wool	2/1 Twill	0.490
S1	100% silk	Plain	0.319	W8	100% wool	2/1 Twill	0.457
S2	100% silk	Plain	0.378	W9	100% wool	2/1 Twill	0.536
S3	100% silk	Plain	0.325	W10	100% wool	2/1 Twill	0.505
P1	100% polyester	Plain	0.354	W0	100% wool	Plain	0.397
P2	100% polyester	Plain	0.206	N1	100% nylon	Plain	0.164
BW1	Wool/bamboo (weft: W 54, B 46%)	3/1 Twill	0.599	BW2	Wool/bamboo (weft:W54,B46%)	3/1 Twill	0.552
SW1	Wool/silk (weft:W83.3,S16.7%)	Satin	0.533	SW2	Wool/silk (weft: W 100%)	Satin	0.552
WN1	Wool/nylon (weft: W90, N 10%)	Plain	0.858	WN2	Wool/nylon (weft:W80,N20%)	2/1 Twill	0.680
WP1	(weft: W 80, P20%)	Plain	0.446	WP2	Wool (weft:W 80,P20%)	2/1 Twill	0.549

3. EVALUATION OF FABRIC AREA

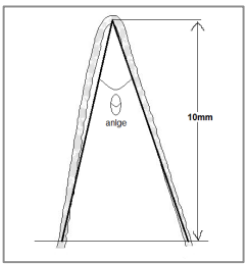

Fig 4: Angle θ

In this study of fabric crease evaluation, we focused not only on the crease angle θ (Figure 4) but also on the shape of the crease at and around the crease-line. From the observation of crease sharpness and crease recovery of various fabrics, we found that even though some fabrics had similar crease angle (~±2°), they did not have same shape at and around the top of their crease. Crease angles of some samples recovered by steam did not sharp line to more roundish. Consequently only the crease angle change after steaming but their crease shapes at and around the top of the crease had significantly changed, for example from measurement is not sufficient to characterise the different crease shapes before and after crease relaxation or recovery. In order to express the shape of the top of the crease (cross-section of the crease-line), we measure the curvature at the top point of the crease and this value is denoted as *K-out*. The method for estimating *K-out* is mentioned above in section (2.1).

Figure 5 shows that there are a number of fabric samples which have similar crease angles but significantly different curvatures, for example, fabrics P1 and P2 as shown in Figure 6. Therefore, both the parameters, crease angle and crease curvature are required to describe

the crease shape adequately.

Figure 7 shows the graph between the values of crease angle θ and *K-out* of pressed creases of various fabric samples before and after open steam relaxation. An inspection of this graph reveals three different types of crease recoveries based on fabric construction and properties. The first type results in change in crease angle only. The second type results in change in both crease angle and crease curvature, and the third type involves change in crease curvature only.

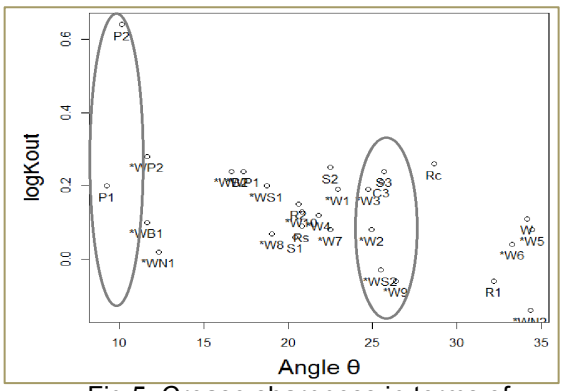

Fig 5: Crease sharpness in terms of crease angle θ and curvature *K-out*

Figure 8 shows photographs of the crease shape of the fabric after pressing (top) and after pressing and open steaming (bottom). It can be seen that the steam relaxation did not cause much change in the crease angle but caused a large change in the curvature at the top of the crease. It is evident that only the crease angle parameter is not enough to measure the crease stability or changes in the crease shape due to relaxation, for example by open steaming. The curvature at the top of the crease, *K-out*, can describe the shape of the top point or surface before and after relaxation.

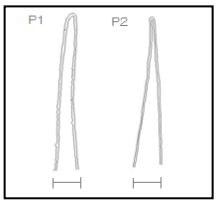

Fig 6: Fabrics P1 and P2 showing similar angles but significantly different curvatures

Crease angle θ is already defined in Figure 4 above. Curvature *K*-out defines the curve shape just at the top point of the crease. In addition to these crease parameters, the crease linearity, *CL*, is also important to describe the crease shape. The crease linearity means how straight or curved the outline of the crease is. This value is based on the area under the crease at 5 mm height from the top of the crease, and integrated between both sides of the crease outline as shown in Figure 9.

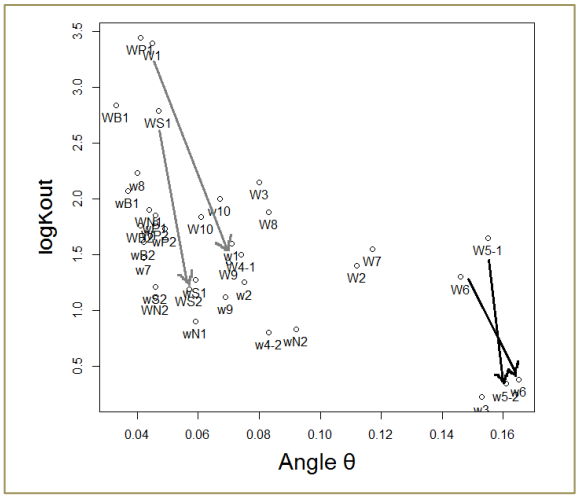

Fig 7: Crease recovery due to open steaming

Let A_s be the area under the straight crease outline (averaged for left and right hand sides), A_c be the area between the curved and straight outlines (averaged for left and right hand sides)

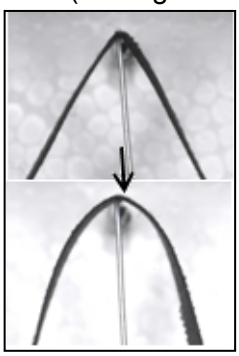

Fig 8: Photographs showing change in crease curvature

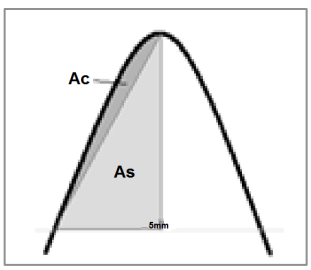

Fig 9: Crease linearity due to open steaming

and A_t be the total area under the crease curve where

$$A_t = A_s + A_c. \quad (1)$$

Then crease linearity

$$CL = A_t / A_s$$
$$= (A_s + A_c) / A_s \quad (2)$$

For a completely straight line crease outline, $A_c = 0$, and, therefore, $CL = 1$. For a concaved outline, $CL > 1$. As CL increases, the crease shape becomes more roundish and curved outside.

Correlation coefficients among these values are as follows; between Angle θ and *K-out*: -0.446, between *K-out* and *CL*: -0.029, and between Angle θ and *CL*: -0.540 (significance level is 0.01). These are not strong correlations. Therefore, these crease parameters differ from one another and are independent.

4. RESULTS AND DISCUSSION

4.1 Comparison between sensory and objective evaluations

An objective of the sensory test A is to subjectively grade a range of fabrics, produced from different fibre types, for the various characteristics of the crease as mentioned in section 2.2. The results of sensory test A are given in Table 3 and are graphically presented in Figure 10 .

Values of Spearman's correlation coefficient (ρ) were calculated to determine the level of agreement in the rankings between two different crease characteristics such as sharpness and beautiful (Table 3).

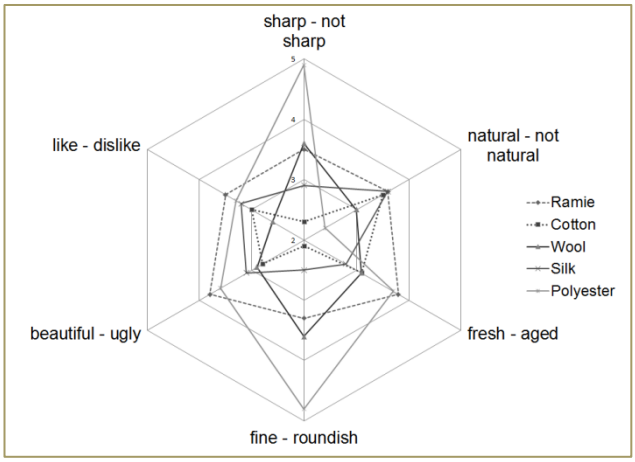

Fig 10: Subjective evaluation for fabrics of different fibre types

Results showed that fabrics having excellent sharp crease also have excellent fine crease (ρ=0.99) but these tend to look unnatural (ρ =-0.67). "Beautiful", "like" and "fresh" characteristics of the crease show high correlation between one another, as expected. Polyester, ramie and wool fabrics have very sharp creases but ramie fabric's crease gave the judges an impression of a natural looking crease. Creases of ramie, cotton and silk fabrics look more natural by comparison with those of wool and PET fabrics.

The results of sensory test B conducted on wool and wool/polyester fabrics are shown in Table 4. An objective of this sensory test B is to identify the human feeling differences between various crease characteristics of 100% wool and wool/polyester blended fabrics which contain 20% polyester in weft yearn.

Table 3. Spearman's correlation coefficients for sensory tests A and B

	Test A						Test B					
	(a)	(b)	(c)	(d)	(f)	(g)	(a)	(c)	(d)	(e)	(f)	(g)
(a)Sharp-not sharp	1.00	-0.67	0.46	0.99	0.50	0.20	1.00	0.16	0.99	0.90	-0.26	-0.23
(b)Natural-not natural	-	1.00	-0.16	-0.67	0.21	0.31	-	-	-	-	-	-
(c)Fresh-aged	-	-	1.00	0.46	0.67	0.67	-	1.00	0.26	0.17	0.66	0.40
(d)Fine-roundish	-	-	-	1.00	0.50	0.20	-	-	1.00	0.94	-0.12	-0.09
(e)Formal-casual look	-	-	-	-	-	-	-	-	-	1.00	-0.06	0.03
(f)Beautiful-ugly	-	-	-	-	1.00	0.90	-	-	-	-	1.00	0.93
(g)Like-dislike	-	-	-	-	-	1.00	-	-	-	-	-	1.00

Values of Spearman's correlation coefficient show that the fabrics that are adjudged to have an excellent sharp crease also have a crease that is fine (ρ=0.99) and has formal look (ρ=0.90). "Fresh" and "beautiful" characteristics of the crease are also positively correlated (ρ=0.66), but there is no tendency that "sharp" crease is also "beautiful". From their principal component analysis, this sensory evaluation data resulted in two crease types. One relates to crease sharpness and the other relates to crease beauty. Crease sharpness components are "sharp – not sharp", "fine - roundish" and "formal – casual look". Beauty components are "fresh - aged", "beautiful - ugly" and "like - dislike".

Table 4. Mean grades for various crease characteristics for sensory tests A and B

Crease characteristic (Grade 5 to 1)	Test A					Test B					
	Ramie	Cotton	Wool	Silk	PET	W1	W2	W3	W4	W/P1	W/P2
Sharp-not sharp	3.5	2.3	3.6	2.9	4.9	3.36	4.55	2.36	3.09	4.55	4.27
Natural-not natural	3.6	3.5	3.0	3.6	2.4	-	-	-	-	-	-
Fresh-aged	3.8	3.1	3.1	2.8	3.7	3.64	3.73	3.18	3.45	3.18	3.00
Fine-roundish	3.3	2.1	3.6	2.5	4.8	3.27	4.09	2.73	2.91	3.45	3.91
Formal-casual look	-	-	-	-	-	3.09	4.27	2.27	2.73	3.82	3.73
Beautiful-ugly	3.8	2.8	2.9	3.1	3.6	3.27	3.73	3.45	3.45	2.91	3.09
Like-dislike	3.5	3.0	2.6	3.2	3.3	3.18	3.82	3.45	3.36	2.82	3.27
Total grade points	21.5	16.8	18.8	18.1	22.7	19.8	24.2	17.4	19.0	20.7	21.3

Table 5 shows correlations between the results of sensory and objective tests. It can be seen that crease sharpness correlates better with curvature *K-out* than crease angle. This means crease sharpness discriminated by human sense relates to the top point of the crease which can be represented by curvature *K-out*. Also crease sharpness correlates well with thickness T_0 which is measured at pressure 0.5 gf/cm^2 and T_m which is measured at pressure 50 gf/cm^2. In particular, wool and wool/polyester fabrics have very high correlation coefficient between crease sharpness and T_m. When crease freshness is related with crease linearity, *CL*, we find that fabrics of different fibre types in Test A having high

freshness value tend to have high *CL*, but for Test B wool and woolblend fabrics, fresh creases tend to be negatively correlated with *CL*. Also positively/negatively of correlation between angle *θ* and *K-out* are showed opposite one. It means among various fibre-based fabrics, evaluation of "fresh" is focused at fabric stiffness and crease sharpness. On the other hand, among wool and wool-blended fabrics, no matter whether the crease is sharp or not, high linearity, which means straight line crease, makes an impression of a "Fresh" crease. In addition, "Beautiful" and "Sharp" characteristics do not correlate well with each other. It means it is not always the sharp crease that is beautiful crease for human sense.

Table 5: Correlation coefficients between subjective and objective evaluations of crease

Crease characteristic	Test	Angle *θ*	*K-out*	*CL*	T_o (mm)	T_m (mm)
Sharp - not sharp	A	-0.62	0.78	0.43	-0.80*	-0.69
	B	-0.48	0.70	0.38	-0.69	-0.90***
Fresh - aged	A	-0.68	0.45	0.91*	0.73	0.65
	B	0.77	-0.52	-0.86*	-0.61	-0.14
Beautiful - ugly	A	-0.72	0.43	0.94*	-0.38	-0.19
	B	0.42	-0.47	-0.58	-0.29	0.20

(Significance level: *: p<0.05, **: p<0.02, ***: p<0.01)

4.2 Crease Stability

Crease stability means stability of crease under effects of conditions such as: elapsed (recovery) time, open steaming, washing etc. Three crease shape parameters, namely, Angle *θ*, *K-out* and *CL*, which are independent in nature, have been defined to express the crease shape. Changes in their values affect the change in the area under the inside of the top of the crease. In this study, crease stability is determined by considering changes in the area due to steam relaxation. This area is the area inside the outline of the crease between the top and the height 3 mm as shown in Figure 11.

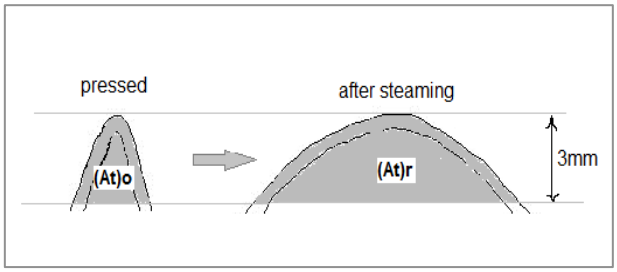

Fig 11: The crease stability

For this study, experiment B was carried out, which has been described in section 2.1 above.

Let total area before steam relaxation = $(A_t)_o$
and, total area after steam relaxation = $(A_t)_r$

Then,

$$\text{crease stability (\%)} = 100 \times [\, 1 - \{(A_t)_r - (A_t)_o\} / (A_t)_r \,] \qquad (3)$$

This crease stability based on the area can be represented by a multiple regression function in terms of Angle *θ*, *K-out* and *CL* as follows. This function is derived by using a multiple regression analysis.

$A_t = f\,(\,\theta,\, K\text{-}out,\, CL)$

$$= a_0 + a_1 \text{ Angle } (\theta/180) + a_2 \log(K\text{-}out) + a_3 \ CL \qquad (4)$$

where

a_0 =17.6599, a_1 = -2.3786, a_2 = 12.7740, and a_3 = -9.5141.

Regression equation (4) gives a good fit as indicated by R^2 value of 0.833 (R^2 (adjusted) 0.826 and p-value is infinitesimally small).

The results of crease stability as calculated by using Equation (3) are shown in Figure 12. When there is no change in the crease shape due to steam relaxation, the crease stability is equal to 100%. Lower the % crease stability, poorer the crease stability or larger the loss in the crease characteristics such as sharpness. Crease stability of over 100% means the crease has become sharper and of higher curvature, and therefore, of smaller A_t due to steaming. This peculiar behaviour is exhibited by fabric samples W7 and W8 probably due to their high density, W/T, (Figure 13) and high drapability, which on steam relaxation makes them droop downwards.

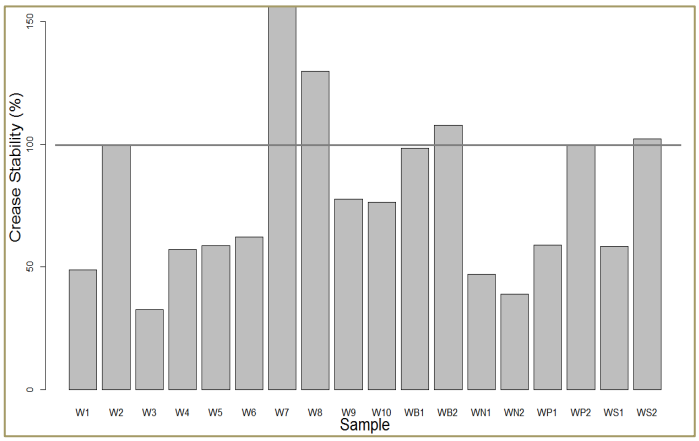

Fig 12: Crease stability for various wool and wool/polyester fabrics

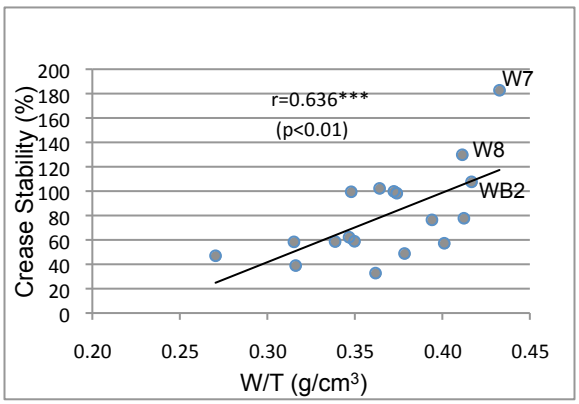

Fig 13: Relationship between crease stability and fabric density

5. SUMMARY

When a fabric is creased or pleated, the crease takes one of the various shapes depending on fabric construction and finish, pressing and steam setting conditions. To express the crease shape, only the crease angle is not enough; the characteristics crease curvature and linearity are also needed. In human sensory evaluation, the results for crease sharpness correlate better with the curvature than the angle. For both fabric groups, i.e. the fabric group based on different fibre types, and the other based on wool and woolblend fabrics, the evaluation of "Fresh" crease characteristic is found to be dependent on different objective values, namely θ, *K-out*, and *CL*. In addition, "Beautiful" and "Sharpness" crease characteristics do not always correlate with each other. Crease stability based on the area under the crease expresses the stability of the crease very well. We can explain variations in the stability of the crease shape in terms of changes in angle θ, curvature *K-out* and linearity *CL*.

This study used a limited range of fabrics in terms of thickness, considering mainly thin fabrics. In order to generalize our research findings, we will now extend the research further to fabrics of other yarn types and of a wide range of thickness. However, the present study provided a good insight into the fabric crease behavior, crease shape characteristics and crease relaxation.

ACKNOWLEDGMENTS

We would like to thank the AgResearch staff who helped us with the sensory testing and technical support. Rino Ouchi is thankful to AgResearch for hosting her as a visiting research scholar and to Dr Surinder Tandon for supervision at AgResearch. We are thankful for, Mr. C. Murata's technical support. He is an engineer at KATO-TECH Co., LTD.

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BIOGRAPHY

Rino Ouchi is a Master course student of Hokkaido University of Education. She studies about clothing materials and apparel sciences. Bachelor's degree thesis was *Control of Wool Fabric's Kansei by Various Finishing Methods*.

Dr. Takako Fujimoto belonged to 1)Niigata University (1977-1981), and then has belonged to 2) Hokkaido University of Education (1992- at present) and has been professor since 1992. She has been i) Head, Japan Section of The Textile Institute of UK (2005-), ii) a member of council of TI, iii) a council member of Japan Research Association for Textile End-uses, iv) a visiting professor, University of University of New South Wales, Australia (1996.9-1997.3). Her major research areas in scientific achievement are a) theory of heat transfer of fibrous materials, b) mechanical properties and handle estimation of clothing fabrics, c) objective evaluation of clothing materials, d) durability of clothing materials. The number of her published original books is 5, of her published original papers and articles is around 130. She received three prizes and awards related to the above scientific achievements.

Dr. Surinder Tandon

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Dr Surinder Tandon is Senior Scientist at AgResearch Ltd where he has been working for 25 years. He specialises in textile technology, structural mechanics, objective measurement technology, technology transfer and commercialization. His current interests are in development of new fit-for-purpose woven and knitted apparel wool products including active sportswear and next-to-skin apparel, and functional interior textiles; development of sustainable wool textile processes and products.

Surinder has B.Text (Hons) from TIT Bhiwani, M.Tech from IIT Delhi and PhD from Leeds University. He is Fellow of the Textile Institute and recipient of 2011 Institute Medal of the Textile Institute. He has 70 publications.

Machiko Murakami graduated the master course of Nara Women's University in 1978 and belonged 1) Kobe Gakuin Women's College (1978-1979), 2) Mimasaka Women's University (1978-1983) and has belonged 3) Gifu City Women's College (1988-at present) and has been professor since 2007. Her major research areas in scientific achievement are 1) mechanical properties and handle estimation of clothing fabrics, 2) objective evaluation of clothing materials and 3) mechanical properties of bi-fabrics related to clothing silhouette.

Dr. Masukuni Mori

1. Born in 1929
2. Retired from a dyeing and finishing company in 1996 after 45 year's service
3. Established Mori Consultant Engineering Office just after retired
4. Got a Doctor Degree from Shizuoka University in 2006, Title of doctor thesis: Shrink-proofing of wool by low temperature plasma treatment
5. Now consultation service in and outside Japan

KEER2014, LINKÖPING | JUNE 11-13 2014
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A New Analysis Method for the Drape Shape of Fabric

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Abstract: A new method of the analysis of drape-ability of fabrics using Fourier descriptor is proposed. Drape-ability is conventionally evaluated by measuring the drape coefficient related to mechanical property of fabrics. However, it was pointed out that the visual appearance of drapes was not always related to the drape coefficient. Recently, a method of the direct characterization of the visual appearance of drapes using Fourier power spectrum was proposed. In this paper, it is proposed that the G-type Fourier descriptor, which is an expansion of a closed curve to a Fourier series, is employed for drape analysis. The proposed method achieves not only the characterization of drapes but also the circular abbreviation of drape shapes and selective reconstruction of vibrations based on their frequencies.

Keywords: drape analysis, image processing, Fourier descriptor,

1. INTRODUCTION

Drape-ability of a fabric is a characteristic yielding an unevenness on the surface of the fabric when it is hung down by its own weight. It is an important characteristic that is highly affective to visual kansei on the silhouette of dresses. A number of investigation has discovered that drape-ability is closely related to bending stiffness, shear properties, weight, and thickness of fabrics (Kawabata and Niwa, 1989; Dhingra et al., 1989). There is a discussion whether drape-ability should be evaluated in static status or its dynamic properties should be evaluated (Matsudaira et al., 1993).

The drape coefficient is a three-dimensional static evaluation which is widely used as a quantitative evaluation of drape-ability. When a sample of a curicular fabric is hung down from a cylinder top, the drape coefficient is defined as $(S_2 - S_0) / (S_1 - S_0)$, where S_0 is the area of the sample table, S_1 is the area of the sample, and S_2 is the area of the vertical projection of the sample, i. e. the area of the drape shape. It is a standard method in the textile science to use the

drape coefficient of fabric in order to evaluate the drape-ability of the fabric. The conventional studies for drape coefficient have often focused on its accurate calculation methods or on its relationship with the mechanical properties (Sanad et al., 2012; Sanad et al., 2013).

However, Mizutani et al. pointed out that fluctuations in the traced contour line of fabric drape are different even when they showed the same value in the drape coefficients (Mizutani et al., 2005). It indicates that the drape coefficient does not always agree with the visual impression. Dhyr et al. proposed a new evaluation method that did not use the ratio of areas such as the drape coefficient but employed statistical abbreviations of the number and sizes of vibrations appearing on an actual fabric and showed relationships to the mechanical properties (Shyr et al., 2009).

Recently, a method of directly analyzing the visual appearance of drapes using Fourier transformation was proposed (Sanad et al., 2012; Sanad et al., 2013; Kokas-Palicska et al., 2008). This is an attracting method utilizing the progress of digital image processing. However, the method only uses the Fourier power spectrum as a general characteristic of a drape.

In this paper, we propose a novel method employing the G-type Fourier descriptor, which decomposes a closed curve into a series corresponding to the frequencies and amplitudes of waves composing the curve, for the analysis of the curves obtained by the measurements of drape-ability. The method generates the average circle of the curve, and generates simplified curves by selecting the frequency of vibrations for observing the characteristics of the vibrations precisely. We apply the method to several kinds of fabrics, and show the relationship between their visual appearance of drapes and their characteristics yielded by the proposed method.

2. G-TYPE FOURIER DESCRIPTOR

Fourier descriptor is a method of expressing characteristics of curves by transforming a curve into a function in some way and decomposing this function into a combination of waves by Fourier analysis. Fourier descriptor has been widely used as a method for feature extraction in pattern recognition problems such as hand-written character recognition. Fourier descriptor is categorized into several types based on the transformation method of a curve into a function. We employ the G-type Fourier descriptor (Granlund, 1972) in this study.

The G-type Fourier descriptor assumes that the target closed curve is on the complex plane. A starting point on the curve is fixed, and we define a function that assigns a complex number $x + yi$ to the length along the curve between the starting point and the point (x, y) . This function is periodic, since it is composed by tracing the closed curve from a point. A periodic function is expressed as a Fourier series, i. e. a series of exponential functions corresponding to sinusoidal waves whose wavelengths are $1 / n$ $(n = 1, 2, \ldots)$ of the period of the original periodic function, and the complex amplitude of the wave of each wavelength is expressed as a Fourier coefficient. A partial sum of the terms where the corresponding wavelengths are longer than a certain value, i. e. the frequencies are lower, yields a simplified curve where vibrations of higher frequencies are removed.

Since the contour of the edge of a fabric is a closed curve in the measurement of drape-ability, the G-type Fourier descriptor can be applied to the analysis. We can obtain a circle that is the



(a) (b) (c)

Figure 1: Experimental setup.

Table 1: Profiles of the samples.

Sample No.	**a** (W1)	**b** (C3)	**c** (C1)
Material	Wool 100%	Cotton 100%	Cotton 100%
Structure	Plain Wave	Plain Wave	Plain Wave
Thickness (mm)	0.473	0.670	0.325
Weight (mg/cm^2)	17.03	16.08	7.58
Bulk Density (g/cm^3)	0.360	0.240	0.236
Density			
Warp	21.3	21.3	40.0
Weft	19.0	18.0	36.0
Yarn Count			
Warp T	40.6/2	41.5	8.5
Warp S	26.4/2	14.3	69.7
Warp T	39.2/2	34.0	11.9
Warp S	25.5/2	17.4	49.7

average shape of the drape, and we can extract the vibrations of the drape in the order from lower frequencies to higher ones.

Since the pixels are discretely arranged in actual digital images, the Fourier series is obtained by the discrete Fourier transformation of a sequence of complex numbers generated by tracing pixels on the curve and finding the corresponding complex numbers. The inverse Fourier transformation of a part of Fourier coefficients yields the partial sum of the Fourier series, i. e. a simplified curve.

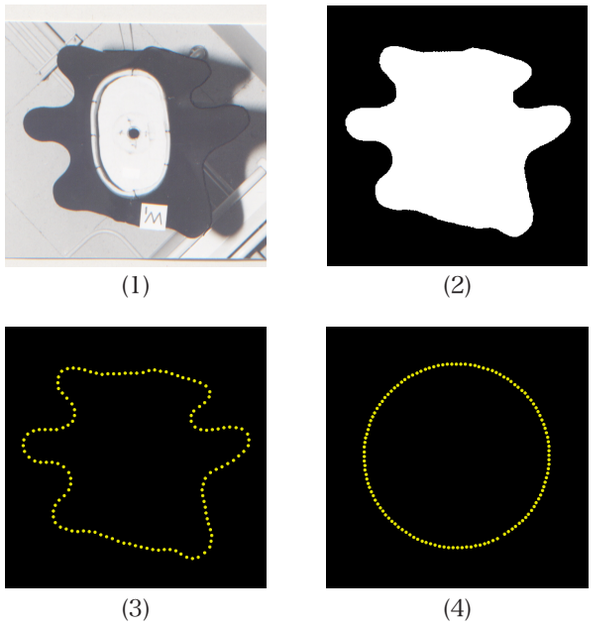


Figure 2: Drape and Fourier descriptor.

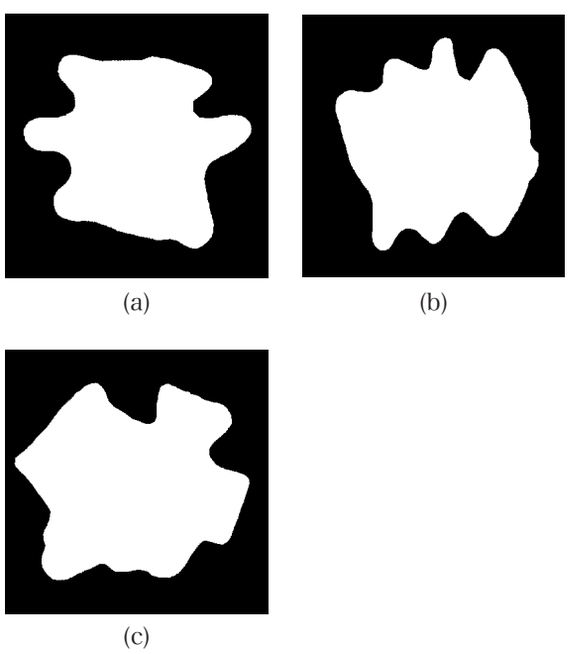


Figure 3: Examples of drapes.

3. EXPERIMENTS AND RESULTS

Figure 1 shows the employed hanging method for the analysis and evaluation of fabric drape in this paper. Table 1 shows the profiles of sample fabrics used for the experiment. The samples (a) and (b) show almost the same fabric weight (mg/cm2), while the former is a wool fabric and the latter is a cotton fabric. The sample (c) is another cotton fabric which show different fabric weight.

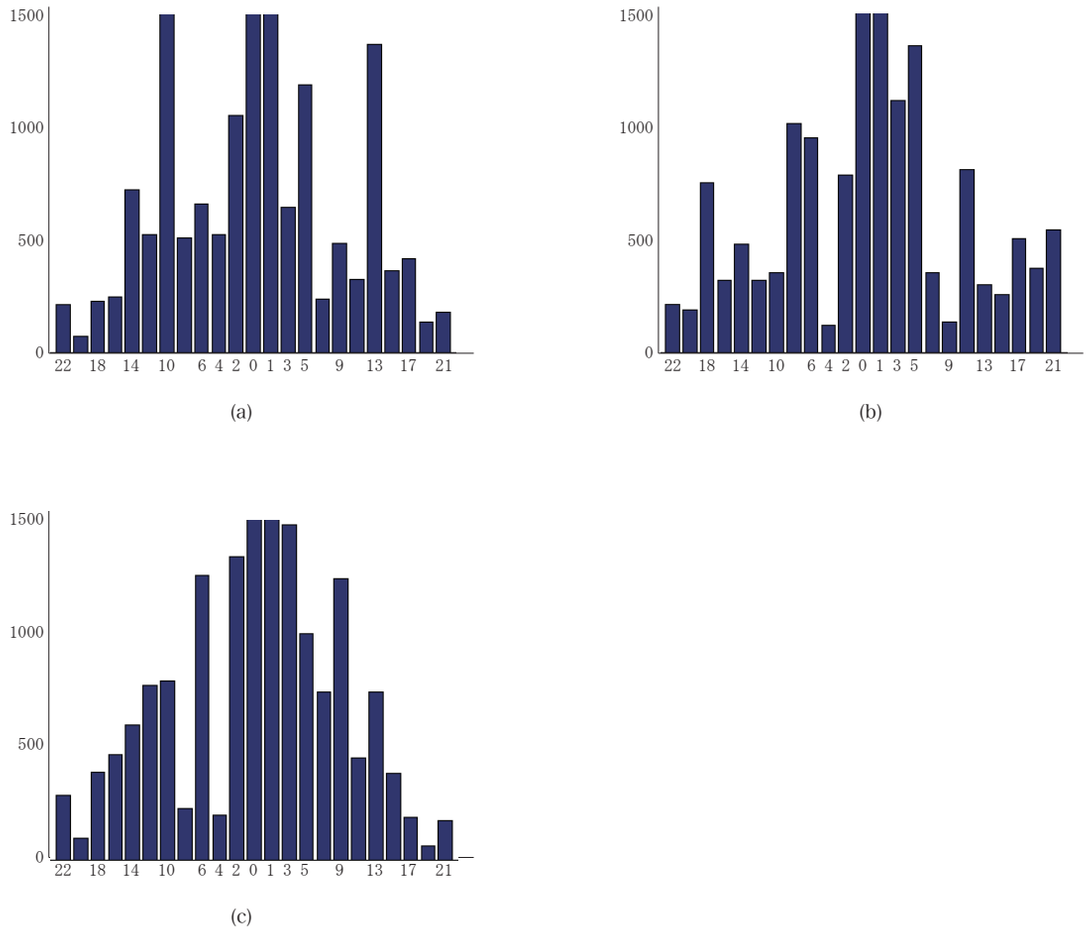
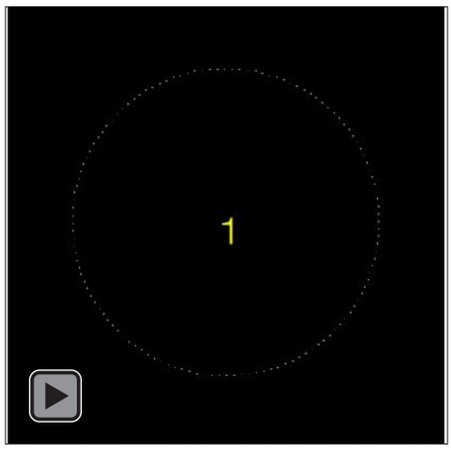


Figure 4: Fourier spectra. The horizontal axis indicates the order of the components, and the vertical axis indicates the absolute values of the intensities.

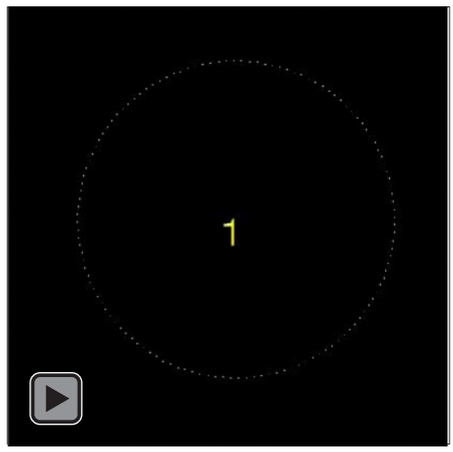
The sample fabrics shaped in gathered skirts were worn on a torso of standard woman's size instead of hanging down from the cylinder-shaped sample stage like a drape tester. This method allows us to evaluate the fabric drape properties of practical skirt directly. The images of cross sectional drape shapes were captured from the lower part of the torso with a hung down skirt, shown also in Fig. 1, and were analyzed for the drape properties of fabrics.

Figure 2 (1) shows an example of a drape of a fabric obtained by the method using this method. Figure 2 (2) shows the binarized image obtained by extracting the contour and its inside manually. The G-type Fourier descriptor was obtained by automatically tracing the contour and assigning 128 points. Figure 2 (3) shows the result of the inverse Fourier transformation using all the 128 Fourier coefficients. The images obtained by all the Fourier coefficients restores the original curve by a sequence of points. Note that the points on the restored images are enlarged and emphasized in color, in order to be visible even when the image sizes are reduced. Figure 2 (4) shows the restored curve by the 0th coefficient, which is a constant term, and the 1st coefficient only. It is the averaged circle of the original curve, and the vibration can be measured by overlapping this circle and the original curve in a manual measurement.

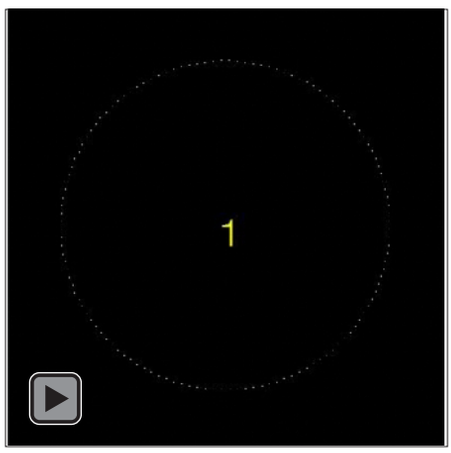
Figures 3 (a)-(c) show the contours extracted from the drapes yielded by the experimental



(a)



(b)



(c)

Figure 5: Reconstrution processes.

setups in Figs. 1 (a)-(c), respectively. Figures 4 (a)-(c) show the absolute values of the Fourier coefficients, which correspond to the square roots of the Fourier power spectra, of the contours in Figs. 3 (a)-(c), respectively. The vertical axis is truncated, since the 0th and 1st coefficients, which compose the averaged circle, are extremely larger than the other components. Each component corresponds to a periodic wave along the circle; the larger the order is, the higher the frequency of the wave is. The 0th component is centered, and the odd-ordered components are on the right side, and the even-ordered ones are on the left. Note that the components are not symmetrical since they are the Fourier transformations of complex functions.

Figures 5 (a)-(c) show animations of the reconstruction process of Figs. 3 (a)-(c), respectively, by appying the inverse Fourier transformation to all the coefficients of lower orders than each specific number. The number is indicated at the center. The animations are Flash movies and can be shown by Adobe Acrobat 9.0 or later and a Flash player. It is recommended to magnify the document to obtain sufficient visibility.

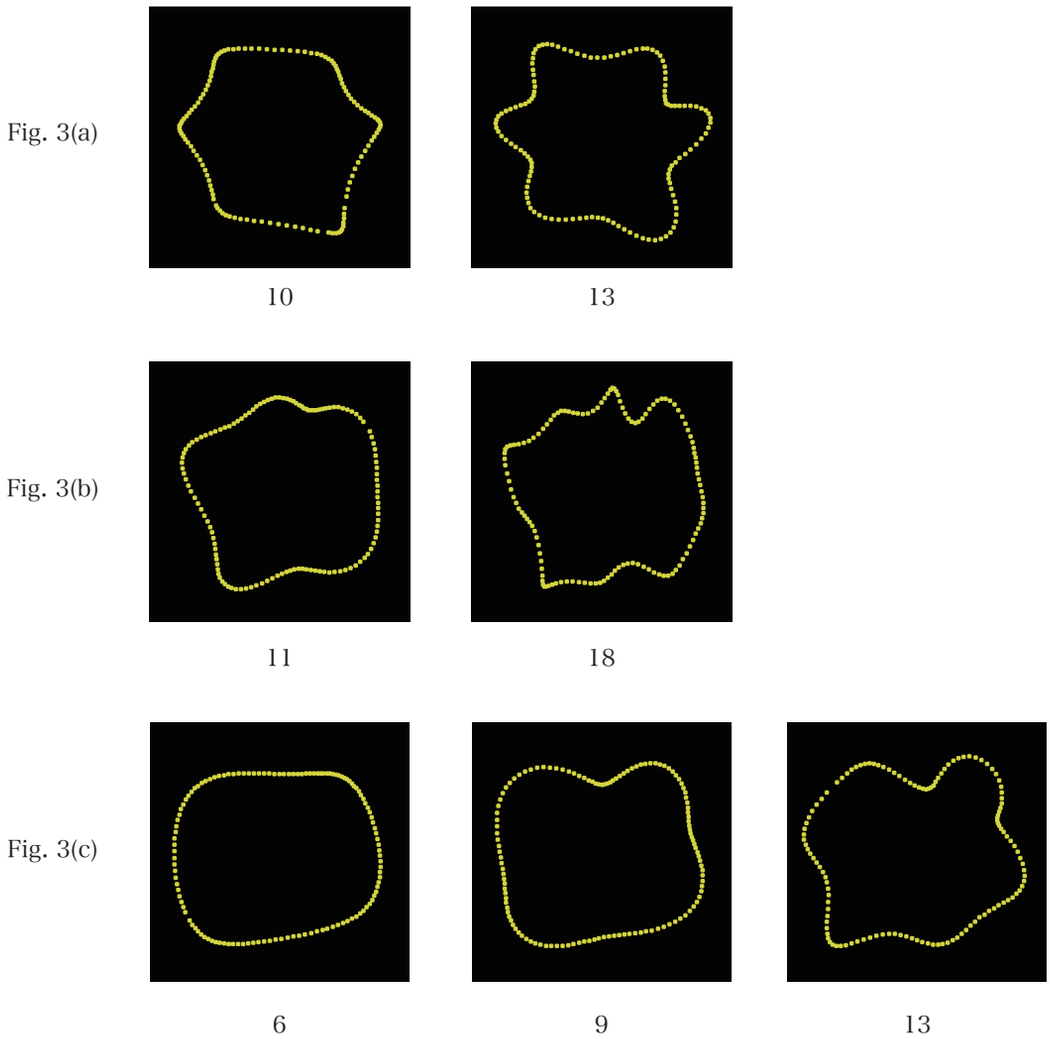


Figure 6: Characteristic shapes reconstructed by the inverse Fourier transformations.

Figure 6 shows partial reconstructions by the inverse Fourier transformations applied to a prominent component and all the components of the lower orders. Each row of Fig. 6 corresponds to each of the images shown in Fig. 3. The number shown under each image indicates the maximum order of the components. The images in Fig. 6 indicate that a prominent coefficient corresponds to a reconstruction of characteristic shape of the images.

4. DISCUSSION

The Fourier power spectra shown in figure 4 indicate that the strong feature of the sample (a) of wool fabric shows relatively long periodic waves, as the components of lower orders such as 5, 10 and 13 show highly prominent intensities.

While the relatively long periodic wave of the sample (b) of cotton fabric, whose weight is similar to the sample (a), shows moderate intensities in the components of lower orders but less than wool fabric, while prominent peaks appear in higher orders such as 18 and 21. It indicates short

periodic waves are another remarkable characteristics of this fabric. In the case of the sample (c) of the cotton fabric in the lighter weight, the prominent component does not clearly appear in higher orders. It indicates that significant wave does not clearly appear on this fabric.

The sample (b), which has more remarkable characteristics in higher orders indicating waves of higher frequency, showed higher softness in visual impression than the sample (c), according to the visual evaluation of cotton fabrics in another experiment. The above results show the usability of the suggested analysis method in this paper for characterizing the drape properties of fabric relating with visual evaluations directly.

5. CONCLUSIONS

This paper has proposed a method of the measurement of drape-ability by regarding the contour composed by edge of a fabric as a closed curve and describing vibrations of the closed curve using the G-type Fourier descriptor. The method enables quantitative expression of visual characteristics of drapes. It yields the average circle of the contour and the restorations of simplified curve by selecting the frequencies of vibrations in the contour. We are now planning to analyze drapes of various fabrics using this method.

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BIOGRAPHY

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Environmental Effect on Emotion in Waiting Areas Based on Kansei Engineering and Affective Neuroscience

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Abstract: In general, for health care centers it is vital to know the kind and the intensity of emotions felt by its patients and how to influence their quality of life and their response to therapies. In particular, waiting areas in which patients spend a lot of time without significant interactions is an important focus of this study. Recent studies suggest that a quality in fact and in perception is two significant parts, which affect and play a powerful role in an overall satisfaction in health care. The aim of this study is to understand how to increase positive and decrease negative emotions by a re-design of waiting areas inside health care centers where patients spend a considerable amount of time without any significant interactions. To measure the quality of satisfaction felt by patients inside of such an environment we refer to their emotions that we model basing on Affective Neuroscience. According to Panksepp, we have a categorized and unambiguous number of emotions, precisely defined from a neuroscientific and physiologic point of view: SEEKING, PLAY, CARE, FEAR, GRIEF, RAGE and LUST. We collect Kansei words and structure them with these emotions. We perform 600 surveys on 200 patients in 4 different waiting areas found in 2 hospitals to reveal differences in perceptions. We conduct experiments and our results lead us to several considerations about how to design desirable emotional characteristics of a waiting area.

Keywords: Waiting Areas, Health Care, User Experience, Primary-Process Emotions, Kansei Engineering.

1. INTRODUCTION

Among numerous features, quality of healthcare is affected by several factors such as context and condition of environment and behavior of personal factors and patient (Irurita, 1998). More recently, a growing body of evidence is suggesting that the environmental design of healthcare centers influences the quality of care. As suggested by Omachonu (Omachonu, 1990), the quality of care involves an increase in desirable and reduction in undesirable patients' outcomes. However, quality of care is an ambiguous term, which can refer to its two constituents: quality in fact and quality in perception. Patients' perception plays a critical role in their satisfaction with healthcare (Devlin and Arneill 2003; Omachonu, 1990). Arnel and Devil also argued that the quality of care perceived by patients is considerably associated with the amount of empathy, warmth, and friendliness that the patient experiences. Namely, Winkel states that an environment does convey empathy and warmth even before the patient interacts with the staff. The environment's overcrowding, noise, lack of privacy, implied communication between patients and healthcare providers, strange equipment in assisting in treatments may influence the persons' feelings (Winkel, 1986).

These stress factors can have a negative impact on the process of healing the patient. Ulrich has defined the consequences of such stress, psychologically, physiologically and behaviorally, and found that a key underlying mechanism generating these consequences phenomena appears to be the "diversion of one's attention from the immediate ailment to environmental stimuli that is pleasant to the senses" (Ulrich, 1992). He also found further supportive qualitative evidence in literature review that a design of environment (the usage of daylight, nature distraction, appropriate lighting, better ergonomic design, rooms, floor layouts, work settings) does influence a patient's experience in health care (Ulrich, 2008).

A waiting area is thus referred to as a "servicescape" where a part of service is delivered, perceived and where the staff and patient interact (Bitner, 1992). Reimer also confirms that this interaction within servicescape influences users' evaluation and has a direct and indirect effect on perceived service quality (Reimer, 2005). Thus, by mapping the psychological experience of persons' waiting in waiting area we can understand better the perception of the users. (Katz, Larson and Larson, 1991). Latest research has also proposed a framework for creating the environment change that can be related to the improvement of health (Berke and Moudon, 2014). In numerous services, waiting has become a pivotal factor in satisfaction and quality judgment (Dube, Schmitt and Leclerc, 1991; Taylor, 1994; Taylor and Claxton, 1994). Many providers attempt to reduce the negative effects of waiting by solely cutting the length of the wait through modifying the service delivery system (Sasser, 1976; Shostack 1987). Indeed, an improvement in the interaction experience of physical design attributes could help to create customer value for physical aspect of Kansei (Nagasawa, 2006). These studies clearly demonstrate the influence of the environment on human perception and suggest a hypothesis that a redesign of waiting area environment can have an impact on human emotions.

Our study aims at determining the environmental characteristics critical to design emotionally satisfactory waiting areas. We ameliorate existing study in Kansei Engineering by expanding the same technique focusing on the design of an interior. Second, these results help us to know more about psychological responses to the physical setting of healthcare environment. Finally, the usage of Panksepp's basic emotion as a main model in our research helps us to have a comparable and

unambiguous definition of emotion in our research.

CAN WAITING AREAS DEPICT EMOTIONS?

There is a growing interest in understanding patients' needs in health care services (Arnel and Devil, 2003; Leather et al. 2003). Respectively, patients' needs should be correlated with their feelings. Overall research in Affective Computing uses measures of the emotional responses of individuals which has been experimental-based and generally relied on analyzing the participants' facial (McDuff, el Kaliouby and Picard, 2012), vocal (Dellaert, 1996) and bodily expressions (Kleinsmith, Bianchi-Berthouze, 2013; Radeta and Maiocchi, 2013) in addition to their verbal descriptions of their feelings. In this study we focus solely on verbal interpretations of the perception in waiting areas (in further WA).

As our aim is to assign emotions to physical properties of the space we opted for emotional model from general research in Affective Neuroscience which describes 7 primary-process emotions: SEEKING (expectancy), FEAR, RAGE, LUST, CARE, GRIEF (sadness) and PLAY (social joy). Names of emotions are written with capital letters according to authors' notice as they represent the exact brain areas and neurotransmitters. These emotions are similar for all mammals (Panksepp, 1998) and we can understand them as being both positive (desirable) and negative (not desirable) for each person. When referring to the WAs, we will use this taxonomy of emotions as our model for structuring our collected Kansei words which we will explain in further.

Briefly, Kansei is a Japanese word which depicts senses, human preferences, feelings etc. Kansei Engineering is a technology and methodology on design or development level, which translates "Kansei", (that is, senses, human preferences, feeling, images etc.) of a person into a concrete product (Takagi, 2004). The data in Kansei engineering is obtained from a collection of adjectives (which are treated as kansei words) that help to construct the semantic space for the design of a product. As an overall goal of Kansei is translating human emotions into appropriate product physical design elements, which contain size, shape, color and texture, in the remainder of this paper we try to group and assign these words to human feelings per each of the waiting areas. We use Kansei words combined with the defined taxonomy of the emotions for the purpose of understanding the perception and emotions felt by persons in WAs.

2. METHODOLOGY

For this study, Kansei Engineering (KE) type "I" was used. We opted for KE model proposed by Schütte, which was feasible in our facilities. This model is a 6-step process and was used in our previous study to link product emotions with product properties (Shafieyoun, Koleini Mamaghani and Jahanbakhsh, 2010). In this paper we apply the same model, however, we use it for the physical environment and in particular, the waiting area. We follow Shütte who anticipated that the "future growth of Kansei Engineering and the application of new areas make it necessary to allow the integration of more tools and methods from other areas" (Schütte, 2004).

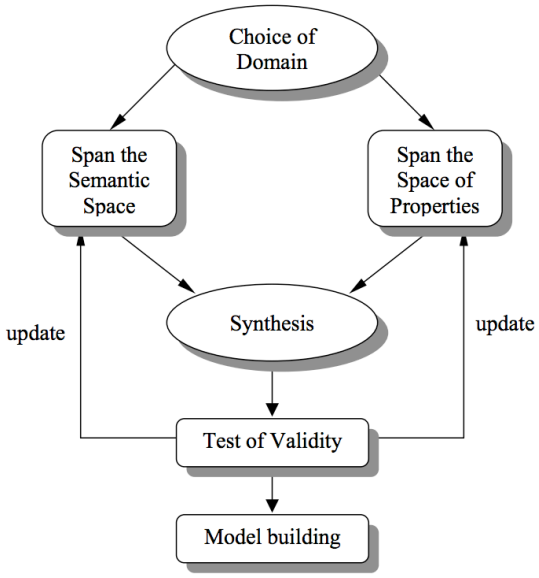

Figure 1: KE model proposed by Schütte (2005).

2.1. Choice of the Domain

Our study subjects were 200 patients who are diagnosed with cancer. Fifty patients for each four WAs were distinguished in two hospitals (Istituto Nazionale dei Tumori and Besta in Milan, Italy).

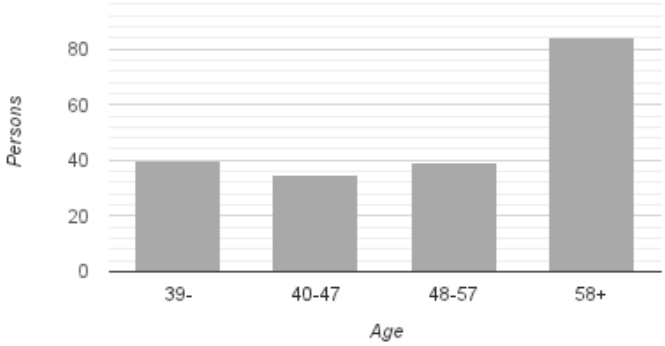

Figure 2: Age distribution among subjects

2.2. Spanning the Semantic Space

In our study, we use Kansei words (KWs) to describe the environment of the WAs by obtaining 650 adjectives (KW). We collect them from magazines, Internet, books, papers, and dictionaries, as well as from personal observations where adjectives have been collected by spending one week during both day and night inside the hospital. In the next step, we used manual expert method by the designer's choice to perform the word structuring (Table 1). We grouped 325 of them and finally to 24 which we classified into 6 out of 7 primary-process emotions. Some of these KWs are presented in Tables 1 and 2 below. We excluded LUST as it did not apply to the hospital environment. For each of the emotion we obtained in average 4 Kansei Words, which we believe are the nearest representatives to the emotion definition in Affective Neuroscience (Panksepp, 1998).

Table 1: Manual Expert Method of structuring the Kansei Words (from left to right)

650 KW (vocabulary)	650 KW (grouped by synonyms)	325 KW (filtering by similarity)	24 KW (representative Factor Word)	Assigned Emotion per KW
Stressful	Stressful Troublesome	Stressful	Stressful	RAGE
Scared	Nervous Anxious	Anxious		
Shocked	Scared Agitated	Agitated		
Anxious	...	...		
Troublesome				
Crowded				
Agitated				
Frozen				
Nervous				
...				

Table 2: Final 24 Kansei Words structured per 6 emotions from Affective Neuroscience

SEEKING	CARE	PLAY	FEAR	GRIEF	RAGE
Calm	Nice	Moving	Hateful	Depressed	Agitated
Slow	Funny	Alive	Confusing	Boring	Heavy
Quiet	Beautiful	Active	Exciting	Sleepy	Chaotic
Apathetic	Friendly	Dynamic		Dozy	Lazy
	Tranquil				

2.3. Spanning the Space of Properties

We choose four WAs, which had easier access for performing our study. It is worth mentioning also that patients in these areas are suffering from cancer. These areas had diverse characters (as depicted in the Table 3 and in Figures 3 to 6) for the purpose of revealing similarities and differences in patients' perception. Each WA had the capacity of 50 persons waiting to be accepted for medical check.

Table 3: Characteristics of the Waiting Area (WA)

WA	Regional Characteristic	Social Characteristics	Design Characteristics
1	Radiology (INT)	Patient and Family	small, warm color, painting, sculpture, TV, alarm, timetable, private, small, magazines and books, compliment book.
2	Small for test (INT)	Reception, Patient, family and staff	metal desk, cold colorful, public, big windows, flower vase, table and chair at reception, doors
3	Main (INT)	Patient, family, staff	big, metal desk, cold color, timetable, alarm, skylight, windows, painting, public, flower vase, doors
4	Small for test (Besta)	Patient, family, staff	metal chair, gray, painting, public, timetable, alarm, magazine, door



Figure 3: Waiting Area 1



Figure 4: Waiting Area 2



Figure 5: Waiting Area 3



Figure 6: Waiting Area 4

2.4. Synthesis

We ascribed KW's to WA's by using the Manual Expert Method, as it is the oldest and being accepted as having more accessible tools (Shütte, 2005). Our study participated 200 patients and we performed a total of 600 surveys in 4 WA's. The distribution of patients was equal for each of the WA's, having 50 patients per room. Each patient had 3 types of the surveys and a task to match 24 KW (short listed above in Table 2). The same KW was used for each of the 3 surveys: color, furniture layout and materials. Survey was based on semantic differential method with 7-point empty spaces ranging 1-3 (not so good), 4 neutral and 4-7 (very good).

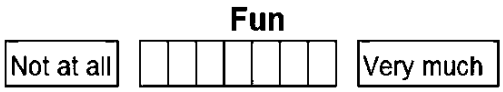

Figure 7: An example of 7-Point Scale used throughout the survey

After collecting the participants' answers, in next step we asked 10 designers to perform the same structure of 3 surveys (additional 30 surveys), however by imagining an ideal WA.

3. RESULTS

Below are survey results of all 4 WAs and Ideal WA. We observe that in Ideal WA “Beautiful”, “Friendly”, “Nice”, “Active”, “Alive” and “Dynamic” Kansei Words have higher rates.

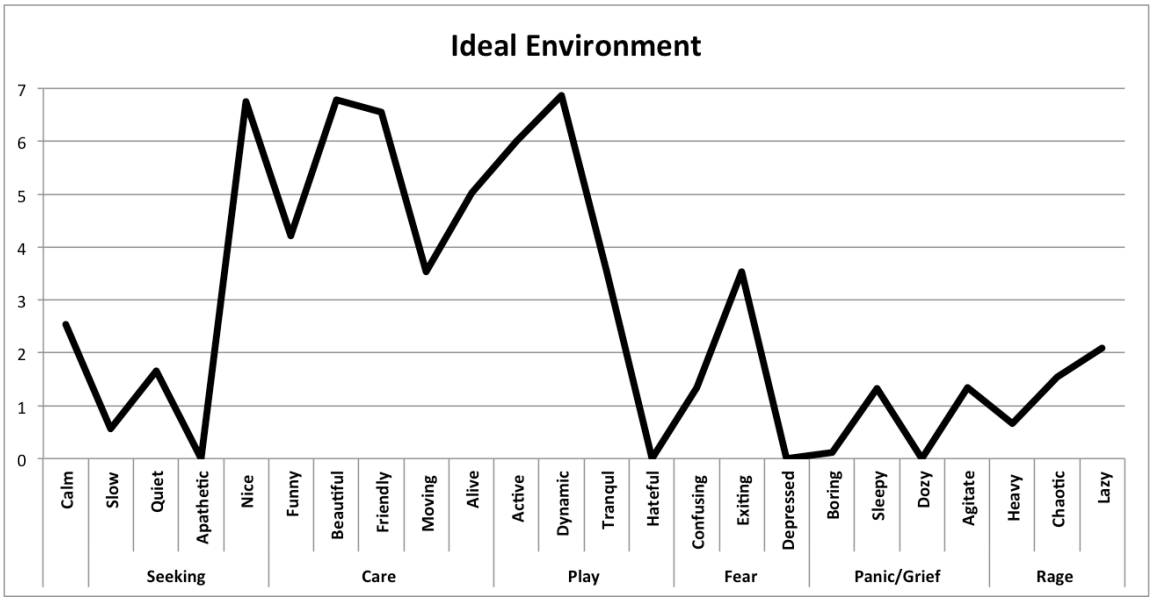

Figure 8: An Ideal Waiting Area seen by designers

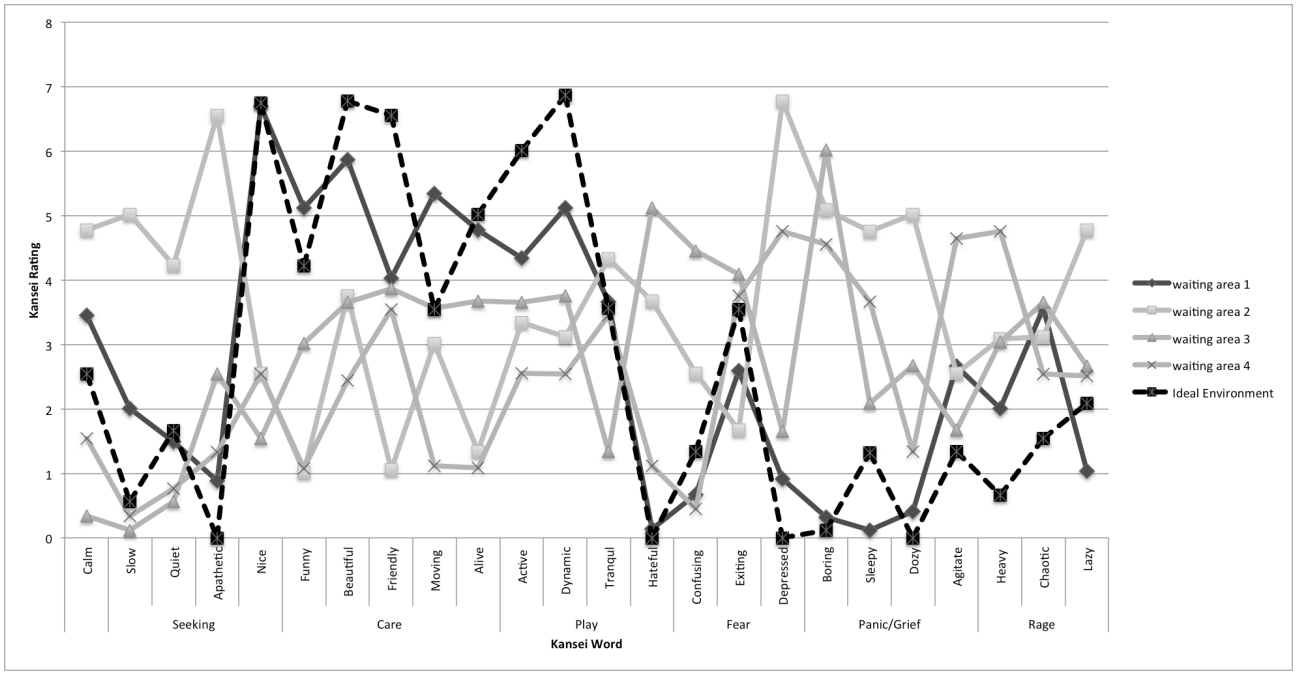

Figure 9: All Waiting Areas seen by participants

The data was treated with factor analysis with the purpose of semantic structuring. This was done in SPSS (Statistical Package for Social Sciences), which is commercial statistical software. The input data were the mean values for the 24 KW’s describing each of the 4 WA’s and including an ideal WA. We used this method as the factor analysis to simplify this raw data and to reveal connections between each of the WA’s. Results below demonstrate new categories of KW by

performed factorial analysis. All KWs were reduced to five factor-words: Gloomy, Friendly, Active, Confusing and Agitated, which had the highest loading in more than one analysis. Factor 1 (Gloomy) for color are: “Tranquil”, “Calm”, “Quiet”, “Boring”, “Sleepy”, “Dozy” and “Depressed”. We can observe that there are no adjectives +4 in Ideal WA. Factor 2 (Friendly): “Nice”, “Funny”, “Beautiful” and “Friendly” are +4 in ideal WA. According to the amount of Kansei Rating in 4 WAs we can observe that WA 1 have +4 rating in these adjectives. Factor 3 (Active) “Alive”, “Active” and “Dynamic” we observe +4 in Ideal WA and WA 1 having all of this adjectives +4. Factors 4 and 5 respect the similar trend. Finally, we find out that the color of WA 1 has been perceived friendlier and have more positive emotion for users. Results below demonstrate a comparison of an average participants’ of 1-7 ranged values among all 3 attributes: color, furniture layout and material.

Table 4: Kansei words per Color
(* Adjectives 4+ are rating for Ideal Waiting Area)

Factor 1: Gloomy	**Factor 2: Friendly**	**Factor 3: Active**	**Factor 4: Confusing**	**Factor 5: Agitated**
Tranquil Calm Quiet Boring Sleepy Dozy Depressed	* Nice * Funny * Beautiful * Friendly Slow Apathetic	Moving * Alive * Active * Dynamic	Confusing Exciting	Agitated Heavy Chaotic Hateful Lazy
-	= **WA 1**	= **WA 1**	-	-

Conversely, Factor 1 in Table 5 is “Slow” and includes “Hateful”, “Tranquil”, “Quiet”, “Slow” and “Apathetic” which has no +4 adjectives however having instead 3 adjectives (“Hateful” and “Apathetic” and “Slow”), which are less than 1 in Ideal WA. We can also observe that the WA’s 2 and 3 have +4 rating of Kansei in these adjectives. In addition, in Table 7 we observe the results of negative emotions in WA’s. Table below shows WA’s 1 and 3 as favorite selection for furniture layout.

Table 5: Kansei words per Furniture Layout
(* Adjectives 4+ are rating for Ideal Waiting Area)

Factor 1: Slow	**Factor 2: Nice**	**Factor 3: Active**	**Factor 4: Dynamic**	**Factor 5: Chaotic**
Hateful Tranquil Quiet Slow Apathetic	* Nice * Beautiful * Friendly Sleepy Dozy Lazy	Moving * Alive * Active	* Dynamic Confusing Exciting	Agitated Heavy Chaotic Calm Depressed * Funny Boring
-	= **WA 1, 3**	= **WA 1, 3**	= **WA 3**	= **WA 3**

Under the word "Material" we consider any material in environment, which can be tangible material in furniture or a wall texture. We can see in table below that users chose WA1 as the best WA in case of material.

Table 6: Kansei words per Material
(* Adjectives 4+ are rating for Ideal Waiting Area)

Factor 1: Sleepy	**Factor 2: Calm**	**Factor 3: Active**	**Factor 4: Confusing**	**Factor 5: Agitated**
Slow Apathetic Boring Sleepy	* Beautiful * Friendly Depressed Tranquil Calm Quiet	Alive * Active Dynamic * Nice Funny	Hateful Confusing Exciting Moving	Agitated Heavy Chaotic Dozy Lazy
-	= **Waiting Area 1**	= **Waiting Area 1**	-	-

We believe that decreasing negative emotion and increasing positive ones in new WA's would be possible by knowing better the perception of people. Though, we can depict negative elements of each WA by choosing adjective less than 1 in Ideal WA and +4 in our WAs. The result is shown in the table below.

We merged SEEKING with GRIEF; SEEKING is a mother emotion (Panksepp, 1998), which serves as a channel to enhance other ones. Results below depict comparison of Kansei Words of four WAs with negative and positive adjectives for three characteristics: color, furniture layout and material. In overall, WA1 has more positive emotions for all three factors. WA3 has a friendly Furniture Layout but other factors dominate negative emotions. By analyzing the character of WAs we obtained a better insight in perception of participants.

Table 7: Kansei words with 7 Panksepp's Emotions per WAs

	Positive		**Negetive**		
Emotion	**CARE**	**PLAY**	**FEAR**	**SEEKING/ GRIEF**	**RAGE**
COLOR					
KW	Friendly	Active	Gloomy	Confusing	Agitated
WA	= **WA**1	= **WA**1	= **WA**3	= **WA** 2,3	= **WA**4
FURNITURE LAYOUT					
KW	Nice Funny	Active Dynamic	Hateful	Slow	Heavy
WA	= **WA**1,3	= **WA**1,3	= **WA**3	= **WA**2	= **WA**4
MATERIAL					
KW	Calm	Active	Agitated	Apathetic	Boring
WA	= **WA**1	= **WA**1	= **WA**3	= **WA**2,3	= **WA**2,3

4. DISCUSSION

This study applied Kansei Engineering (KE) type I to design a waiting area (WA) for two hospitals in Milan, Italy. The majority of participants used in our study are being diagnosed with cancer. The results of this study were qualified by using factor analysis of user's perception of the WA. KE type I was used because it was compatible with available resources. Our study shows that the WA1 is the best sample of Positive emotion according to color, furniture layout and materials, whereas WAs 2 and 3 have more negative emotions. It is also notable that a WA1 resembles a private room with a warm color (decorations, paintings and sculptures) where the texture of furniture is warm and friendly. Patients prefer warm colors instead of bright colors (Devlin, Arneil 2003). Based on our on-field observation, people generally sit next to each other and enjoy by sharing their feelings during the waiting time in WA1. We also observed that people in WA1 had a more expressed feeling of respect. Our study suggests that using artworks in WA can stimulate PLAY. Textures and warm colors can provide satisfaction by provoking CARE. It is also obvious that a furniture layout can enhance more SEEKING in this WA. According to our findings, Was 2 and 3 included negative signals among the participants that could be attributed to cold colors and the usage of metal for furniture as well as by the dispersion of furniture. This implies that these two remaining WAs together with other characteristics reported in literature are being in general more negative. Therefore, by understanding increased positive feedbacks in WA1 against findings in literature review we have a potential candidate for PLAY/CARE WA. Comparing an ideal environment with the results of our research study underpins how it is possible to decrease negative and increase positive emotions in a WA. Our future step is to perform a validity test as well as to propose a concrete design model.

After completing comparison with other cases which used KE method, we figured out negative elements of WAs besides positive ones which can be used to decrease the impact of negative emotions and increase positive ones in designing the new environment.

A recent study conducted by Ebru Ayas, Jorgen Eklund and Shigekazu Ishihara (Ayas, 2008) used KE method to design WA. They applied CA (Correspondence Analysis) and X2 independency tests analyses in SPSS and Rough Set (RS) method to extract decision rules between Kansei in ROSE software. They used interviews in their survey with closed questions. Obviously, this method is not a usual method for designing the environment but it seems possible to propose a new approach in KE type I in Design Environment.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Applying Eye-Tracking in Kansei Engineering Methodology for Design Evaluations in Product Development

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Abstract: Customers base their emotional quality judgments on their product perception. Therefore, the aim of customer-centric product development should be to satisfy needs and requirements of the specific target group and to develop products that attract user attention and evoke positive emotions. Since visual impressions are crucial for the evaluation of the Perceived Product Quality, the ascertainment of data about visual impressions should be of high importance. To use Perceived Quality data of visual impression there is a need to investigate how latent needs and requirements are influencing the conscious and unconscious visual perception. This paper presents a methodology that extends the traditional Kansei Engineering methodology for gathering customers' requirements and evaluations (e.g. questionnaires) by using Eye-Tracking. The elicitation of visual impressions with Eye-Tracking means to derive objective data of customers' product perception and evaluation. The methodology uses comparisons of design alternatives on a general as well as on an even more detailed level of product perception based on a structured approach. The paper also presents precisely a study design for applying the developed methodology and shows valid results of a conducted Eye-Tracking study by using descriptive (e.g. Pareto-analysis) and statistical analysis procedures (e.g. repeated-measures ANOVA). In conclusion, knowledge about and interpretations of the customer product evaluation and about latent and implicit requirements can be derived from the parameters ascertained with Eye-Tracking (e.g. fixations). By gradually integrating the methodology into the product development process, it can be applied by product designers for evaluating product design concepts from the customer's perspective.

Keywords: Kansei Engineering, Eye-Tracking, Perceived Quality, Design Evaluation, Product Development.

1. INTRODUCTION AND MOTIVATION

Since quality judgments about products are linked to emotions and, obviously, affect purchasing decisions, it is crucial for a company's success to develop products that attract user attention and evoke positive emotions. Especially visual impression influences the evaluation of products because nearly 80 percent of all information is gathered by the eye (Berghaus, 2005). As a consequence, product designers have to become aware that an active design of Perceived Quality fosters an emotionally inspiring of product characteristics (Köhler & Schmitt, 2012). Nevertheless, influencing actively the perception of products means to base decisions on valid data about the customer product attention and measuring this kind of objective data poses a big challenge during the product development process (PDP). Measuring conscious requirements and unconscious impressions of emotions of the target group (e.g. by physiological signals) has already been applied in the methodology of Kansei Engineering (e.g. Saeed, 2012). However, gathering valid data about customers' visual impressions by visually comparing design alternatives seems to be an important additional application during the PDP in order to decide for or against design concepts. Thus, this paper presents a methodology to ascertain objective data and parameters about visual impression and emotional evaluation of different design alternatives by using Eye-Tracking. The methodology extends the traditional methods of Kansei Engineering by gathering data and knowledge of latent and unconscious visual impressions of product components.

2. PERCEPTION AND KANSEI ENGINEERING

Kansei Engineering provides approaches for customer-oriented product design. Thereby, knowledge about customers' latent and articulated perception of products is essential for emotional product design (see Fig. 1). Thus, applying the Kansei Engineering methodology for developing products with a high Perceived Quality means to understand the different levels of perception (2.1). Moreover, measuring user attention (2.2) and comparing different design concepts by objectified data (2.3) are important to develop products that evoke positive emotions.

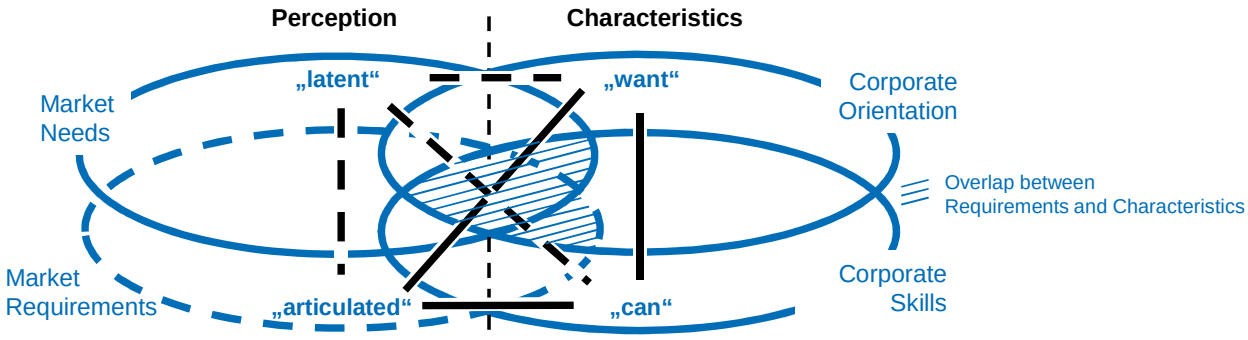

Figure 1: Understanding of Perceived Quality

(Köhler, Falk & Schmitt, 2013 based on Schmitt, Quattelbaum & Lieb, 2008)

2.1. Perceived Quality and Kansei Engineering

Improving Perceived Quality became an important lever to differentiate from competing companies (Falk, Quattelbaum & Schmitt, 2008). *Perceived Quality* is defined as the emotional and cognitive comparison between product characteristics and requirements and needs of the target group. The comparison is based on conscious as well as on unconscious perception and linked to

customer experiences and expectations (see Fig. 1 and (Schmitt, Quattelbaum & Lieb, 2008)).

Thereby, the customer's product perception is complex and can be structured in different levels of perception which differ in their level of detail from overall impression down to technical parameters. Customers' emotional perception begins with an overall impression of the product which is essential to a later design evaluation and often based on harmonic aspects. On a more detailed level, perception clusters are formed by different quality attributes. Then, one or several descriptors are determined to further identify and structure the product. Correlating characteristics of a descriptor with technical parameters, leads to relevant technical parameters that ensure a harmonic appearance of the product. Therefore, an application which captures latent needs and articulated requirements is necessary in order to compare different product concepts and alternatives on different levels of perception. (Falk, Quattelbaum & Schmitt, 2008)

The traditional methods of Kansei Engineering try to translate impressions, feelings and demands regarding established products or concepts into new design solutions and precise technical parameters (Nagamachi, 1989; Lee et al., 2002; Schütte, 2002). Typical methods of Kansei Engineering are the semantic differential (Osgood, 1957), the Kano Model (Kano, 1987), systems and functions analysis as well as measuring physiological signals (e.g. GSR, EMG).

Studying established products runs the risk that customer requirements have already been neglected in previous design decisions and any future change of the product can lead to high costs for redesign. The economic dimensions during PDP indicate that 75% of all production costs are induced at the phases of product concept and design (Schmitt & Pfeifer, 2010). Thus, the evaluation of different design alternatives is important in all phases of PDP but crucial in early phases.

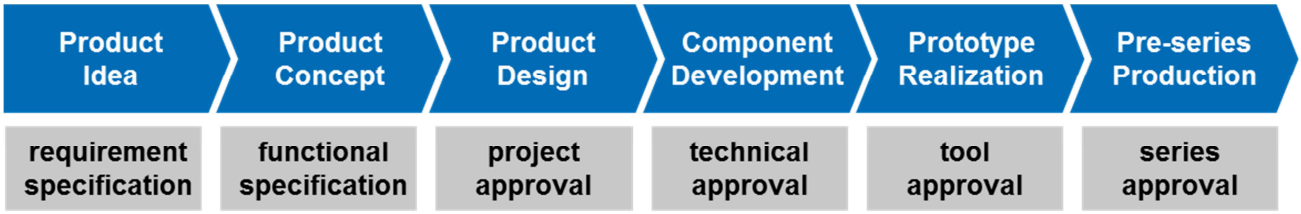

Figure 2: Phases of the PDP (based on Ehrlenspiel, 2009; Beaujean et al., 2011)

Since measuring visual impressions is often more decisive during the early phases of PDP than other impressions (e.g. haptic, acoustic) (Duchowski, 2007), it seems to be important to extend Kansei Engineering methodology by techniques that are able to evaluate the perception of concepts and designs of non-established products. The developed methodology focuses ascertaining objective data and parameters about visual perception of design alternatives by Eye-Tracking in order to evaluate different design concepts and to gradually integrate the ascertained knowledge into the PDP. Thereby, even visual requirements can be defined and registered (e.g. in functional specifications or project approval).

2.2. Measuring user attention via Eye-Tracking

The measurement of user attention and design evaluation can be divided into verbal methods (e.g. face-to-face survey, phone interview, online survey) and non-verbal methods (e.g. Eye-Tracking, ECG). Concerning the measurement of visual attention and evaluations, the oldest and simplest approach of detecting the eye movements of a target person is direct observation of a trained observer. Although movements of 1° are measureable, those are not quantifiable, biased and, subsequently, this approach is not comparable to modern Eye-Tracking systems. (Hofer & Mayerhofer, 2010) Nowadays, Eye-Tracking systems are used mainly to deduce the attention

evoked by product components and to evaluate different designs visually. Thereby, fixations, saccades and scan paths are the most important key figures to record valuable and objective input data for product development. *Fixations* are time intervals in which the eyes rest in one special position, taking in or encoding information. *Saccades* are rapid eye movements between fixations and *scan path* means a sequence of saccade-fixation-saccade. Some additional metrics as gaze (look), pupil changes and blink rates are also studied. (Mello-Thomes, Nodine & Kundel, 2004; Hoeks & Levelt, 1993; Stern, Boyer & Schroeder,1994)

2.3. Established methods for objectifying design evaluations

There are several methods for transferring customer requirements into product characteristics, as for instance Quality Function Deployment (QFD) (Akao, 1990), Conjoint Analysis (Backhaus, 2003), Means-End-Analysis and, in addition, Kansei Engineering which uses statistical analysis such as cluster analysis, factor analysis and semantic differentials combined with psychophysiological methods (Nagamachi, 2011). However, these concepts often lack the ability of quantifying emotional user evaluation, especially concerning design comparisons. Unconscious impressions are neglected because these methodologies mainly rely on questionnaires, which mainly collect subjective data. (Schütte, 2002) Directly articulated design evaluations are often influenced by study design, the experimenter or the fact that the user does not want to express true feelings. Additionally, users may have problems in deciding between alternatives because the product complexity or very slight differences. (Czerwinski, Horvitz & Cutrell, 2001; Nielsen & Levy, 1994)

Different researches focused on interdependencies between Eye-Tracking parameters (see 2.2) and people's perception as well as design evaluations and preferences (e.g. Kukkonen, 2005; Koivunen et al., 2004; Hammer & Lengyel, 1991; Hammer & Lengyel, 1989). These researches point out the need to investigate which product characteristics are carrying the brand's product strategy (Kukkonen, 2005). Consequently, there is potential to combine Kansei Engineering with measuring bio-signals which holds lower possibilities for influences while evaluating design alternatives (Saeed, 2012). In conclusion, the measurement of visual impressions of non-established product concepts and designs should be focused during the early phases of PDP to evaluate concepts and to fulfill customer requirements. Thus, Eye-Tracking appears to be a very useful method to gather objective data even about latent customer requirements and especially about visual design evaluation. (e.g. Schmitt et al., 2013; Köhler, Falk & Schmitt, 2013; Kukkonen, 2005)

3. EXTENDING KANSEI ENGINEERING METHODOLOGY

This paper points out an excerpt of an investigated and comprehensive methodology for objectifying design evaluations of product alternatives, especially regarding design comparisons by visual impressions via Eye-Tracking. At the beginning of the PDP, the link of the product understanding (described by semantic concepts) with the perceived product components is essential to guarantee a high Perceived Quality of the future product.

In order to evaluate design alternatives on different levels of perception from overall impression down to quality attributes as illustrated in chapter 2.1, Eye-Tracking was applied to compare various design alternatives (see Fig. 3). Since the gaze track is affected by current thoughts and emotions (Yarbus, 1967), Eye-Tracking is able to gather objective data about the visual product impression in order to interpret the implicit and latent customer requirements.

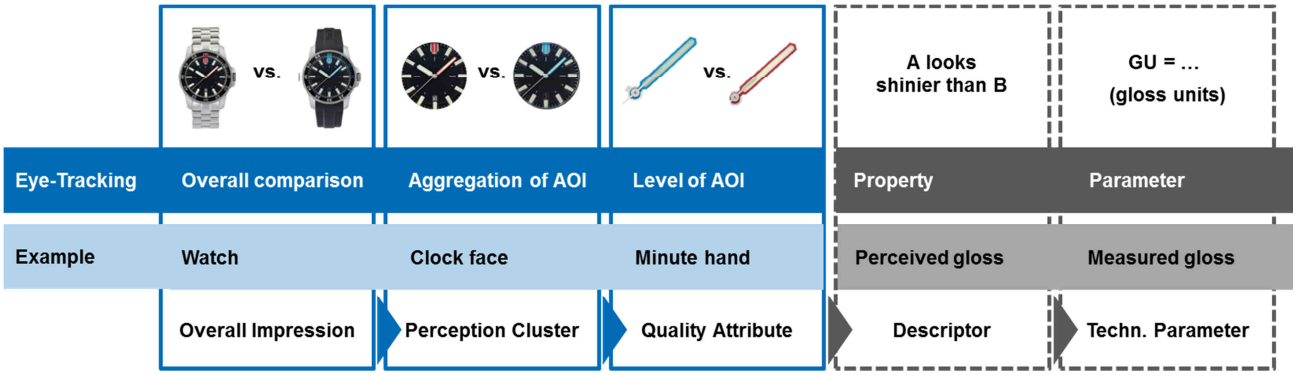

Figure 3: Study design corresponding to the different levels of perception (based on Schmitt & Pfeifer, 2010)

3.1. Research questions and general methodology

The subsequent research questions are of importance for ascertaining a high Perceived Quality and an Emotional/Affective Engineering and consequently for entrepreneurial success:

- What are the most relevant components according to visual perception?
- How is the visual perception of components distinguished by expectations and thoughts?
- Can Eye-Tracking be used to solve these tasks?
- Should the Kansei Engineering methodology be gradually extended by Eye-Tracking in order to detect and measure customer's attention in a more objective way?
- Can it be used in order to align customer's product understanding with specific product characteristics and designs?
- Which data can be used in order to improve customer orientation and efficiency during the PDP?
- How can design alternatives be compared even if they have only subtle differences?

As part of a comprehensive methodology (Köhler & Schmitt, 2012; Schmitt et al., 2013; Köhler, Falk & Schmitt, 2013) the following methods and steps are used to answer the aforementioned research questions:

- Collecting and reducing different product strategies and deriving semantic concepts
- Applying semantic concepts to compare design alternatives
- Structuring the product by system-analysis and a structured approach towards Perceived Quality
- Investigating the conscious product evaluation and design comparisons by a questionnaire
- Gathering unconscious visual impressions of different product alternatives via Eye-Tracking
- Identifying the most relevant components for different product understandings
- Applying Eye-Tracking to align customer's product understanding with product characteristics
- Using Eye-Tracking to gather objective data of visual design evaluations in pairwise comparisons

3.2. Experimental design and analysis procedure

The illustrated methodology was investigated and proven in different user studies during the research project CONEMO (Köhler & Schmitt, 2012; Schmitt et al., 2013). In this paper results are presented concerning a case study on various design alternatives of men's watches. The study aimed at comparing different design alternatives by using Kansei Engineering methodology. Therefore, Eye-Tracking was applied in order to gain objective data about visual perception and to link the customer's product understanding to specific product characteristics. The design

alternatives vary in the type of bracelet and the color of clock face (see Tab. 1). The clock faces only differed in a small area right in the top of them.

Table 1: Different design alternatives analyzed in the study

Type of bracelet		**Color of clock face**	
steel (silver)	silicone (black)	Red	blue

3.2.1. Generating a semantic framework

First and analogous to the Kansei Engineering methodology, a pre-study was conducted to generate an overview of semantic concepts that are associated with the watches. Semantic concepts are crucial to align the company's strategy with customer's feelings and product understanding (Köhler & Schmitt, 2012). Interviews with experts, product description and internet research were applied to generate an overview of about 22 semantic concepts.

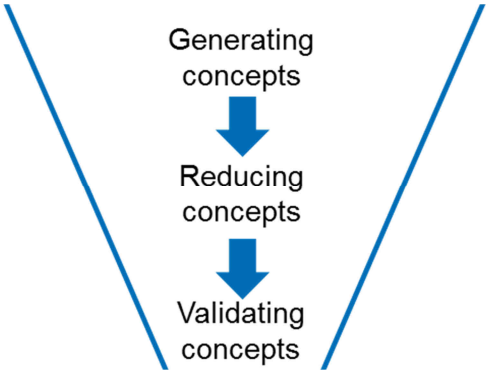

Figure 4: Generating and reducing the semantic framework

Subsequently, the amount of concepts was reduced to six by logical exclusions, diagrams of affinity, focus group workshops and factor analysis (see Fig. 4). Afterwards, a questionnaire with 72 watch affine people was set up to validate the following six concepts on a 5-point-scale (1: not important; 5: very important): *sportive*, *masculine*, *modern*, *impressive*, *massive* and *optically harmonious*. A statistical analysis was applied to estimate the importance of each semantic concept by using 95% confidence intervals for the means (see Fig. 5). As a result, the test subjects evaluated *optically harmonious* as most important (mean = 4.36 and sd = .954) and significantly higher than *massive* (mean = 2.75 and sd = 1.135)

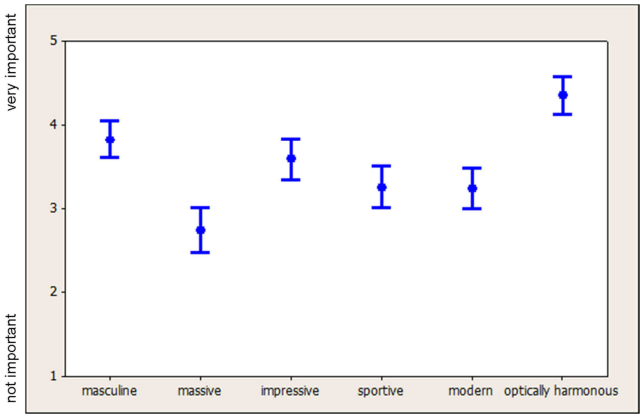

Figure 5: Importance of semantic concepts

3.2.2. Determination of the product structure

Studying a product in detail requires a precise knowledge of the product structure in order to align the level of customers' perception to the level of technical parameters. Therefore a structured approach towards quality perception is indispensable in order to divide the product in relevant visual clusters of perception. As presented in former studies, the amount of clusters mainly depends on the product complexity (e.g. for a car exterior 20 and for a mountain-bike 6 areas of interests (AOI)) (Schmitt et al., 2013). Since the product structure of modern watches is relatively complex a system analysis was applied to virtually disassemble the product into its subcomponents (Köhler & Schmitt, 2012). As a result, the clusters of perception were defined and the AOIs determined (see Fig. 6).

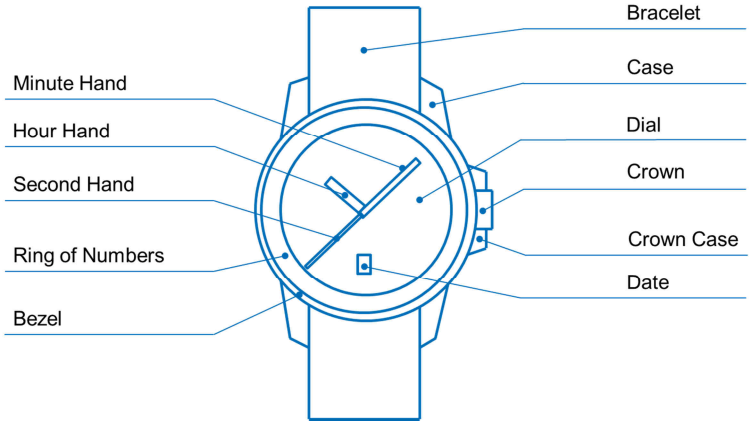

Figure 6: Definition of areas of interest

3.2.3. Study design and measurement equipment

For reasons of study design and in order to minimize systematic influences, the product comparisons were presented in same manner (e.g. same size, same angle, same background). As described below, a video-based Eye-Tracking system using pictures of a product was applied during the study. Former studies produced that the duration that each picture should be shown to the test subjects depends on the product type and the complexity of the product structure. A former think-aloud study within the research project (for think-aloud study see e.g. van Someren et al., 1994) revealed that pictures of products, such as watches, should be presented between 14 and 17 seconds.

After generating the semantic framework and the determination of the product structure, the Eye-Tracking schedule was organized. First (*free interaction*), a picture of each design alternative was shown separately for 10 seconds to gather a reference value and to gain information about the relevant components that a test subject focuses after seeing an unknown watch for the first time. Since initial excitement and learning effects can influence the results essentially, the 4 watches were presented in a randomized order to each test subject. Afterwards (*pairwise comparison*), the subjects were asked to visually compare 2 design alternatives for 12 seconds regarding one semantic concept. During this sequence, for each semantic concept pairwise comparisons of the product pictures were presented. For reasons of learning effects and upcoming exhaustion, the order of the semantic concepts as well the compared alternatives were organized randomly. At the end (*preferences*), in one overall comparison the test subjects visually favored different design alternatives. In addition to the design alternatives which were introduced before, another 2 colors of clock face (black and orange) were added so that there were entirely 8 design alternatives in order to study the influence of further design alternatives on visual design evaluations. The study had an overall length of 8 minutes. (see Fig. 8)

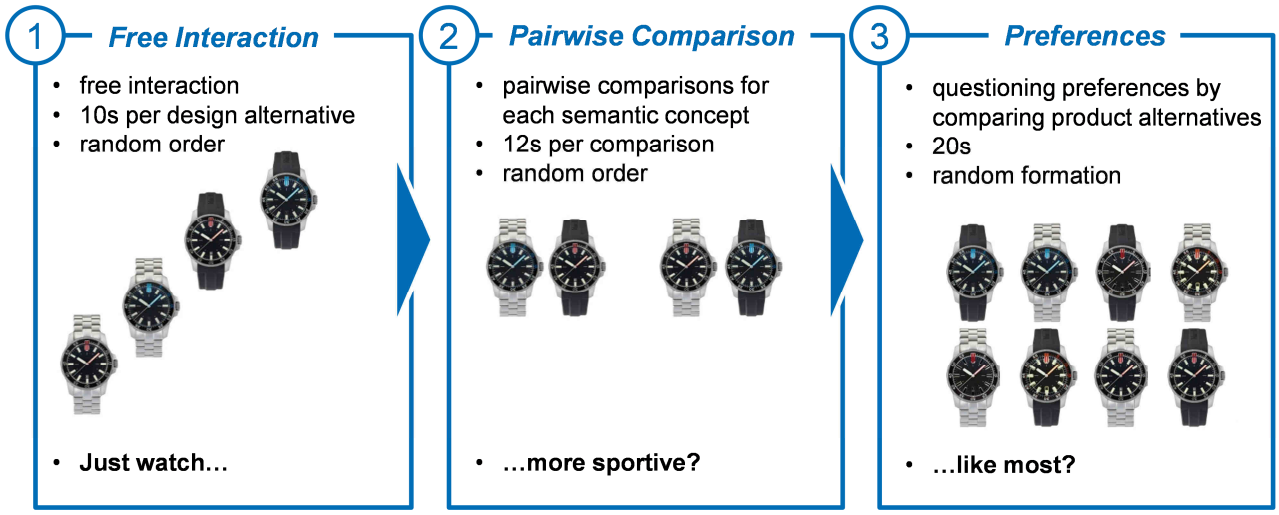

Figure 7: Phases of the Eye-Tracking study

A video-based combined pupil/corneal reflection Eye-Tracker, a so called remote Eye-Tracker, was applied to gather the test subjects' eye movements such as fixations, saccades and scan path. Two infrared light sources, two video cameras and a two-dimensional screen were used. Since no mechanical components as cables or chin are between the test object and the measuring system, remote Eye-Tracking systems are categorized as non-contact measurement systems (Young, 1975). Infrared light is reflected by the customers' eye, precisely by the center of the pupil, and captured by the video camera to analyze changes of eye movement. In comparison to other Eye-Tracking systems, a remote Eye-Tracking system has some crucial advantages with regard to head movements. Movements of several centimeters do not influence any result. Moreover, the system is able to reconstruct the gaze vectors without any negative effects if the test subject moves the head out of the recorded area or blinks. Not loosing the gaze is from great advantage, especially while studying complex product structures such as watches. In addition, remote systems can be characterized by a short calibration time. (Issing & Mikasch, 1986)

For reasons of comparing explicit and implicit user opinion, the Eye-Tracking study was supported by a questionnaire after the Eye-Tracking study. It consisted of similar design comparisons with regard to the identical semantic framework and preference decisions concerning the same design alternatives. The questionnaire was arranged in two different modifications differing in the order of questions and the pairwise comparisons. In addition, the watches were compared on a level of overall impression as well as on a level of perception clusters (see Fig. 3).

The test subjects (age: 17 to 50 years, mean = 22.8) were asked about their fascination for watches in general on a 5-point-scale (1: very low; 5: very high). They could be characterized as medium watch affine (mean = 3.25 and sd = 0.92) and over 35 percent intended to buy a new watch in the near future. After being instructed about the study and seated ca. 60cm in front of the screen, all test subjects had to follow a short calibration process for the remote system.

3.2.4. Statistical analysis

A Pareto-analysis was used to identify the most relevant components during *free interaction.* Nevertheless, the focus of study was to compare different design alternatives in various semantic frameworks. Thus, a repeated-measures ANOVA and an analysis of the pairwise comparisons (analysis of T-Paired-tests) were applied to figure out which product differs significantly (e.g. $p < 0.1$) according to a specific semantic concept. Eventually, recommendations for the product design were derived.

3.3. Results

3.3.1. Identifying the most relevant product components

With regard to Eye-Tracking, the mean times concerning all design alternatives were summarized according to the areas of interests in order to get an overview about possible relevant components. A Pareto-analysis revealed that during *free interaction* the test subjects observed three of eleven areas of interests more than 80% of the whole time: bracelet, dial, ring of numbers. As a result, dial and the ring of numbers were integrated into the clock face for further study (see Tab. 2). Eventually, the most important component regarding the test subjects' perception was the clock face and, with some distance, the bracelet. In the following analysis, clock face and bracelet were examined as an excerpt of the whole Eye-Tracking study. In contrast to Eye-Tracking and with regard to all semantic concepts, the questionnaire showed that only 25% of the test subjects directly stated the clock face as reason for a design evaluation. This fact emphasizes that measuring also visual impressions (e.g. via Eye-Tracking) is an essential step to understand customers' perception entirely.

Table 2: Mean time ratios for the defined areas of interests (if time ratio > .02)

Component	Mean [%]
clock face	.697
bracelet	.132
bezel	.054
crown	.035
minute hand	.028
date	.022

3.3.2. The effect of expectation on design comparisons

First, strategy-structure-matrices were constructed for each design alternatives in order to get an overview of the measured time ratios. Strategy-structure-matrices can be used to present the correlation between components and semantic concepts. As a consequence, the most important components concerning a semantic concept can be detected. Thereby, the mean time ratios of all AOI are analyzed and transferred into an absolute scale whereby the component with maximum mean time gets the value 10 and the others are scaled linearly. Moreover, each entry is colored from high value (dark) to low value (bright). (Köhler & Schmitt, 2012) As a first result, some small evidence could be revealed that the silicon bracelet was valued as more sportive in comparison to the steel bracelet (see Fig. 8). Since dial as part of the clock face was always scaled with the value 10 according to the mean times, the importance of the component clock face could be emphasized.

Component \ Semantic concept	Optical harmonious	Sportive	Masculine	Impressive
Bracelet	2,4	3,8	1,6	2,
Ring of numbers	2,1	1,9	2,1	2,6
Dial	10,0	10,0	10,0	10,0

Component \ Semantic concept	Optical harmonious	Sportive	Masculine	Impressive
Bracelet	1,6	1,8	1,6	1,8
Ring of numbers	2,9	2,8	1,8	3,2
Dial	10,0	10,0	10,0	10,0

Figure 8: Strategy-structure-matrices for silicon bracelet with red clock face (left) and steel bracelet with blue clock face (right)

ANOVA was conducted in order to test differences between means of fixation time ratios for significance on a level of overall impression as well as on a level of perception cluster. T-Paired tests were used to analyze all design comparisons regarding the relevant semantic concepts. For purposes of illustration, the results of bracelet and clock face are presented according to the three semantic concepts: *sportive*, *masculine* and *optical harmonious*. In the following, the label '*color of the clock face_type of bracelet'* is used to describe the different design alternatives.

On the one hand, the study revealed that on a level of overall impressions watches with silicon bracelet were significantly more focused than watches with steel bracelet regarding the semantic concept *sportive.* On a level of perception cluster, the watch with silicon bracelet and red clock face and the watch with the silicon bracelet and blue clock face were significantly more focused in comparisons with watches with steel bracelets (see Tab. 3). Consequently, a silicon bracelet made the studied watches appear more *sportive*.

Table 3: Significant differences of overall impression and perception cluster regarding *sportive*

Comparison	**Test statistic**	**p-value**	**Significantly more focused**
red_silicon vs. red_steel	T(12) = 6.1415	.0000	red_silicon
red_silicon vs. blue_steel	T(16) = 7.3684	.0000	red_silicon
blue_silicon vs. blue_steel	T(13) = 4.1502	.0011	blue_silicon
blue_silicon vs. red_steel	T(16) = 2.3749	.0304	blue_silicon
Perception cluster *bracelet*	**Test statistic**	**p-value**	**Significantly more focused**
red_silicon vs. red_steel	T(13) = 5.2266	.0002	red_silicon
red_silicon vs. blue_steel	T(18) = 3.7427	.0015	red_silicon
blue_silicon vs. blue_steel	T(13) = 3.8731	.0019	blue_silicon
blue_silicon vs. red_steel	T(18) = 2.7540	.0131	blue_silicon

Additionally, the clock face of watches with a silicon bracelet was significantly more focused while thinking of *sportive*, even if both clock faces had the same color. One possible explanation is that the bracelet influences the perception of the whole watch (see Tab. 3 overall impression). Similar results could also be revealed according to *massive* when the clock face was significantly more focused for watches with steel bracelet although the clock face was identical.

Furthermore, on a level of overall impression it was shown that the blue steel edition was significantly more focused than the blue silicon edition while thinking of *optical harmonious* (T(18) = 3.0064; p = .0076). On a level of perception cluster, it could be revealed that clock face and bracelet of the blue steel edition were significantly more focused than clock face and bracelet of the blue silicon edition concerning *optical harmonious* (T(19) = 2.6331; p = .0164 for clock face; T(19) = 1.7371; p = .0986 for bracelet). In addition, the clock face of the red steel edition was also significantly more focused than the clock face of blue silicon edition (T(13) = 2.0041; p = .0664). As a consequence, a steel bracelet, especially with blue clock face, let the watches appear more *optical harmonious* than watches with a silicon bracelet.

Moreover, it could be revealed that there are nearly no significant differences concerning design comparisons on overall impression as well as on level of perception cluster while thinking of

masculine. However, that concept was characterized as one of the most important concepts in the determination of the semantic framework (see 3.2.1). One explanation could be that *masculine* can be widely interpreted and the interpretation of the test subjects differed a lot.

The questionnaire could validate the fact that the watches with a silicon bracelet were evaluated more *sportive* than watches with steel bracelet on a level of overall impression as well as on a level of perception cluster. On a 5-point-scale (1: very low; 5: very high) the test subjects scored both watches with silicon bracelet at least one point higher in direct comparison to a steel edition (see Tab. 4). On a level of perception cluster, between 50 percent (concerning red_silicon) and 80 percent (concerning blue_silicon) of all test subjects stated the bracelet as reason for that sportiness. As further result, the fact, that a steel bracelet appears more *optical harmonious* than a silicon bracelet could not be validated by the questionnaire.

Table 4: Average value of evaluation of pairwise comparison regarding *sportive*

		Material of bracelet – silicon	**Material of bracelet – steel**
Color of clock face	**red**	3.61	2.63
	blue	3.83	2.65

3.3.3. Identifying preferences

As discussed before, explicit articulated and implicit recorded or even latent customer requirements can differ essentially. Thus, the results of Eye-Tracking and the data of the questionnaire were compared asking for the preference of a watch alternative separately and in an overall comparison of eight different watches. The analysis of Eye-Tracking revealed a higher preference of watches with a steel bracelet (see Tab. 5). That result underlines the importance of the bracelet as also mentioned in 3.3.1 and 3.3.2 concerning the fact that the choice of bracelet influences both the semantic evaluation and the overall preferences.

Table 5: Overall comparison – Eye-Tracking (if time ratio > 1.65 seconds)

Design alternative	**Mean time ratios**	**SD**
blue_steel	3.610	3.744
black_steel	3.025	3.541
orange_steel	2.353	3.973
blue_silicon	2.290	2.774
red_steel	1.672	1.940

A repeated-measures ANOVA according to Tab. 5 was conducted and revealed an significant effect of the watch type according to preferences in the overall comparison (Pillai's-Trace = .369; $F(7,37) = 3.093$; $p = .0110$). Since the Mauchly's test of sphericity was not fulfilled ($p < 0.05$) for the watch type, the Greenhouse-Geisser correction was applied for the p-level of univariate tests ($p_{Greenhouse\text{-}Geisser} = .019$ for watch type). Post-hoc T-paired tests affirmed that the watches with steel bracelet, especially with blue and black clock face, were significantly preferred (see Tab. 6). All design alternatives were valued with 0 (significantly less focused), 2 (significantly more focused) or 1 (no significance in pairwise comparison) (see Tab. 7).

Table 6: T-paired test concerning overall comparison of Eye-Tracking ($p < 0.05$)

Comparison	p-value	Significantly more focused
red_silicon vs. blue_steel	.002	blue_steel
red_silicon vs. black_steel	.010	black_steel
red_steel vs. blue_steel	.005	blue_steel
red_steel vs. black_steel	.019	black_steel
blue_silicon vs. blue_steel	.040	blue_steel
blue_steel vs. black_silicon	.012	blue_steel
blue_steel vs. orange_silicon	.008	blue_steel
black_silicon vs. black_steel	.049	black_steel
black_steel vs. orange_silicon	.049	black_steel

Table 7: Evaluation of design alternative in pairwise comparison

	red_silicon	blue_silicon	orange_silicon	black_silicon	red_steel	blue_steel	orange_steel	black_steel	Sum
red_silicon		0	1	1	1	0	1	0	**4**
blue_silicon	2		1	1	1	0	1	1	**7**
orange_silicon	1	1		1	1	0	1	0	**5**
black_silicon	1	1	1		1	0	1	0	**5**
red_steel	1	1	1	1		0	1	0	**5**
blue_steel	2	2	1	2	2		2	1	**12**
orange_steel	1	1	1	1	1	1		1	**7**
black_steel	2	1	2	2	2	1	1		**11**

The results of the questionnaire could validate the fact that watches with steel bracelet were more preferable than watches with a silicon one. All watches with steel bracelet were scored higher than watches with silicon bracelet with regard to the separate evaluation. Comparing the results of Eye-Tracking and questionnaire, the watch with blue clock face and steel bracelet was evaluated as most preferable. Since the watch with red clock face and silicon bracelet was less focused in the overall Eye-Tracking comparison as well as less scored at the separate and overall questionnaire evaluation, this watch can be characterized as less preferable.

4. DISCUSSION

The results show that expectations and different product understandings influence customers' perception on the level of overall impression as well as on a more detailed level of perceived product components (see Fig. 3). Consequently, studying perception (e.g. with Eye-Tracking) can be applied to align product understanding and product characteristics by customers' physiological product evaluations. Comparing design alternatives visually appears to be an appropriate method to evaluate various design concepts. As a consequence, applying the Kansei Engineering methodology for design evaluations requires the extension with Eye-Tracking in order to add data about visual impressions of design alternatives.

Furthermore, Eye-Tracking can be used to detect most relevant components. However, clustering the product is one difficult, but essential step while preparing an Eye-Tracking study. Nevertheless, a more or less detailed cluster of the product goes with different results. The analysis and the evaluation of results were complicated caused by a randomized order of questions and comparisons. Nevertheless, learning effects were minimized. For future studies, the advantages and disadvantages of a random order have to be contrasted and evaluated. Semantic concepts should be selected wisely, that way they are understood by all test subjects in the same manner. Moreover, the time ratios of the presented pictures should be adapted to the recommended span of 14 to 17 seconds for design comparisons. In order to not stress and exhaust the test subjects too much, the amount of semantic concepts could be decreased. As the clock is the most relevant component, the design alternatives could have differentiated more than only in the color of a small area of clock face. Furthermore, the influence of layout and amount of the presented pictures has to be studied in detail in the future.

5. CONCLUSION AND FUTURE DIRECTIONS

In conclusion, results of an Eye-Tracking study can be used to optimize synthesis as well as validation of the determination of the product structure as well as the generation of a semantic framework (also see Schütte, 2005). Moreover, measuring the visual impression of product alternatives via Eye-Tracking can be used to build a model which aligns a product strategy to specific product characteristics and technical parameters. Nevertheless, Eye-Tracking or other objective measurement applications (e.g. GSR, EMG) should be used to optimize the methods of determining the product structure as well as to generate the semantic framework (see Fig. 9).

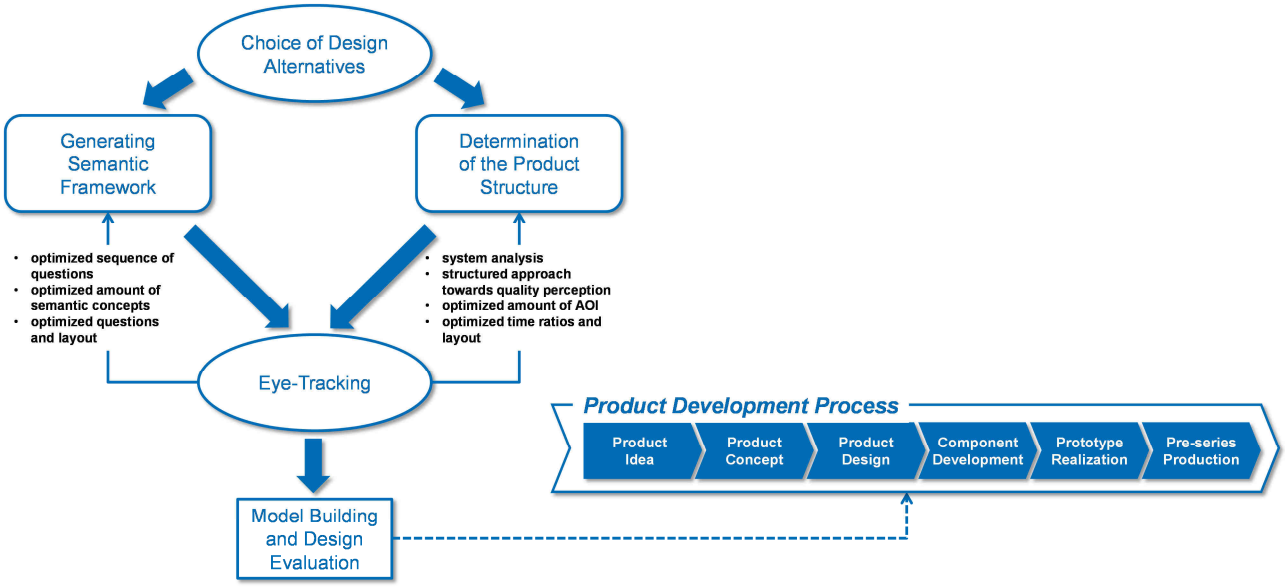

Figure 9: Extending Kansei Engineering for design evaluations in PDP by Eye-Tracking (adapted from Schütte, 2005)

The presented methodology revealed how to use visual measurement systems as Eye-Tracking to define relevant components of products and to compare different product designs on different levels of perception. The presented results are valuable input data for all steps of PDP, especially for early phases. Eye-Tracking within the Kansei Engineering methodology can be applied to align customers' product understanding with technical and functional parameters in order to design

products with a high Perceived Quality. Moreover, the results show that usual techniques for gathering customers' product impressions (e.g. questionnaires) should be supported by more objective application in order to understand customers' product evaluations and decisions entirely. In the future, the main effects on customers' perception have to be proven and validated by further research. Moreover, the methodology can be extended by studying further levels of customers' perception, e.g. the level of descriptors.

ACKNOWLEDGMENTS

The paper presents results from the cooperative research project CONEMO (funded by CORNET program) of the Laboratory for Machine Tools and Production Engineering (WZL), RWTH Aachen University, Germany together with the Institute of Biomechanics of Valencia (IBV), Spain. The funding agencies are IMPIVA (Operational Programme FEDER of the Comunidad Valenciana, Spain) and AiF (Germany). The CORNET promotion plan 47 EN of the Research Community for Quality (FQS), August-Schanz-Str. 21 A, 60433 Frankfurt/Main has been funded by the AiF within the program for sponsorship by Industrial Joint Research and Development (IGF) of the German Federal Ministry of Economic Affairs and Technologies based on an enactment of the German Parliament. The authors would like to express their gratitude to all parties involved.

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The relationship between Nagara action and working memory

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Abstract: In Japan, multi-tasking action is commonly referred as ***Nagara* action.** Nowadays, it is important that to think about relationship between *Nagara* action and products because of pursuing the convenience. On the other hand, inspite of difficulty of doing *Nagara* action in cognitive process, people can do *Nagara* action. The back of this topic, we think Working Memory is related. Working memory is a kind of short term memory, but it is not static but active and has important roll to support cognition. We think that when people do *Nagara* action, they use working memory for one task. So in this paper we aim to reveal the relationship between *Nagara* action and working memory, and experiment on like below with Picture Span Test. -1.Subjects is tested Picture Span Test(PST) for measuring capacity of working memory. 2.After testing PST, they answer the questionnaire about “How many *Nagara* action do you do in daily life”. 3.We analyze correlation between capacity of working memory and the frequency of *Nagara* action in daily life. From the above, we find the correlation between *Nagara* action and working memory and people whose capacity of working memory is higher tend to do *Nagara* action.

Keywords: behavior, interaction, kansei process, parallel attention, working memory

1. INTORODUCTION

1.1. Background

After the smartphones become popular communication tool, occasions for multi-tasking action, including parallel attention, tends to have risen in daily lives. In Japan, this kind of multi-tasking action (doing something while already doing original action) is commonly named as *Nagara* action. *Nagara* means ‘do while’ in one word of Japanese. Recently, accidents caused by *Nagara* action through the use of mobile phones in the public places such as train station or while driving a car are also consequentially increasing. In 2011, Google presented the concept of “Google Glass”, an argument reality eyewear which projects a smartphone-like experience with voice-enabled

interaction into the field of vision. Devices such as this, considering its convenience of use and multi-tasking capacity, might further intensify activities with *Nagara* action.

In this situation, we think that *Nagara* action is an important factor to contribute the developing devices and products and it is aim to identify more safe and smart ways to engage in *Nagara* action.

We found that *Nagara* action can be divide into two types, one is Uniprocessing *Nagara* Action and another is Piural processing *Nagara* action, and *Nagara* action starts because people could not stop the previous task they already began before they added another task to fills up the intervening times in previous research.

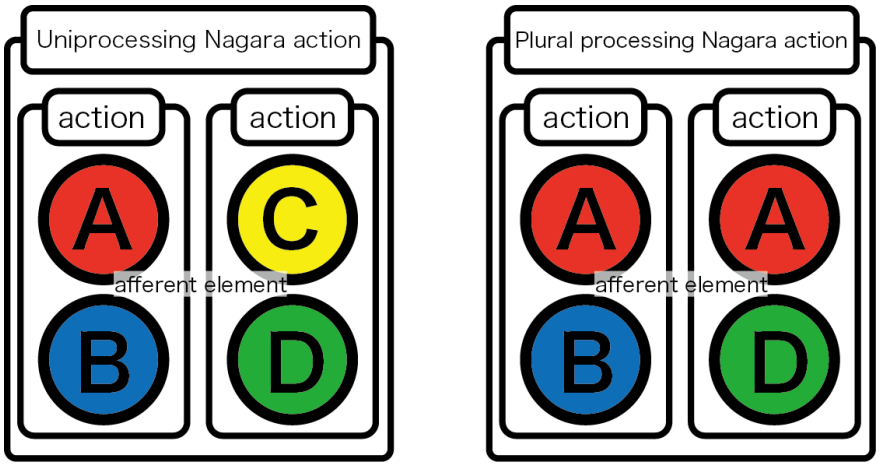

Figure 1: Description of *Nagara* action

On the other hand, Wicken said that if two tasks need one Resources, they will block each other as compared to when they need separate Resources(Wicken, 2002). However people can do *Nagara* action in such situation. How is *Nagara* action done in such situation?

1.2. Purpose

In this research, we focus on working memory, which is a kind of short memory. Our goal is revealing relationship between *Nagara* action and working memory using the Picture Span Test which is the test tool of visual working memory.

2. ABOUT WORKING MEMORY

Working memory is a kind of memory which has some features like that: memorizing 7+-2 matters for form 30 seconds to several minutes, deciding action to choice the information from the outside. Working memory is differ from short term memory which maintains information just as it is, and positively process the information.(Osaka, 2000)

There are two kind of working memory, one is visual working memory and another is verbal working memory. So we think that visual working memory is related to *Nagara* action.

Working memory has a capacity. There are differences among individuals and people whose capacity is large tend to remove interference information effectively, conversely people whose capacity is small tend not to remove them.

Furthermore working memory has an attentional control function which can advert to requisite information and ignore to redundant information. And this function's indicator is the capacity of working memory. Our goal oriented action is based on this function.

It can be said that working memory has important roll to support the foundation of highly cognition.

3. THE RELATIONSHIP BETWEEN WORKING MEMORY AND NAGARA ACTION

From the above, there are the relationship between *Nagara* action which process in two sensory areas and working memory. So we think that people whose capacity of working memory, in a word, span is high tend to work attentional control function well so that the corresponding of *Nagara* action is also high.

4. EXPERIMENT

To reveal the relationship between Nagara action and working memory, we do the experiment using Picture Span Test (Tanabe and Osaka, 2009) and questionnaire.

4.1. About Picture Span Test

Picture Span Test (PST) is the test tool of measuring the capacity of working memory developed by Tanabe and Osaka, Kyoto University. In addition to remembering a designated target object, subjects are required to judge whether each object in the scene is likely to appear in the situation of the background or not. Procedure is like that:

1. Subjects were presented with a set of scene images for 4 sec.

2. The task required judging whether each object was congruent with the semantic constrains imposed by the background of each scene image,

3. while concurrently remembering the part of the target surrounding with a red square frame. The frame was presented for the final 1 sec of the duration in order to prevent subjects from memorizing target without judging the context.

4. Subjects were instructed to respond by clicking the button placed on the computer screen.

5. The set size of PST is increased from 2 to 5, and in each set size five trials are performed.

(Tanabe,Osaka 2009)

4.2. Method

At first, we test PST for subjects (16 students at University of Tsukuba, 8 male, 8 female, age range is 21-43years). After testing PST, subjects are required to answer the questionnaire about *Nagara* action in daily life. The questionnaire is composed of 8 questions about visual Uniprocessing *Nagara* action and 8 questions about visual Piural processing *Nagara* action which we often do in daily life. These questions are required to choose the answer from [often do / sometimes do / not to do] in each time. In addition, there are 4 expletive questions about *Nagara* action. These questions are required to choose the answer from [Yes / No].

The list of questionnaire

Q1. Manuevering a mobile phone while riding a bicycle

Q2. Eating while manuevering a mobile phone

Q3. Manuevering a mobile phone while up or down the stairs

Q4. Reading a book while watching TV

Q5. Watching TV or mobile phones while brushing teeth

Q6. Telephoning using a mobile phone while walking

Q7. Eating while manuevering a PC

Q8. Manuevering a mobile phone while walking

Q9. Looking at something else while driving a car

Q10 Eating while watching TV

Q11 Listening to the music while reading a book

Q12 Write someting while talk with someone

Q13 Walking with map or map app

Q14 Looking at car navigation system while driving

Q15 Eating while walking

Q16 Listening to the music while manuevering a PC

Q17 Do you use bicycles or cars well in daily life?

Q18 Do you use smart phones well in daily life?

Q19 Are you good at doing Nagara action?

Q20 Have you ever been in danger because of Nagara action?

Figure 2: List of the questionnaire

4.3. Analyze

We compute a correlation coefficient between the score of PST and the score of the questionnaire. We convert the answer of Q1~Q16 in the questionnaire “often do” and “sometimes do” into 1, and “not to do” into 0. The total of Q1~Q16 is called Sum A, the total of questions about Piural processing *Nagara* action in Q1~Q16 is called Sum B.

Subjects whose score of PST is more than 55 are assigned to one group “high span” (in other

words “large capacity”), and the other group consisted of subjects whose score of PST is less than 24 “low span” (in other words “small capacity”).

4.4. Result

The result of PST is the number of “high span” is 5, and the number of “low span” is 1. We expected that the number of “high span” and “low span” are almost the same. However “high span” is a lot more (31%) than “low span” (0.6%).

The correlation coefficients between PST and Sum A, Sum B are summarized figure 3, the correlation coefficients between PST and Sum A is .539, and between PST and Sum B is .498, which showed that the score of PST correlated with *Nagara* action. And both correlation coefficients are significant.

Correlation coefficients

		PST score	Sum A
PST score	Pearsons ‘	1	.539*
	P value		.031
	N	16	16
Sum A	Pearsons ‘	.539*	1
	P value	.031	
	N	16	16

Correlation coefficients

		PST score	Sum B
PST score	Pearsons ‘	1	.498*
	P value		.049
	N	16	16
Sum B	Pearsons ‘	.498*	1
	P value	.049	
	N	16	16

Figure 3: The correlation coefficients between PST and Sum A, Sum B

5. DISCUSSION

High score of Sum A means that people do more *Nagara* action in daily life. So the correlation coefficient between PST and Sum A shows that people whose span of working memory is high tend to do *Nagara* action in daily life as compared to people whose span of working memory is low.

Piural processing *Nagara* action happens to be added new task (task B) to previous task (task A). Because two stimuli are processed in one sensory area at the same time, they impede each other.

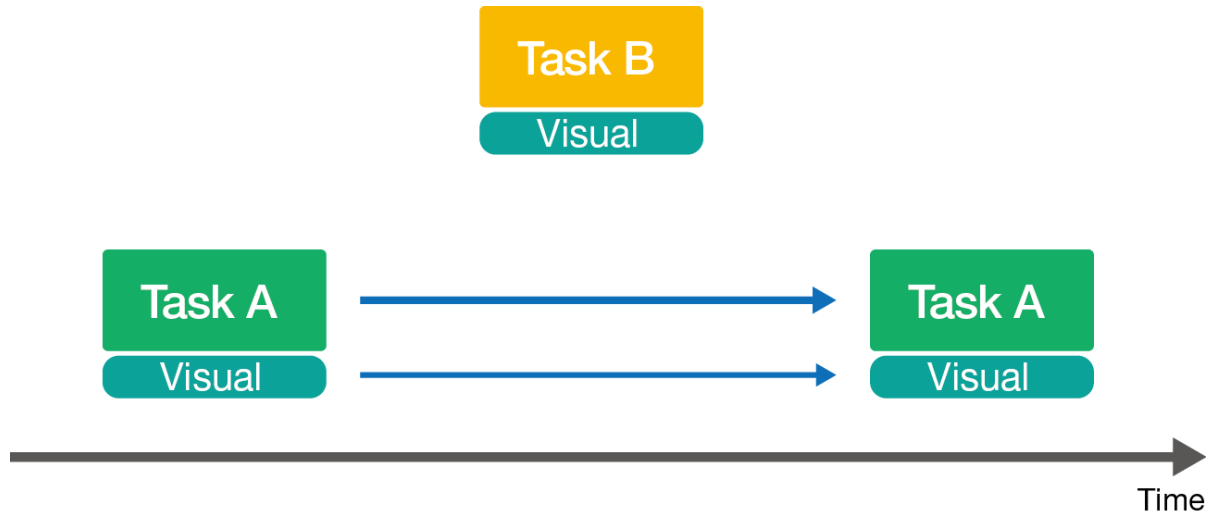

Figure 4: The mechanism of Piural processing Nagara action 1

However, because of the correlation coefficient between PST and Sum B, it can be said that people do *Nagara* action using working memory for processing task A and sensory area is used for only processing task B.

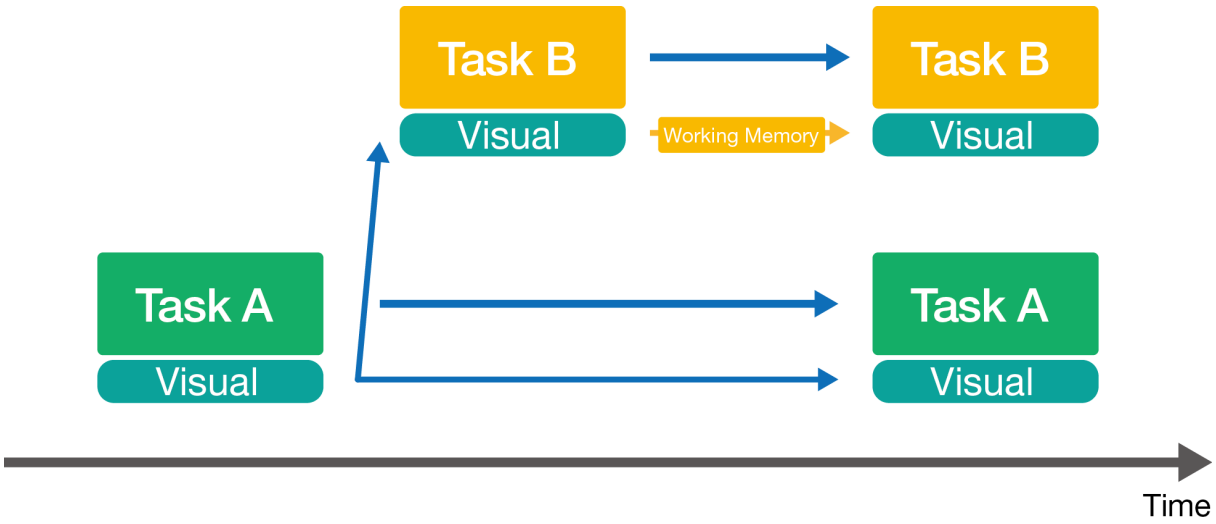

Figure 5: The mechanism of Piural processing Nagara action 2

Almost subjects answered “yes” in Q20 ”Have you ever been in danger because of *Nagara* action?”. It is thought that to keep on processing task A in working memory in spite of slipping on between a present situation and remembrance by working memory causes the occur of accidents because of *Nagara* action.

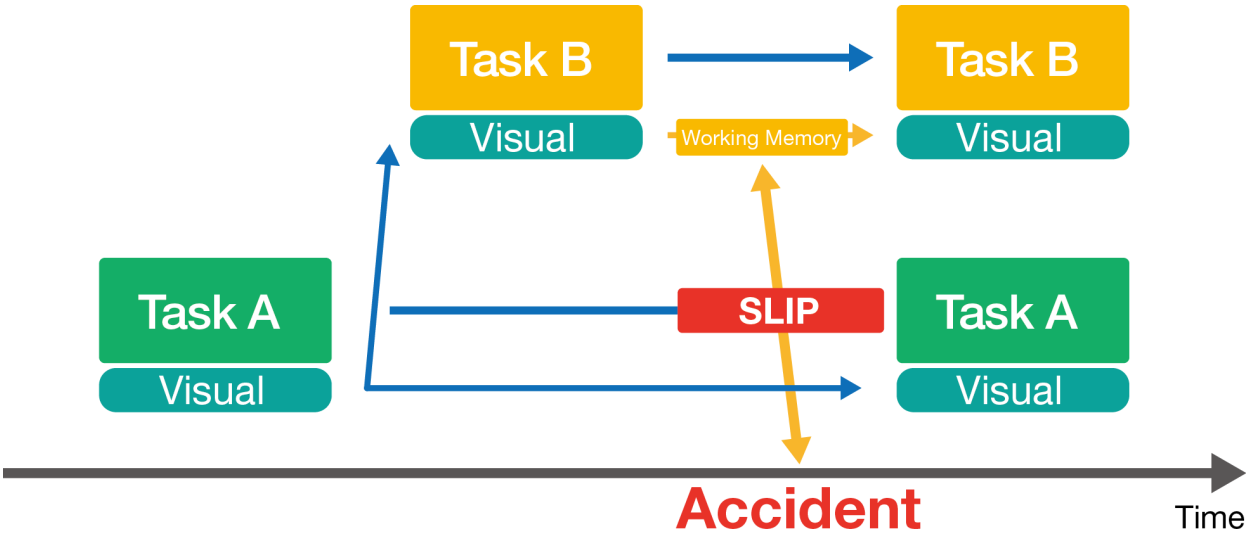

Figure 6: The mechanism of Piural processing Nagara action 3

6. CONCLUSION

From the above, it can be said that working memory is correlated with Nagara action and people whose score of PST is high tend to do more Nagara action as compared to people whose score is low.

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EYE TRACKING BASED ANALYSIS OF EFFECTS OF MOTIF COMPOSITION ON IMPRESSIONS OF PAINTINGS

In the case of Katsushika Hokusai's "Thirty-six Views of Mount Fuji"

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Abstract: The presence of pictures that people recognize as great beyond the borders of cultural differences over 100 years could suggest that such paintings would have certain aesthetic elements in common, and if people are able to recognize them through a shared sense of beauty, it might be able to study what kinds of properties influence people's evaluation of paintings. This paper investigates influences of motif compositions on impressions of pictures. In the first experiment, participants were asked to answer their impressions of the printings using two kinds of rating scales: information rate scale and semantic differential scale, where "symmetry", "complexity" and "order" are defined as the elements of "beauty". Results showed that these three perceptual features influence strongly on people's impressions. However, this experiment poses some questions. Do participants sense the existence of the golden ratio from motif composition? In recognizing that the ratio had been broken, did their impressions change as a result? Do their impressions change according to degrees of symmetries of motif, no matter if the golden ratio exists? To find answers to these questions, we conduct the second experiment to analyze the relationship between motif compositions and gaze movements detected by an eye-tracking system.

Keywords: Beauty of Paintings, Motif Composition, Golden Ratio, Eye-tracking

INTRODUCTION

BACKGROUND AND PURPOSE

There are pictures that have been almost universally recognized as great for over 100 years, such as Da Vinci's "The Last Supper" and Monet's "Water Lilies." Their existence suggests that there are certain common aesthetic elements among great paintings, and if people can recognize them through a shared sense of beauty, we can identify the properties that influence people's evaluation of paintings.

Many theorists dating back to ancient Greece saw that "one of the factors of beauty is symmetry" [Arnheim(1974),Birkoff(1933),Gombrich(1984),Humphery(1997)], and symmetry-based order is also a factor [Birkoff(1993)]. Birkoff, who described the two defining features of beauty, complexity [Eisenman(1967),Berlyne((1970),Jacobsen(2002)] and order [Birkoff(1933)] as the aesthetic properties, suggested that perceptual features and beauty are closely related. With regard to "symmetry," recent research found that "sexual attractiveness is strongly related to the degree of body symmetry as sex-typical bodily characteristics function as a signal of underlying developmental stability, and such research therefore predicted that these characteristics would negatively correlate with FA in bodily features in general" [Brown(2008)]. From this theory, one may assume that people would have innate criteria of "beauty." The argument of this theory is that there can be no existence of a perfect bilaterally symmetric body, but humans know instinctively that a high degree of body symmetry indicates its underlying genotypic quality, hormonal and health status, competitive ability, reproductive potential, or some combination of these factors; thus, people tend to be attracted to another sex peer with a highly symmetric body. One may then assume that people always instinctively judge whether the object is bilaterally symmetric when they see anything. If bilateral symmetry can be considered one of the factors of beauty [Arnheim(1974), Birkoff(1933),Gombrich(1984),Humphery(1997)], people would have instinctive judgment of whether the target is beautiful; moreover, this judgment should be instinctively based on competition for survival. One theory holds that a perceptual feature such as symmetry is processed during the initial phase in the psychological model of the aesthetic experience judgment [Leder(2004)].Based on these issues, one may think that judgment of the aesthetic level of beauty should be decided within a few seconds, at the initial sight.

In this study, we hypothesize that beauty should be easy-to-understand, super-rational, implicit knowledge, and the purpose of the study is to construct an automatic recognition model of aesthetic evaluation that can measure the level of beauty underlying systematic algorithms. First, focusing on a visual art such as a painting, we investigated which elements make paintings beautiful.

We adopted the "golden ratio" as one of the scales of beauty; this ratio (1:1.618) widely exists throughout nature and in the arts, such as in the Khufu Pyramid of Egypt (the ratio of the height of its triangular face to half the side of its base), the Venus de Milo (the ratio of its body proportions), the chambered nautilus shell (the ratio of its spiral structure), and so forth. The golden ratio has been introduced into much research that discusses the nature of beauty; for instance, in various art domains, researchers confirmed the existence of the golden ratio by adding auxiliary lines into compositions that used it [Livio(2003)]. In the Oriental art domain, researchers used it for analyzing the structural ratio of Buddha statues [Matsubara(2008)], and Kansei engineering adopted it to analyze the properties of the attractiveness of a human smile [Sugawara(2004)].

The psychological model of aesthetic experience judgment [Leder(2004)] showed that affective processing is defined in five steps: perceptual analyses, implicit memory integration, explicit classification, cognitive mastering, and evaluation. These affective evaluations are sequentially processed. Perceptual features like symmetry, complexity, and order are processed in the initial phase. The processing of these perceptual features tends to elicit positive emotions because of a significant feature they hold, which is an "easy to identify stimuli's physical properties" [Reber(2004)], as indicated by psychological and physiological findings. We followed these traditional theories, and the focus of this experiment was to explore correlations between the perceptual features and affective state induced by stimuli.

This study investigated the influence of motif composition on people's impressions of Hokusai's paintings, particularly focusing on their perceptual features. In this analysis, we adopted the perceptual features symmetry, complexity, and order. As relevant research suggests, "beauty induces pleasurable experience" [Herzberger(1989), Santayana(1995), Tatarkiewicz(1970)]; therefore, we used "pleasant-unpleasant" as the affective state factor, and "aroused-unaroused" as the influential factor that causes a change in feeling. We asked participants to evaluate the original picture and a re-worked version, in which the motif composition had been changed, to analyze the relation between perceptual features and affective impressions of paintings.

If a relationship is revealed, the processes behind the human aesthetic experience is further clarified and enables construction of an automatic recognition of aesthetic evaluation that can measure the level of beauty underlying systematic algorithms as the final goal of our study. First, in focusing on a visual art such as painting, we investigated which elements make paintings beautiful.

1. STANDPOINT OF BEAUTY

As the factors of the beauty of paintings, two aspects: physical properties make people sense beauty and psychological properties make people feel physical responses such as "beautiful." In this study, we defined physical factors as attributed to material nature, and psychological factors as attributed to psychological nature. Thus, psychological factors can be considered perceptual factors that recognize objects as creating meanings such as symmetry, complexity, and emotional factors such as pleasantness caused by perceived features. We defined "measure" as the level of influence of effect for the impressions of beauty caused by physical and psychological factors.

1.1. Hokusai's painting style

Previous studies evaluate Hokusai's paintings as having "elements of surprise," being "full of wit" and "unpredictable" [Fukumoto(1947), Narasaki(1980), Tsuji(1972), Ukiyo-e Society(1994), Yanagi(1957)]. We believed that such evaluation would result from his works having certain influential factors that arouse such positive responses.

Strong relationships exist between positive awareness and pleasantness [Fujimoto & Suzuki(2007), Russell & Block(1985)], and so one could say that Hokusai's works somehow cause pleasant feelings. Haltmann, who proposed a structural analysis of beauty, said that the basic structure of the acceptance effect in aesthetic experience comprises sensuous and inner intuition, and only when people sense pleasantness from these factors' interaction, does the object become beautiful [Haltmann(2001)]. Because intuition is in the basic structure of aesthetic experience and pleasantness, and the pleasantness feeling based on that institution and perception of beauty are explained as very close in this research, the psychological factor that Hokusai attempts to elicit should be "pleasantness." Let us examine how he attempted to convey "pleasantness" in his work.

1.2. Hokusai's method

For Japanese woodblock artists, the artistic process or technique was a valuable secret, so that most of them were reluctant to show it, but Hokusai, who was not only a gifted woodblock artist but also a talented educator, published many text books such as "Hokusai manga" to mentor many pupils. Through these teaching books he revealed his distinguishing characteristic method of composition. For instance, according to "Ryakuga-Haya-Shinan" (One point lessons for rough drawing), published when he was 53 years-old, he described the method of drawing with a compass and scale, based on the fundamental rule that the basic shape can be a circle and triangle [Yanagi(1957)]. Researchers have noted that in "Thirty-six views of Mount Fuji," he tried to resolve natural forms to perfect geometric figures [Tsuji(1972)]. Thus, his practice concurs with Cezanne's famous words, "The whole configuration can be summarized as circles, circular cones, and circular cylinders" [Zeki(2000)]. For Hokusai, there is no doubt that the geometrical composition was his vital strategy to create his characteristic work.

Regarding his composition method in "Thirty-six views of Mount Fuji," of a total of 46 pictures, 2 adopted 2-part-segmentation, 17 adopted 3-part-segmentation, 8 adopted both odd-even segmentation, and others adopted Hokusai's distinctive method called "Hokusai's 3-part-segmentation", "telescopic method", "back and forth placement of triangles", "circle and triangle composition", and so forth [Yanagi(1957)].

The "telescopic method" is the manner of using certain motifs such as barrels, waves, and bridges to resemble a peephole, and set Mount Fuji inside the hole, to make the mountain appear from the small place. "Back and forth placement of triangles" describes triangle motifs such as house roofs allocated back and forth to create a rhythm [Fukumoto(1947)]. "Hokusai's 3-part-segmentation", especially as adopted in many instances, arranges screens in 3 partitions: top, center, and bottom, and sets the sky or land in one-third of the area, which is obviously affected by Western methods. To be precise, in "Thirty six views of Mount Fuji," we observe "Koshu-Mishima-Etsu," whose layout is "Hokusai's 3-part-segmentation" [Figure 1].

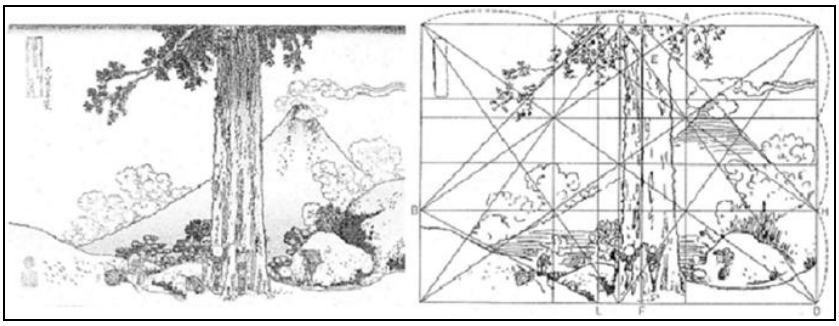

Figure 1: The composition of "Koshu-Mishima-Etsu"

"The Great Wave," [Figure 2] probably his most iconic work, draws a tiny Mount Fuji in the distance among massive waves. Authorities have said that each motif is defined by 2 diagonal lines and 19 circles [Yanagi(1957)].

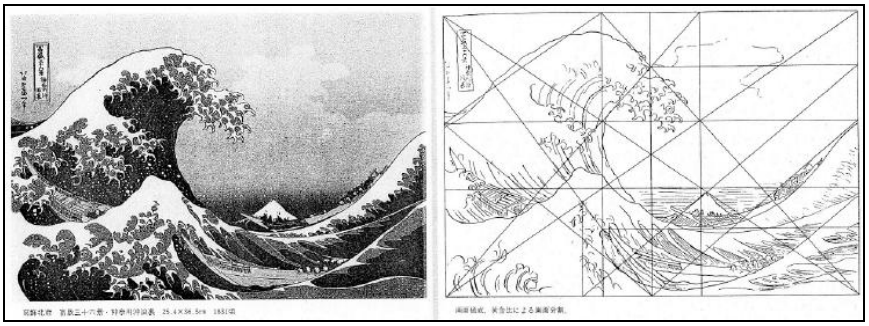

Figure 2: The composition of “The Grate Wave”

Based on these geometric composition rules, the following 4 features are noted [Yanagi(1957)]:

1. Direction and movement. - Set the key motif, Mount Fuji, on the edge of the screen and let painted people point fingers toward the mountain to create a sense of depth.
2. Contrast of color and shape - Drawing Mount Fuji quite small to focus attention.
3. Double motifs. - Although drawing ships and a bridge in the distance, two motifs are similar in shapes and this repetition creates the effect of harmony.
4. Allocation of humans and animals - Allocate living creatures such as humans and many types of animals to cause the feelings of uplift and vitality.

Given these issues, we can consider that Hokusai’s method is to create 4 effects through underlying geometrical rules of composition and motif allocation.

1.3. Aspects of “Thirty-six Views of Mount Fuji”

Various theories explain why Hokusai made Mount Fuji the main motif of this series. There are many records of the facts that during the Edo period, the pilgrimage to Mount Fuji was a great event in everybody’s life. People build miniature Mount Fuji mounds to revere and pray for protection from natural threats. Nothing was higher than Mount Fuji, and so its greatness was remarked by everyone as a symbol of awe to be revered by the Edo people, the most successful people in the country. Thus, Mount Fuji should symbolize Japanese pride and such concepts. In this series, Mount Fuji is not only a motif but also a special symbol with many meanings such as Japan itself, Japanese culture, the greatness of nature, awe, and there being but one unique existence. Mount Fuji is an image with an informational function [Tsuji(1972)]; therefore, it is a special symbol that attracts people’s attention. Hokusai would have been deeply aware of this fact and used this motif as a tool to achieve the purpose of his works.

2. ANALYSIS FINDINGS OF THE PREVIOUS EXPERIMENT

We designed the analysis point of this experiment based on the tentative theory that if people experience beauty upon seeing a golden ratio in a motif composition [Nojo, Muramatsu, Kojima & Matsui(2012)]. In the first experiment, participants were asked to answer their impressions of the printings using two kinds of rating scales: information rate scale (IRS) and semantic differential (SD) scale, where “symmetry”, “complexity” and “order” are defined as the elements of “beauty”. Results showed that these three perceptual features influence strongly on people’s impression of "beauty" of printings. Moreover, the results showed that the three properties of motifs that most influence our impressions are (1) motif size, (2) the ease of recognition of motif composition, and (3) the balance of motif composition.

3. ANALYSIS POINT OF EYE-TRACKING EXPERIMENT

There remain some questions—in the first place, do participants sense the existence of the golden ratio from motif composition? In recognizing that the ratio had been broken, did their impressions change as a result? Alternatively, was their change in impression not related to the ratio? Did their impressions change due to a change in the symmetry of motif composition? How did they perceive the edge lines of each motif, and is this a result of recognizing them? To find answers to these questions, we use an eye-tracking system to confirm the following three points.

1. Whether people watch the center point of the large motifs such as Mount Fuji or others.
2. Whether the eye-line moves to check size of motifs (height and width).
3. Whether the eye-line moves to check the distance of the motif's center point from the screen edge.

If the subject recognizes the golden ratio as we established in the previous experiment, the result would demonstrate that the eye movements concur with the above three points, but if not, we can conclude that other factors affect the impression of beauty.

4. REVIEW OF LITERATURE

4.1. Studies of the physiologic function of eyesight

It has been observed that in screen watching, the eyesight tends to move in the horizontal direction and returns to the same point just before it observes, in reaction to the screen. [Shioiri(2007)]. Further, the distance between objects (distance or background) affects the functions of the neuropsychology of eyesight. Kovacs, Feher, and Julezs found that the sensitivity of brightness contrast becomes high around the medial axis point of a figure [Ogawa & Inui (2011)]. One visual feature is the "attention model", which shows that intentional selection is caused by changing contrast sensitivity, space frequency, or brightness [Ogawa & Inui (2011)]. Humans have been observed to possess space coordination, called human-object-centered coordinates, which exists in the brain's right PMv, with a visual perspective point called the "cyclopean eye" [Ogawa & Inui (2011)]. Human can optimize their behavior space with much stronger sense of horizontal direction than vertical [Gregory(1997)].

4.2. Early studies related to visual issues and paintings

During picture appreciation, eye movement shows a "wide search", which glances around the entire picture and "specific search" (stay time is more than 300 ms) [Shioiri(2007),Solso(1994)]. A study of attention selection based on objects found that each unit of selection is an object [Taketani(2011)]. In the aesthetics domain, regarding visual images and paintings, there is a "right-half side matter" that insists "the most important content exists on the right-half side of the art painting" [Restak(1979), Nakatani & Fujimoto(2002)]. Related to this issue, in psychological fields focusing on the visual gap caused by cerebral hemispheric asymmetry, and based on many experiments, Restak noted that the main factor of the visual gap can be explained as hemispherical asymmetry, and people tend to be more attracted to the picture that has a major emphasis on the right side of the screen [Nakatani & Fujimoto(2002)]. Moreover, later research found that when the picture has some directional meaning, people are attracted to a picture drawn with the primary motifs on right side, but direction has preference from left to right [Nakatani & Fujimoto(2002)].

4.3. Psychological study of visual information

According to the early study, human faces have an especially strong property of drawing attention. This is a baby's innate function based on the survival instinct to identify its mother [Gregory(1997)]. In addition to the human face, animal motifs or characters have the same property. The same study found that babies have an innate ability to grasp spatial features such as depth; therefore, it is a genuinely innate ability to accurately perceive distance in motifs drawn on pictures [Gregory(1997)].

5. THE PRESENT EXPERIMENT

5.1. Experiment design

We use Tobbi technology's T60 Eye tracker which provides a 23.5 inch LCD monitor with an integrated eye-tracking system. It performs binocular tracking at 60 Hz and allows for head movement within a 44 × 22 × 30 cm volume centered 70 cm from the camera. The distance from the eye to screen is 53 cm, displayed gray-scale 1920 × 1080 pixel images on the screen. The participants are 19 students (3 females and 16 males) aged from 23 to 50 years, who viewed the 8 stimuli presented on the screen for 30 second each.

5.2. Materials and methods

We totally prepared 8 pictures including 4 original and 4 reworked pieces from the previous our experiment [Nojo(2012)], at the evaluation scores of the 1st experiment, they showed obvious differentials in 3 psychological factors such as "Symmetry", "Order" and "Complexity", between the original and the worked.

In this experiment, we saw the golden ratio as "a visual balance which is created by dividing an area" [Livio(2003)], with two underlying rules: (1) the ratio of the lesser segment to the greater segment should be 1:1.618 and (2) the dividing point of either the greater or lesser segment should be on the center line of the Mount Fuji motif. Figure 3 shows the original picture on the left side, which has the golden ratio indicated by a solid arrow and dashed arrow, and the re-worked picture on the right side in which the Mount Fuji motif was moved to disrupt the ratio.

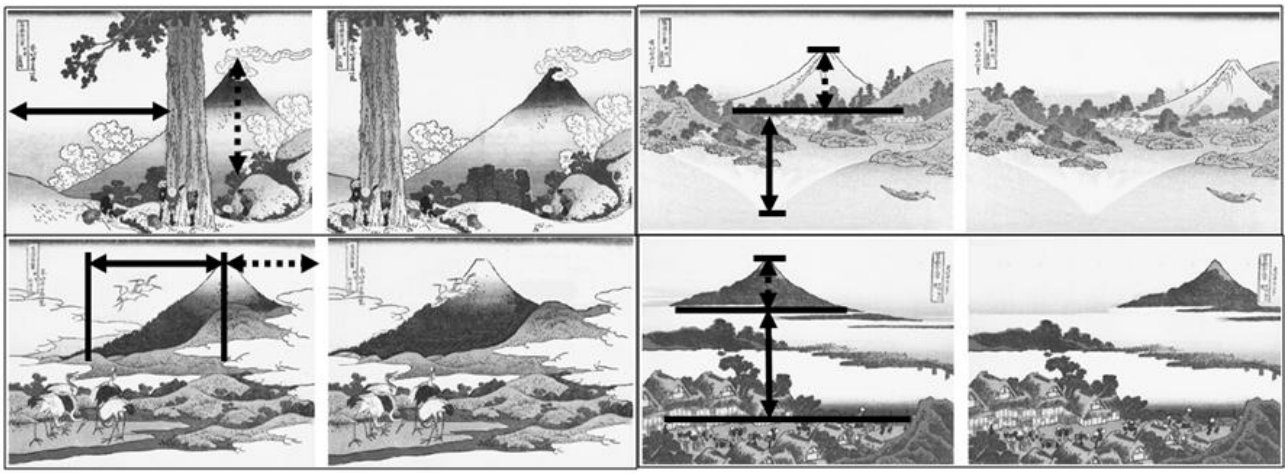

Figure 3: The 4 pairs of stimuli. Originals on the left, re-worked on the right.

"Koshu-Mishima-Etsu," the ratio is found in the spaces to the left and right of the tree and the height of Mount Fuji; we disrupted it by moving the tree farther to the left. This stimulus also has

another golden ratio in the distance from the foot of Mount Fuji and its height. “Soshu-Umesawa-Hidari” shows the ratio in the distance from the beginning of the slope of the mountain to its top, and the space between the top and the right edge of the picture; we moved Mount Fuji to the center to disrupt the ratio. In “Koshu-Misaka-Suimen,” the ratio is found in the height of Mount Fuji and the height of Fuji’s reflection on the lake; we moved the Fuji motif. “Koshu-Isawa-Akatsuki” shows the ratio in the height of Mount Fuji and the distance from foot of the mountain to the village road; we moved Fuji again to the right side to disrupt the ratio. And using the free software Ogama, we analyze the results.

6. RESULTS

To validated the three hypotheses listed in Section 3, we extracted a 300 [ms] retention point from the result of experiment, based on previous research [Yoshitka,Nishida&Hirashima(2009)]. Due to the error, 2 participant data was unable to use, therefore totally 17 data was based on following result.

KOSHU-MISHIMA-ETSU (ORIGINAL / WORKED)

The distinctive findings were in the original, people gaze at the center point of the picture (Figure 4), even though there seems nothing particular about the motif without serried bore lines with a bit of dark contrast. As shown in figure1 in the section 1.2, this point is just the geometrically center of this painting. In the worked version, it did not occur. In both cases, the point receiving the most attention was the center -positioned-person among the pilgrims, the person drawn third (5.0%) from the left side in the original, and in the worked, it is the fourth person (5.9%) from the left [Table1]. In the case of existing same kind of motifs in the horizontal way, such as pilgrims in this case, people tend to check the center positioned motif among the motif group. The little person drawn first from the right side, leaning on a giant rock located at just under the crest was gazed almost as same times as top of Mount Fuji, a vertical connection lines between this person and the top of Mount Fuji were especially prominent. The eyes traced over the line from the crest to the left side of the mountain skirts. Triangle lines connected the top of Mount Fuji, the end point of the mountain skirt, and a giant rock located at the lower right. Triangle-like eye trace lines were also found between the signature, top of Mount Fuji, and the end of the mountain skirt.

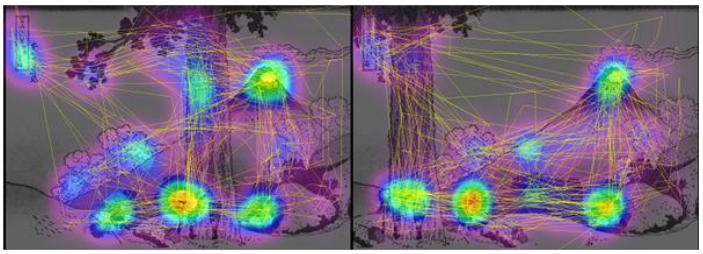

Figure 4: The result of “Koshu-Mishima-Etsu”. (original on the left, worked on the right.)

SOSHU-UMESAWA-HIDARI (ORIGINAL / WORKED)

In the original, the top fixation point was flying cranes. The horizontal connection lines from

this point to the signature and to the top of foreground mound were incessantly caused. Two standing cranes abreast on the alley were gazed at almost same times each other. In the worked, the top gazed point was the rightmost standing crane. It was prominent that the vertical eye-tracking lines between the flying cranes and the center point of this screen were incessantly occurred. And the fixation rate of the top of Mount Fuji was the lowest (1.2%) in this experiment [Table1], people watched the flying cranes (6.4%), allocated foreground of Mount Fuji.

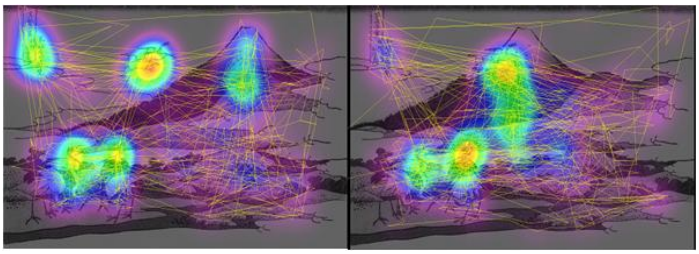

Figure 5: The result of “Soshu-Umesawa-Hidari”. (original on the left, worked on the right.)

KOSHU-MISAKA-SUIMEN (ORIGINAL / WORKED)

This picture has a strong symmetric composition with two images of Mount Fuji, rising from the ground and mirrored on the lake (Figure6). All participants gazed at the center point of these symmetric motifs many times in the both the original and worked versions [Table1]. It found many eye derivations, from the top of Mount Fuji to the top of mirrored, through the center point. The triangle zone comprising the top of Mount Fuji, the center point, and right side of the center the end point of the slope of the foreground mound. A very tiny triangle figure allocated on the edge line of the left side of lake, was gazed in both cases. In both cases, eye moved on very the line of slope of Mount Fuji. The fixation time of signature was very much less than the center point.

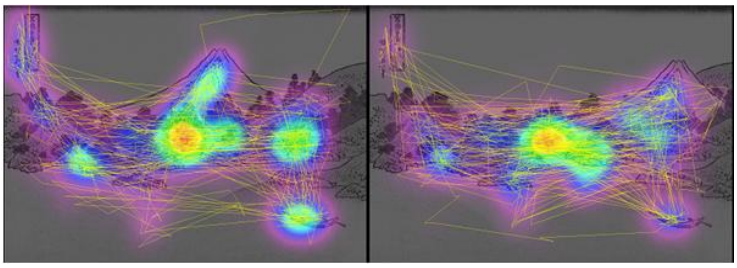

Figure 6: The result of “Koshu-Misaka-Suimen” (original on the left, worked on the right.)

KOSHU-ISAWA-AKATSUKI (ORIGINAL/WORKED)

In the original, top of Mount Fuji and the long islands which is allocated vertical below of Mount Fuji, and pilgrims were traced in all cases. The horizontal line from the signature to the top of Mount Fuji was caused in many cases. In the worked, the eye derivations between the center point of Mount Fuji and the other each high-contrasted motif were occurred. Gazing at left side of Mount Fuji, even where there is no motif was confirmed. The center of Mount Fuji, not the top, was gazed many times in the worked. In both cases, slanting movements from the top downward particularly occurred, and tended to move to the point with high contrast in a top-downward direction.

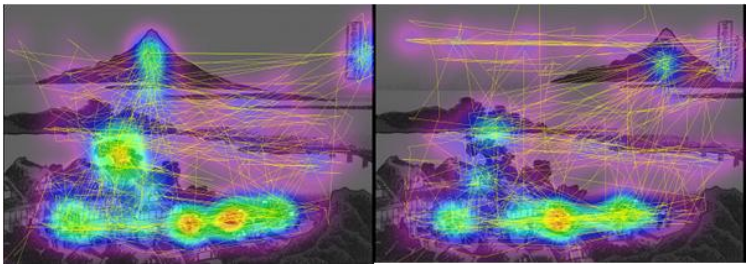

Figure 7: The result of “Koshu-Isawa-Akatsuki”. (original on the left, worked on the right.)

Regarding to several feature points where people gazed at very frequency, we analyze its efficiency based on the number of fixations as follows;

		Feature points										Other Fixation Points	Total Fixation Points
		Mt.Fuji	Signature	Humans, Animals					Koshu-Misaka-Suimen				
		Top							Mirrored Mt.Fuji	Center Point			
Koshu-Mishima-Etsu Original	No. of Fxation	72	129	80	88	94	46	80	-	-	669	1,194	1,863
	No.of Fix / Total	3.9%	6.9%	4.3%	4.7%	5.0%	2.5%	4.5%	-	-	35.9%	64.1%	
Koshu-Mishima-Etsu Worked	No. of Fxation	104	164	79	73	35	115	78	-	-	673	1,286	1,959
	No.of Fix / Total	5.3%	8.4%	4.0%	3.7%	1.8%	5.9%	4.4%	-	-	34.4%	65.6%	
Soshu-Umesawa-Hidari Original	No. of Fxation	66	124	62	147	46	44	105	-	-	625	1,159	1,784
	No.of Fix / Total	3.7%	7.0%	3.5%	8.2%	2.6%	2.5%	5.9%	-	-	35.0%	65.0%	
Soshu-Umesawa-Hidari Worked	No. of Fxation	23	96	48	106	56	44	123	-	-	496	1,412	1,908
	No.of Fix / Total	1.2%	5.0%	2.5%	5.6%	2.9%	2.3%	6.4%	-	-	26.0%	74.0%	
Koshu-Misaka-Suimen Original	No. of Fxation	53	66	55	60	-	-	-	8	245	582	1,299	1,881
	No.of Fix / Total	2.8%	3.5%	2.9%	3.2%	-	-	-	0.4%	13.0%	30.9%	69.1%	
Koshu-Misaka-Suimen Worked	No. of Fxation	26	68	42	88	-	-	-	17	179	476	1,371	1,847
	No.of Fix / Total	1.4%	3.7%	2.3%	4.8%	-	-	-	0.9%	9.7%	25.8%	74.2%	
Koshu-Isawa-Akatsuki Original	No. of Fxation	60	153	80	69	85	51	-	-	-	517	1,339	1,856
	No.of Fix / Total	3.2%	8.2%	4.3%	3.7%	4.6%	2.7%	-	-	-	27.9%	72.1%	
Koshu-Isawa-Akatsuki Worked	No. of Fxation	48	155	95	60	63	68	-	-	-	526	1,399	1,925
	No.of Fix / Total	2.5%	8.1%	4.9%	3.1%	3.3%	3.5%	-	-	-	27.3%	72.7%	
Average Original	No. of Fxation	63	118	75					8	245	598	1,248	
	No.of Fix / Total	3.4%	6.4%	4.1%					0.4%	13.0%	**32.4%**	**67.6%**	
Average Worked	No. of Fxation	50	121	73					17	179	543	1,367	
	No.of Fix / Total	2.6%	6.3%	3.8%					0.9%	9.7%	**28.4%**	**71.6%**	

Table1: Analysis of feature points

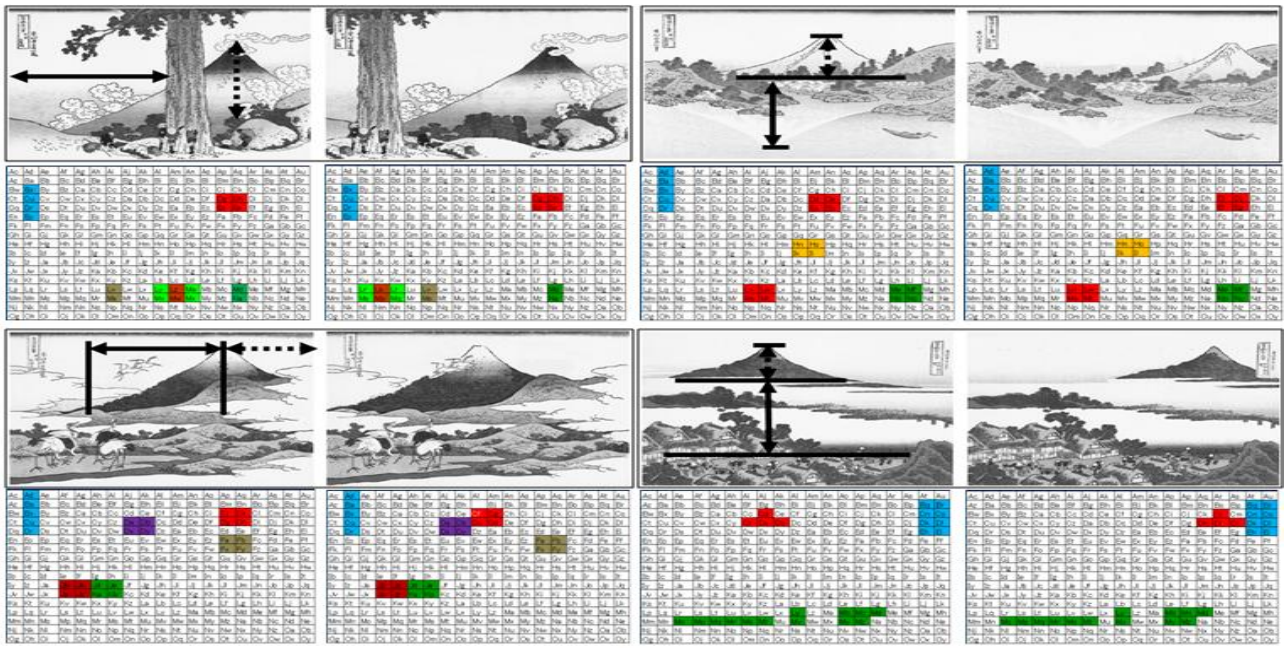

Figure 8: The base data of analysis of feature points. (original on the left, worked on the right.)

This result shows that in the totally around 1,800 fixation points in each picture, in the original, several feature points that we proposed in this paper were account for 32.4 %, Mount Fuji was gazed average 3.4%, signature 6.4%, humans and animals 4.1%. Of special note is in Koshu-Misaka-Suimen, its center point was gazed at over 13.0%, this is the top percentage within other feature points.

7. DISCUSSION

From these results, we confirmed the three purposes of the current experiment, as described below.

1. WHETHER DO PEOPLE WATCH THE CENTER POINT OF THE LARGE MOTIFS SUCH AS THE MOUNT FUJI OR OTHERS, OR NOT.

Without one case, there was no case that people gazed the center point of the large motifs. People tend to watch the feature points (top of Mount Fuji) or feature motifs (animals, humans, signature) in every case. Only the case of worked of Koshu-Isawa-Akatsuki, we could confirm that people gazed at the center point of Mount Fuji. And in this case, there happened many connection lines from this point to other motifs. This eye movement indicating that as if participants were confirming the interspace distances between several motifs suggest that people see motifs' comparative positioning and may want to understand the overall balance of motifs in the picture. Not the center point of the large motifs, but in the case of the originals of Koshu-Mishima-Etsu and Koshu-Misaka-Suimen, people gazed the center of the pictures and this findings may hold a special meaning for viewers.

2. WHETHER THE EYE-LINE MOVES TO CHECK THE SIZE OF MOTIFS (HEIGHT AND WIDTH).

In all original cases, it was confirmed that eyes traced the center line of Mount Fuji, from the top to something feature motifs allocated its vertical lower point. This movement makes viewers check the height of Mount Fuji. But regarding other motifs, there seems nothing particular feature motif to trigger such a movement. This fact suggested that perhaps Hokusai would intend to make viewers sense the perspective of paintings by recognizing the real size of Mount Fuji, —as mentioned in subsection 4.3, we can sense the distance or depth of an object instinctively. — It would be possible if people know its' real height in common. However, in all cases, eye did not moved from this point to the certain end point as we defined as the distance of golden ratio.

3. WHETHER THE EYE-LINE MOVES TO CHECK THE DISTANCE OF THE MOTIF'S CENTER POINT FROM THE SCREEN EDGE.

In all cases, there was no movement to the screen edge. This fact suggested that perhaps people would be able to sense the overall size of the object without explicit eye movement, or the balance of feature motifs would be more important than checking the distance from the edge.

This experiment's results enabled us to confirm how Hokusai's motif composition affects the viewer's eye movements and impressions of paintings.

KOSHU-MISHIMA-ETSU

The result shows that perceiving the “center” should be quite important. If Hokusai intended to make the viewer’s eye movement triangle-like way based on motif allocation, —a triangle is important figure in his method— it succeeded. In this picture as well, most motifs were located at right side. Thus, from the perspective of the previous theory—the “right-side problem” mentioned in Section 4—this picture has many properties that make people perceive this picture as an example of “beauty.”

SOSHU-UMESAWA-HIDARI

There are rhythmical line-position from top of Mount Fuji to foreground mound, and double-motifs such as flying and standing cranes, if Hokusai intended right-left, upper-lower eye movement by these motifs, he did succeed. By the fact that flying cranes were more gazed than the top of Mount Fuji, its weight of importance as motif should be heavier than Mount Fuji.

KOSHU-MISAKA-SUIMEN

According to the fixation analysis [table1], perceiving the center point of the object (13.0%) seems to be much more instinctively important than doing top of Mount Fuji (2.9%), this presumed the existence of “cyclopean eye” as mentioned in section 4.1, search for the symmetric property; thus, humans tend to react easily to symmetry. It means that the symmetric composition should be a physical factor which gives strong influences for the psychological factor of impressions of paintings. This evoked Brown’s theory mentioned at the beginning of this paper, and this picture should give strong impressions of “beauty”.

KOSHU-ISAWA-AKATSUKI

Only a material among 8 pieces in which Hokusai’s signature was allocated at the top right. It seems that Hokusai intended to allocate his signature at a longer distance from Mount Fuji. This suggests that Hokusai treated his signature as one tricky motif to induce eye movement as he intended. Hokusai’s signature, in particular, is a brand symbol, which means that “this picture is not drawn by somebody unknown, but is drawn by Japanese great woodblock printer, Katsushika Hokusai, who has a significant talent with profound skill; this is a very special picture and different from the others” that makes viewers perceive it positively. Also, this signature has a role to enhance the stability of the picture’s left-right and up-down directions; when people observe this picture from the top down, they can recognize the mountains with correct direction and understand that “this is an inverted image.” Therefore, in the series of “The Thirty-six Views of Mount Fuji,” the signature is quite effective as an informatic signal.

These results confirmed that on Hokusai’s geometric motif allocations, 4 effects have occurred as mentioned in Section 1.2, and further confirmed that the special motifs cause eye derivations. As mentioned in section 1.1, If Hokusai attempted to elicit “pleasantness” by his systematic tricky composition method, it seems to be quite succeed. And the outcome suggested that for impressions of beauty of paintings, people would understand the motif balance on the basis of a much simpler ratio, not a subtle ratio such as golden ratio.

8. SUMMARY

For the final target of our research, “construct a system of automatic recognition of the aesthetic level of pictures,” we adapted the golden ratio as the aesthetic measure that affects physical and psychological properties; we also confirmed its availability using an eye-tracking system. However, the results suggest that the golden ratio seems an ineffective influence on the impression of a painting’s beauty. If the golden ratio is adopted as a composition rule, the issue remains for further study.

Based on above results, we suggest 2 physical factors which give influences of impressions of “beauty” of paintings. The first physical factor, which effects for the perceptual feature “symmetry” would be feature motifs and feature points, and the second physical factor, which gives influences for the perceptual factor “order”, can be Hokusai’s unique motif composition rules.

Instead of the golden ratio, what should be adapted as the next “measure” as the level of influence of effect for the impressions of beauty caused by physical and psychological factors. Determining the match rate of composition rules and motif allocations, and the match rate of a motif’s shape and ideal motif shapes? First, when considering the motif’s ideal shape, we adopt Leibniz’s theory of pre-established harmony to the issue of the motif’s figure to assume that “all motifs should have an ideal shape.” Further, from the concept of pregnant figures in Gestalt psychology, Hokusai said in his textbook that triangles and circles are the basic shapes of whole things. In 90 figures that Birkoff displayed as degrees of aesthetics, the top was a square, followed by a rectangle. Cezanne, who set great store on composition, said that everything can be expressed by a circular cone. These theories suggest that the ideal shapes are basic figures such as square, rectangle, triangle, and so forth. If one compares the degree of the matching rate of composition and motif allocation, and the rate of the motif figure and the ideal shape, one could validate this “measure.”

Research in recent years, visual structure has both statistical self-similarity and common predisponency. To benefit from Kant’s words, “art is nature’s copyism” [Kant(1790)], we assume that the properties of “Beauty” would also relate to nature, and we intend to continue our research at that level.

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Analyzing Kansei from Facial Expressions by CSRBF Mapping

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Abstract: This paper describes an application where a new Kansei/Affective Engineering (KAE) system was applied to define the properties of the facial images perceived as *Iyashi*. *Iyashi* is a Japanese word used to describe a peculiar phenomenon that is mentally soothing, but is yet to be clearly defined. Instead of analyzing facial expressions of an individual to determine his emotional state, the proposed system introduces a fuzzy-quantized holographic neural network (FQHNN) to find the rules involved in the Kansei evaluation provided by the subjects about the limited dataset of 20 facial images.

In order to validate and gain a clear insight into the rules involved in the Kansei evaluation process, Procrustes analysis and Compactly-Supported Radial Basis Functions (CSRBF) are combined to generate new facial images. Procrustes analysis is used to find the minimal dissimilarity measure between two facial images with opposite classification (i.e. Iyashi and Non-Iyashi). CSRBFs are proposed for tuning of 17 facial parameters and mapping between facial images within opposite classes. The experiments with two subjects demonstrate that if only two from the five most important parameters of the face are changed then the Kansei evaluation can change to the opposite class. This paper shows that a continuous and efficient tuning of the design space can be achieved by introducing CSRBF mapping into the new KAE system.

Keywords: Kansei evaluation, Iyashi expressions, neuro-fuzzy classifiers, radial basis functions.

1. INTRODUCTION

In an attempt to understand what motivates people to buy consumer products product manufacturers often rely on questionnaires and polls to investigate the consumers preferences and

why they purchase or avoid certain items (Sandhusen 2000, Fitzsimons et al 2002). The major problem with this approach is that, as shown by a variety of studies (e.g. Sandhusen 2000), consumer attitudes and behaviors are frequently formed and influenced by non-conscious emotional and cognitive processing (Fitzsimons et al 2002), which is not subject to detection via traditional survey or interview methods. Here KAE systems (Nagamachi 2011) assume that product-related stimuli (e.g. paintings or photographs) are shown as questionnaires to the consumers and at the same time a machine automatically recognizes and analyzes interactive signals while consumers evaluate what they felt about products in photographs. Then, using simple (e.g. "yes/no") answers to evaluate Kansei words, a comprehensive analysis of those results could play an important role during analysis of consumer state of mind (cognitive and emotional reaction, both conscious and un-conscious) at the time of review, selection or use of a product or product-related stimuli.

1.1. How to measure subject's emotional response to a picture?

Psychological researchers use diverse methods to investigate emotions (Bradley et al 1994, Lang et al 2008, Mikels et al 2005). These procedures range from imagery inductions to film clips and static pictures. One of the most widely used stimulus sets is the International Affective Picture System (IAPS, Lang et al 2008), a set of static images based on a dimensional model of emotion (Russel 1999). The image set contains various pictures depicting mutilations, snakes, insects, attack scenes, accidents, contamination, illness, loss, pollution, puppies, babies, and landscape scenes, among others. However, while many samples are desirable for estimating the response of a person more accurately (e.g. how much the person likes a product), in a real world situation, only a small number of samples needs to be obtained because of the efforts required for the persons to provide their responses from many samples. Hence in this paper as in our previous works (Diago et al 2011) we use a small dataset of portraits to teach the machine to classify the facial images in the same way that people perceive them.

1.2. Why faces?

Facial expressions are our primary means of communicating emotion (Ekman 1978, Russel 1999, Scherer 1992), and that is why the majority of efforts in affective computing concern automatic analysis of facial displays (Pantic et al 2008, Fasel et al 2003, Tian et al 2005). Instead of analyzing facial expressions of an individual to determine their emotional state, using a database of portraits, (Diago et al 2011) showed that machines are also capable of perceiving faces as they relate to the social impressions they make on people. A new method for the quantification of qualitative judgments and evaluations of facial expressions was proposed in order to gain a clear insight into the reasoning made by nonlinear prediction models, such as holographic neural networks (HNN).

1.3. What type of facial expressions?

In previous works (Kitaoka et al 2008), the term "*Iyashi*[1] expressions" was defined to study facial expressions related with the peculiar phenomenon of Iyashi. In Japan, Iyashi is a popular buzzword today, referring to anything that is physically or mentally soothing (Kitaoka et al 2008, Matsui 2008). Iyashi goods -- books, music, pictures, incense and aromas, bath salts, and plants -- abound, offering to heal the physical and psychological stress of the workplace and of daily life in

[1] We use the word *Iyashi* as the stimulus given to a person that changes its internal condition to a better physical or emotional state (see Kitaoka et al 2008 for details).

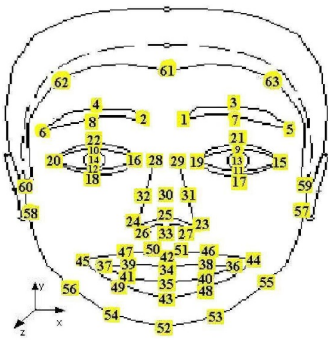
general. In society the expression Iyashi-kei is frequently used to describe laypersons that simply help people to relax. However, the word Iyashi (like other such as pleasure, well-being or satisfaction) does not have a consensus among people. Therefore a KAE system was developed to explain human decision-making by extracting fuzzy rules from the computational models.

In this paper procrustes analysis and CSRBF are combined to validate the extracted rules making a continuous and efficient tuning of the design space. Related KAE sytems are reviewed in section 2. The proposed FQHNN is presented in section 3. The combination of procrustes analysis with CSRBF is introduced in section 4. The experimental results with two subjects are shown in section 5. Finally, conclusions and future works are presented in section 6.

2. RELATED KAE SYSTEMS

Various KAE Systems have been developed to automatically support the design process (M. Nagamachi et al 2011). In this section we do not intend to do a thorough analysis on existing KAE systems but mention some of the methods or systems including similar applications. For example, Benitez et al, 2013 developed a KAE system for Gigakuman Character Design. The system generates different facial expressions of Gigakuman in order to represent an abstract concept. Ohira et al 2010 also use a rough set approach to extract painting composition rules and synthesize drawing and painting from the identification of salient features within images to produce an abstract composition. A more sophisticated system was proposed by (Ando & Hagiwara 2009) to create 3D characters using interactive genetic algorithm and a rule extraction method based on the comparison between attributes of user's evaluated characters. Recently the generation of Kansei rules trends to include parameters from physiological measurements (see e.g. Okuhara et al 2011) but we will not cover this topic here.

Fuzzy Logics, Neural Networks, Genetic Algorithm, Rough-Set Analysis, and Partial Least Square Analysis are used within KAE systems to analyze Kansei (see details in Nagamachi et al 2011). A neuro-fuzzy approach is used in the proposed KAE system (Diago et al 2011). Twenty images represented by seventeen parameters were evaluated by one hundred and fourteen subjects between 15 and 70 years old (102 Japanese and 12 non-Japanese, 47 females and 67 males) and were used to train different neuro-fuzzy classifiers. The participants rated each stimulus on the scale '0'-NO, '1'-DON'T KNOW , '2'-YES to express whether or not they feel an Iyashi-stimulus. Figure 1 shows 63 feature points used to compute the set of parameters describing 20 portrait images.



Face parameters		
Area parameters: p_1 (right eye), p_2 (left eye), p_3 (nose), p_4 (mouth), p_5 (face), p_6 (right eyebrow), p_7 (left eyebrow). Distance/size parameters: p_8 (face height), p_9 (face width), p_{10} (forehead height), p_{11} (forehead width), p_{12} (eye-eye), p_{13} (left eye-eyebrow), p_{14} (right eye-eyebrow), p_{15} (eye-nose), p_{16} (nose height), p_{17} (nose width), p_{18} (eye-mouth), p_{19} (mouth height),p_{20} (mouth width)		
Normalization		
$x_1 = p_1/p_5$	$x_7 = p_{12}/p_9$	$x_{13} = p_{14}/p_8$
$x_2 = p_2/p_5$	$x_8 = p_{15}/p_8$	$x_{14} = p_{19}/p_8$
$x_3 = p_3/p_5$	$x_9 = p_{18}/p_8$	$x_{15} = p_{20}/p_9$
$x_4 = p_4/p_5$	$x_{10} = p_{10}/p_8$	$x_{16} = p_{16}/p_8$
$x_5 = p_6/p_5$	$x_{11} = p_{11}/p_9$	$x_{17} = p_{17}/p_9$
$x_6 = p_7/p_5$	$x_{12} = p_{13}/p_8$	

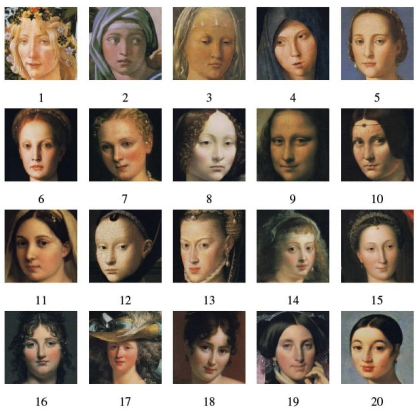


Figure 1: Feature points, Face Parameters and Portrait images

3. FUZZY-QUANTIZED HOLOGRAPHIC NEURAL NETWORKS

Figure 2 shows the architecture of the proposed fuzzy-quantized holographic neural network (FQHNN). The HNN module (upper part) is combined with the FQ module (lower part) to increase HNN interpretability. HNN module is proposed to select the most important parameters of the face from the complex values stored in the holographic memory (**H**). FQ module is proposed to build the membership functions (MFs) describing facial parameters ($\boldsymbol{\mu_{11}}\ldots\boldsymbol{\mu_{kli}}$) and the groups of subject evaluations ($\boldsymbol{\mu_{G1}}\ldots\boldsymbol{\mu_{Gm}}$) without solving a generalize eigenvalue problem ($\mathbf{Ac=\eta^2 Bc}$). Later, the fuzzy reasoning is used to provide transparency to HNN models extracting linguistic rules (see details in Diago et al 2011).

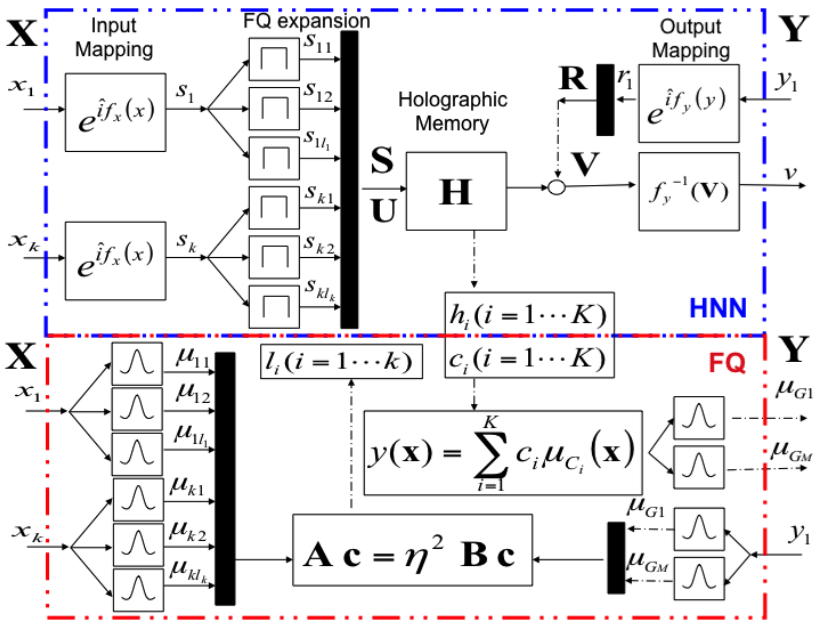


Figure 2: Architecture of the proposed Fuzzy-Quantized Holographic Neural Network (FQHNN).

An initial knowledge base of 35 rules was created from the trained FQHNN representing the evaluations of N=87 subjects reported in Diago et al 2011. Table 1 shows eleven parameters (x_1, x_3, x_5, x_6, x_8, x_{10}, x_{11}, x_{13}, x_{14}, x_{15}, x_{17}) used to explain the meaning of subjects evaluations from the set of 21 rules extracted from N=41 subjects using a single parameter in the antecedent. The first row displays the category (S = Small, M = Medium, L = Large) of each parameter in the rules. The second row shows the number of classes involved in each parameter. The class is specified between parentheses in case of a single class ('0 '-NO, 1 "-DON'T KNOW, '2'-YES). The third and fourth rows show the number of rules and the number of subjects in which each parameter defined the evaluation.

Table 1: Eleven parameters used to explain the meaning of subjects evaluations of Iyashi-expressions

	x_1	x_3	x_5	x_6	x_8	x_{10}	x_{11}	x_{13}	x_{14}	x_{15}	x_{17}
Categories	M	S	**S,M**	**M,L**	M	M	**S,M**	**M**	S	M	**S,M**
No. of Classes	1(1)	1(0)	**3**	**2**	1(1)	1(0)	**1(0)**	**2**	1(0)	1(2)	**2**
No. of Rules	1	1	**5**	**3**	1	1	**2**	**2**	1	1	**3**
No. of Subjects	1	1	**11**	**8**	1	2	**2**	**7**	1	2	**3**

Table 2 shows fuzzy rules corresponding to the 5 parameters (x_5, x_6, x_{11}, x_{13}, x_{17}) influencing the evaluation of many subjects (~80%). Each row represents a rule. Columns 3 and 5 represent the antecedents and consequences of each rule respectively. Column 6 shows the number of subjects in which the rule defined the evaluation. According to the number of subjects (11), x_5 is the most influential parameter. However, the rules are contradictory. The same applies to x_6 and x_{17}. In over 80% of cases S or M values of the parameters x_{11} and x_{13} do not produce Iyashi i.e. Class (Iyashi) = NO. In the next section changing the parameters x_6 and x_{17} new expressions are generated in order to validate the extracted rules.

Table 2: Fuzzy rules to classify Iyashi-expressions

No.		Parameter		Class (Iyashi)	No. of Subjects	
1	IF	X_5 is S	THEN	NO	4	11
2		X_5 is M		NO	1	
3		X_5 is M		DON'T KNOW	2	
4		X_5 is S		YES	2	
5		X_5 is M		YES	2	
6	IF	X_6 is M	THEN	NO	5	8
7		X_6 is M		YES	1	
8		X_6 is L		YES	2	
9	IF	X_{11} is S	THEN	NO	2	4
10		X_{11} is M		NO	2	
11	IF	X_{13} is M	THEN	NO	5	7
12		X_{13} is M		DON'T KNOW	2	
13	IF	X_{17} is S	THEN	NO	1	3
14		X_{17} is S		YES	1	
15		X_{17} is M		YES	1	

4. COMPACTLY-SUPPORTED RADIAL BASIS FUNCTIONS

Compactly Supported Radial Basis Functions (CSRBFs), firstly introduced by Wendland in 1995, are used for tuning facial parameters and mapping between facial images within opposite classes. Firstly, procrustes analysis determines a linear coordinates transformation (translation, reflection, orthogonal rotation, and scaling) of the feature points in the original image to best conform them to the feature points coordinates in the target image. The goodness-of-fit criterion is the sum of squared errors. The procrustes analysis also returns the minimized value of this dissimilarity measure and the transformed coordinates of the feature points from original image. The coordinates of the transformed images are used to compute the movement of the original feature points and to generate the requested expression by CSRBF-based image warping.

In general, from given two data sets in $\mathbf{R}^3$,$\boldsymbol{s}_i$ ={ x_s^i, y_s^i, z_s^i },for a non-deformed object, and $\boldsymbol{d}_i$ = {x_d^i , y_d^i , z_d^i }, for the deformed object, we construct a space mapping F : $\mathbf{R}^3 \rightarrow \mathbf{R}^3$ which is a CSRBF interpolation of form (1) in each of its components.

$$F(\bullet) = p(\bullet) + \sum_{i=1}^{N} a_i \phi(\| \bullet - s_i \|) \tag{1}$$

Here p is a low degree polynomial, ϕ is a positive definite and compactly supported radial function in the form (2) and a_i and s_i are the coefficients and centers of the RBFs respectively. The r_0 is the support radius.

$$\phi(r) = \begin{cases} (1 - r/r_0)^2_+ & 0 \le r \le r_0 \\ 0 & otherwise \end{cases} \tag{2}$$

A system of linear algebraic equations (SLAE) is solved from the displacements of the two data sets to compute RBF coefficients and the coefficients of the low degree polynomial p. The warped images are generated from equation (1) and reevaluated by two subjects in the experimental section.

Figure 3 shows the face profiles derived from the 63 feature points marked on each portrait and the dissimilarity measure between face profiles computed by procrustes analysis. The 20x20 matrix is shown as image and each pixel of the image indicates the minimized value of the dissimilarity measure between the feature points in the firth image and the transformed coordinates of the feature points in the second image. Note that the dissimilarity distance between images is very small. The highest value is shown between pictures 10 and 14 (D = 0.09125). However evaluations of subjects may not match with these values.

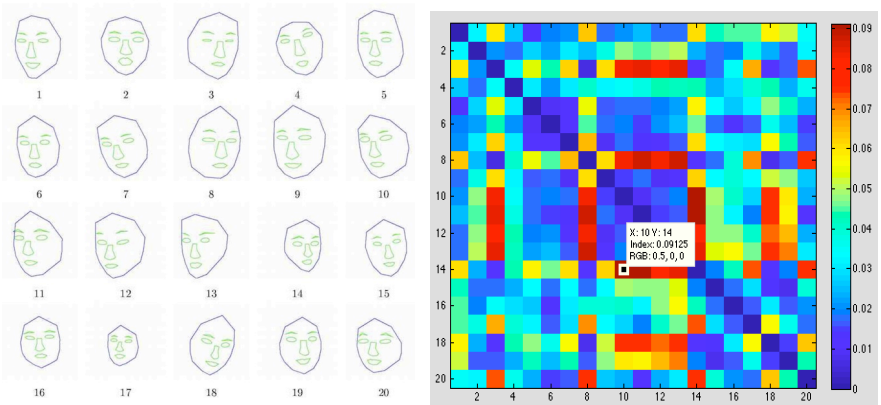


Figure 3: Face profiles and dissimilarity matrix for 20 portrait images.

5. EXPERIMENTAL RESULTS

For the experimental section, the warped images from the 20 portraits were prepared beforehand. As in the previous work, the participants rated each stimulus on the scale ’0’- NO, ’1’- DON’T KNOW, ’2’- YES to express whether or not they feel the emotion in question. The time for evaluating each stimulus was set to a maximum of 10 seconds. In each trial, stimulus were selected at random from the set of 20 images and presented for five seconds. The total time for

evaluation of each image was also recorded. If the time exceeds 10 s, the image is returned to the set of images in order to be presented one more time. The images evaluated within the maximum time interval of 10s are removed from the set. After storing evaluations of each user, the FQHNN was used to learn which are the facial expressions that induce Iyashi on each user. Table 3 shows an example of evaluations made by two subjects.

Table 3: Evaluation of 20 portrait images by two subjects

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Subject 1	2	1	0	1	2	1	2	0	2	1	2	0	0	1	1	2	1	2	1	2
Subject 2	2	0	1	0	2	0	2	0	2	0	2	0	0	2	2	2	2	2	2	2

After FQHNN learning is finished, the system selects which of the rules is closer to user evaluations. Then, it selects one of the images evaluated as 2 and begins to select modified images according to the values of the parameters in the antecedents of the selected rule. For example, in the case of subject 1, the rule number eight in table 2 i.e. IF (x_6 is L) THEN Class(Iyashi) = YES covered about 60% of the evaluations in the class. So, the parameter x_6 was modified to change the evaluation of the subject to the opposite class by using the same image. The image number 5(x_6 =0.0041) was selected. Figure 4 shows the set of warped images from image 5 (left) and image 6 (right). The following sequence of warped images was presented to the subject for evaluation: Image 15 (x_6 =0.0029), Image 10 (x_6 =0.0028), Image 8 (x_6 =0.0018). After image 8 was shown the subject evaluated that the image do not produce Iyashi i.e. Class (Iyashi) = NO as it was expected.

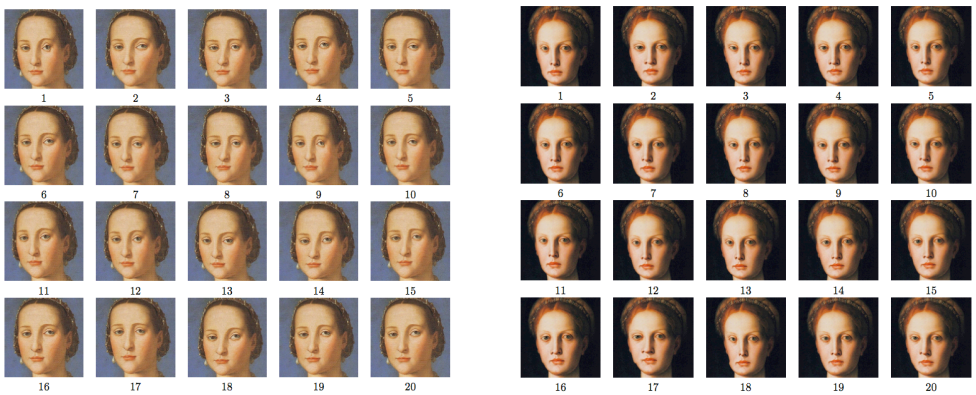


Figure 4: Warped images used to evaluate the rules generated from the evaluations of subject 1.

The rule No.13 in table 2 i.e. IF (x_{17} is S) THEN Class(Iyashi) = NO covered more than 50% of the evaluations in the class. So, the parameter x_{17} was modified to change the evaluation of the subject to the opposite class by using image number 6(x_{17} =0.2339). The following sequence of images was presented to the subject for evaluation: Image 3 (x_{17} =0.2383), Image 16 (x_{17} =0.2463). After image 16 was shown, the subject evaluated that the image produced Iyashi i.e. Class (Iyashi) = YES as it was expected. In both cases, the starting image is selected randomly. The experiments have been repeated several times for both subjects using different starting images but similar results are obtained (results not shown).

6. CONCLUSIONS AND FUTUR WORKS

This paper is a continuation of our previous works in which a knowledge base of 35 rules was created from the trained fuzzy-quantized holographic neural network (FQHNN) representing the evaluations of N=87 subjects. In order to validate the extracted rules, the parameters influencing the evaluation of 80% the subjects were selected from the set of rules. Changing only two of the selected parameters (i.e. normalized area of the right eyebrow and the nose) new warped images were generated and evaluated by two subjects. The experimental results showed that although the dissimilarity distance between images is very small, the evaluation of the subjects could be modified to the opposite classification (i.e. Iyashi and Non-Iyashi) by warping original images with Compactly Supported Radial Basis Functions (CSRBF).

In this work we have explored only single parameters influencing subjects evaluations separately. However, we could employ genetic algorithms to explore combinations of parameters and increase the % coverage of the rules to explore. An active learning technique to explore the design space is also under development.

ACKNOWLEDGMENTS

Several parts of the research work were carried out by the support of the Grants-in-Aid for scientific research (category C) under Grant No. 26420211. We acknowledge its aid dearly.

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BIOGRAPHY

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4D - Screens 2

An Analysis of Effects Provided by High-Gradation Displays Based on Impression Assessments

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Abstract: Recently, even though the use of high-gradation display devices in medical and other specialized fields has become essential, most devices in general field usage are still typically 8 bits luminance level displays. However, since it can be presumed that image quality improves when high-gradation display devices are used, we investigated the results obtained by increasing luminance gradation levels and found that image impressions improved as the number increased. In addition, the results indicated that the impression improvement peaked at just less than 9 bits.

Keywords: High-gradation display, Gradation number, Impressions.

1. INTRODUCTION

Stimulated by recent advances in high-resolution technology, 4K displays (which is a general term for displays with horizontal resolutions of approximately 4,000 pixels) have already entered the market. However, while the spatial resolution of such devices has improved, the gradation number of such devices, which are quantified by their luminance resolution number, has remained static in recent years. In specialized fields where serious quantitative improvements to display quality are in constant demand, such as the medical and color management fields, high-gradation display devices are used (DICOM, 2000). Yet, the luminance gradation level of most general display devices used for presenting content currently remains at just 8 bits. In this study, we began by presuming that image impressions improve with gradation number increases because high-gradation display devices are more capable of reproducing smooth gradation changes. In two

related studies (Daly, Kunkel, Sun, Farrell & Crum, 2013; Kusakabe, Kanazawa, Nojiri, Haino & Furuya, 2011) into qualitative assessments using high-gradation display devices, researchers focused on the dynamic range of display devices, not on their luminance gradation levels. Other studies (Seetzen, et al., 2004; Bimber & Iwai, 2008) discussed the necessity of high-gradation display devices based on the just noticeable difference (JND) factor. These studies determined that the optimum gradation number of a display could be found when the luminance-difference between each pixel value is slightly smaller than the JND.

Although, JND is measured under full adaptation to a given stimulus (DICOM, 2000; Wyszecki & Stiles, 2008), in this study we adapt to the maximum luminance in the displayed content using a general display device. In addition, we look at the entire display, and not at individual pixels. Thus, because the visual performance conditions are different from those used in general viewing, it was considered necessary to examine the effects of a high-gradation display based on impression assessments rather than the JND. Therefore, in this study, we examine the impressions provided by high-gradation display devices and the contents that evoke conspicuous impressions.

2. IMPRESSION ASSESSMENTS

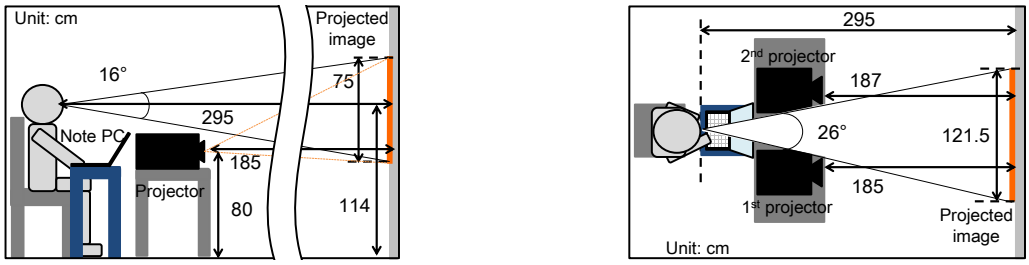
To examine the impressions provided by a gradation number increase, we performed impression assessments using various gradation numbers and assessment terms.

2.1. Environment

Our experimental assessment conditions were based on the International Telecommunication Union-Radio (ITU-R) Recommendation BT. 710 (ITU-R, 1998), in order to align our study with normal viewing conditions. The assessment conditions are listed in Table 1, while Figure 1 shows our assessment environment.

Table 1: Assessment Condition

Conditions	Values
Ratio of viewing distance to displayed image height	4.0
Maximum luminance	2.5×10^{2} cd/m^2
Minimum luminance	1.5×10^{-2} cd/m^2
Contrast	Approximately 16,000:1
Illumination from other sources	3.6×10^{-1} lx
Displayed image size	55 in



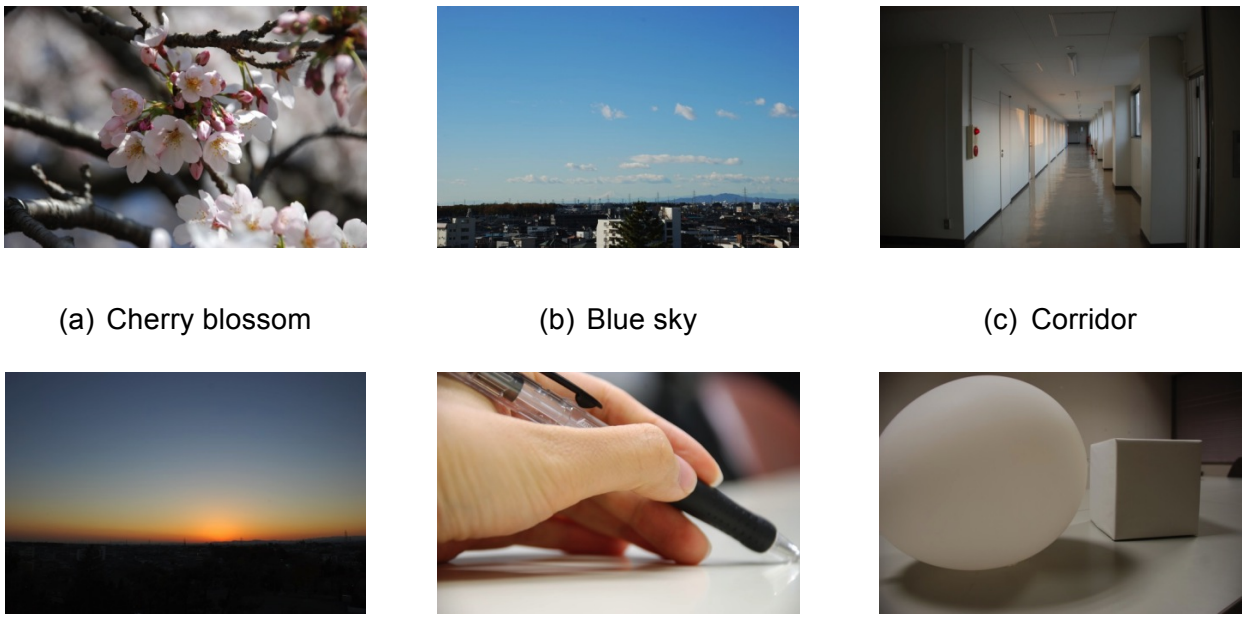
(a) Right side view (b) Top side view

Figure 1: Experimental assessment environment

We performed multiple projections using two projectors (JVC DLA-X9) to create a high-gradation display device that has a maximum gradation level of 612. Our display device has a luminance range of 1.5×10^{-2} – 2.5×10^{2} cd/m^2 and a 55-in projected image size. Each projector has a resolution of 1,660 × 1,040 pixels.

2.2. Stimuli

We used six different images, as shown in Figure 2. The stimuli included photographs of skies, skin, walls, and a spherical surface because we presumed that the gradation numbers in these images would be significant. In addition, the images of "cherry blossom" and “hand” include background blur. The background blur also produce smooth gradation change. All images were obtained from a single-lens reflex camera (Nikon D80) in 12-bit raw data at a resolution of 3,900 × 2,613 pixels.



(a) Cherry blossom (b) Blue sky (c) Corridor

(d) Sunset (e) Hand (f) Balloon and cube

Figure 2: Stimuli photographs

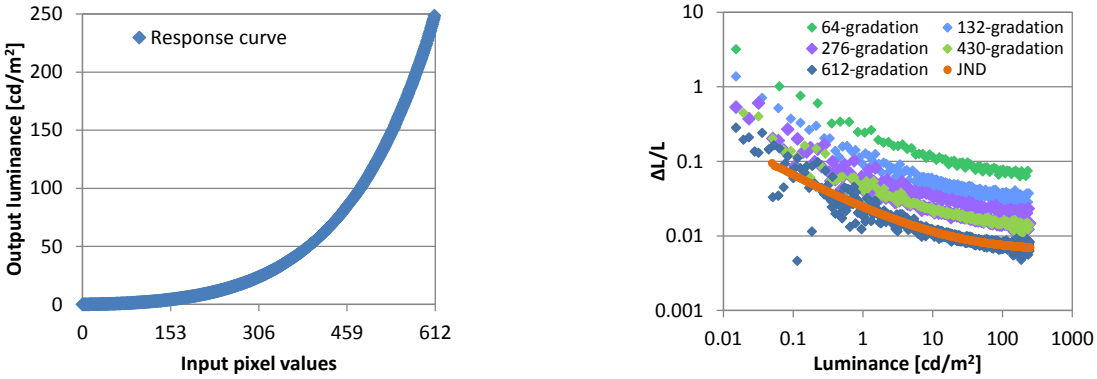
Next, we will explain how we created the input images for the two projectors.

i). We began by creating a lookup table containing the input pixel values of the two projectors and the output luminances of our high-gradation display device. The output luminances were the sum of the output luminances of the two projectors. Figure 3 (a) shows the response curve of our high-gradation display device, while Figure 3 (b) compares the luminance differences between each pixel value and the JND (DICOM, 2000). The vertical axis in Figure 3 (b) represents the luminance contrast.

ii). When creating input images, we performed inverse gamma processing because the output luminances of our high-gradation display device were not linearly changed. We then converted raw data values into input pixel values in our high-gradation display device. We also set an optional gradation number by changing the set gradation number of our high-gradation display device.

iii). Using the lookup table, we then determined the input pixel values of the two projectors using the input pixel values of our high-gradation display device.

iv). The input images of the two projectors were overlapped with each other by imposing geometric correction. Each projector projected gray-code patterns (Damera-Venkata & Chang, 2007), which were then photographed. We then performed geometric correction on the second projector's input image by using the first projector's coordinates as the standard.



(a) Response curve (b) Luminance differences (Log_{10} scale)

Figure 3: Characteristics of our high-gradation display device

Five gradation numbers (612, 430, 276, 132 and 64) were prepared. These gradation numbers were chosen because the values after inverse gamma processing are close to standard bit values (512, 384, 256, 128 and 64). As mentioned above, the luminance-difference of each gradation number is shown in Figure 3 (b). Moreover, we converted the raw data to gray scale values based on the National Television System Committee (NTSC) standard.

2.3. Assessments

We referred to a previous study (Inoue, Sotome, Sato, Ayama & Hashimoto, 2013) for the assessment terms. That study used a total of 29 words from which we selected just six ("like," "smooth," "natural," "be moving," "rough" and "dislike") because they showed conspicuous impression differences in impression assessment results. On the provided assessment sheets, we used the seven-step Likert scale. The test viewers were five men in their twenties.

First, each test subject was provided three minutes for dark adaptation. Then, the participants were asked to perform a practice session before giving their first assessment. During the actual assessment process, they recorded their judgments on provided assessment sheets. No time limits were given for making assessments. The image was presented as orders of the gradation number and the type of image differ depending on the viewer.

2.4. Results

We weighted the answers from one to seven on the seven-step Likert scale, and then created box plots. The vertical line extending above and/or below the box shows the minimum and maximum, while the short horizontal line inside the box itself shows the median. The horizontal axis is the gradation number after inverse gamma processing.

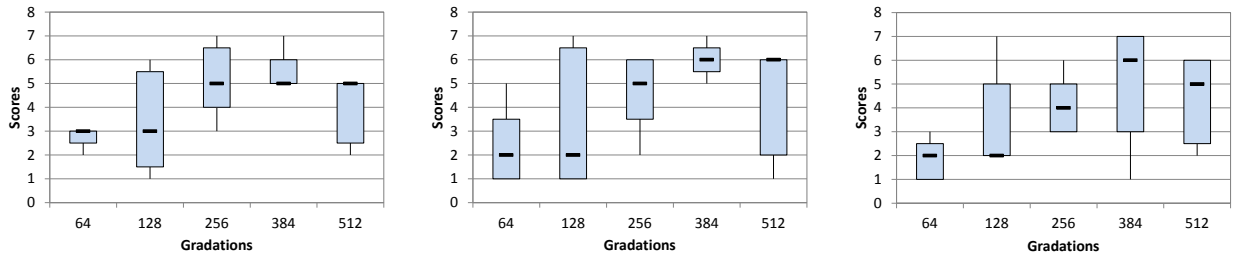
Figure 4 shows the box plots results for the "blue sky" image, which showed notable trends. As can be seen in the figure, as the gradation number increased, the scores for the words "like," "smooth" and "natural" became higher, while the scores for "rough" and "dislike" became lower. This indicates that impressions improve as the gradation number becomes larger. In addition, the results show that impression trends stabilized above the 256- or 384-gradation levels. However, because no stable trends could be detected in the scores for "be moving", these words may not be

suitable for use in gradation number assessments.

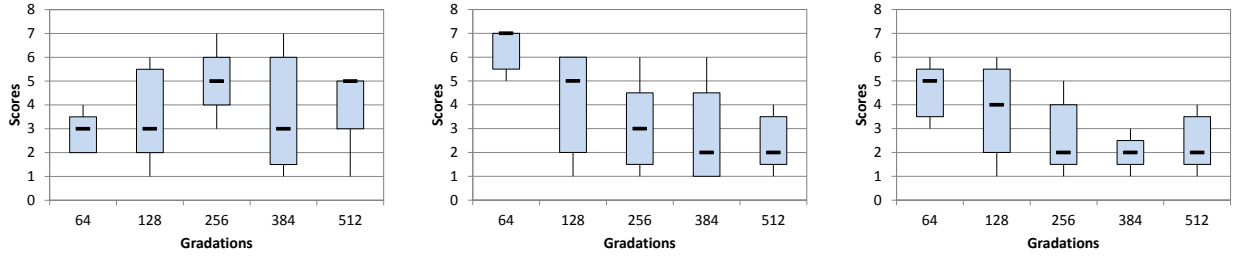
Figures 5 and 6 show the results of “smooth” and “rough” for all images. In both result sets, the “blue sky,” “corridor,” and “balloon and cube” images show strong impression trends. We believe that a common point of three images is their inclusion of a large gradation area where pixel values change gradually, such as the sky, wall, and a spherical surface. On the other hand, the “cherry blossom” and “hand” images also include gradation areas, such as background blur and skin, but no trends were recorded for these images. Therefore, it appears the viewers did not notice the changes to the gradation numbers. This, in turn, indicates that impression changes may not occur when the gradation area is small and/or situated in the background. Furthermore, while the “sunset” and “blue sky” images include similar large gradation areas, the “sunset” image showed a smaller impression trend. Thus, it can be considered likely that changes to impression trends relate to not only the gradation area size, but also to the gradation area range.

Additionally, in the “cherry blossom” result, the 64-gradation score is better than the 128-gradation score, which was significantly different from the scores recorded for other images. We think that a cause of this difference is as follows. When the viewer assessed, the other images were compared with actual views. Therefore, the viewer lowly evaluated the image including a pseudo contour appeared by the decrease of the gradation number. In contrast, an image that includes background blur is different from an actual scene. Therefore, the viewer might not perceive bad qualities from a pseudo contour that appears due to a gradation number decrease. This indicates that it will be necessary to study the effects of background blur in the future.

Overall, we believe that there are two reasons for the rather large score variances that were observed. The first is the small size of the sample set, the second is the fact the some viewers did not notice the pseudo contour because the gradation number change resulted in very slight differences. Hence, it will be necessary to examine the way assessments are conducted in the future.

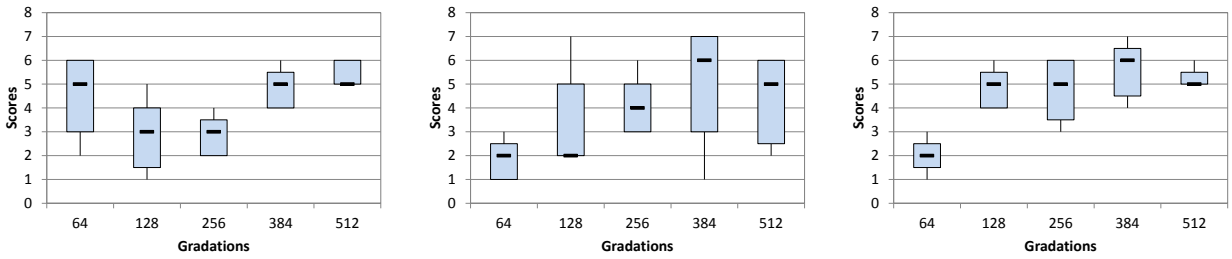


(a) Like (b) Smooth (c) Natural

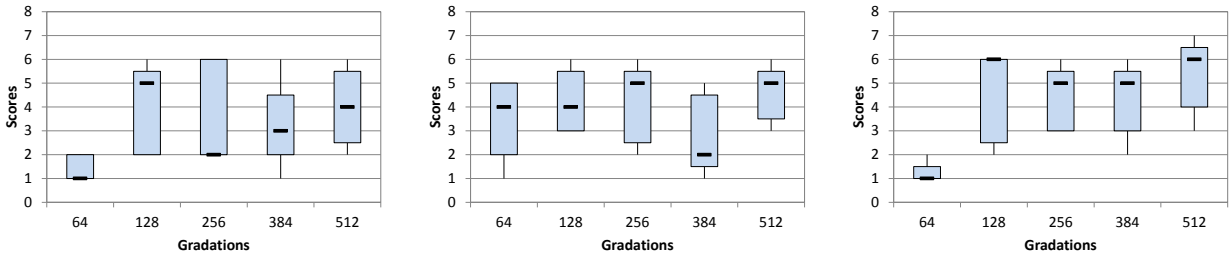


(d) Be moving (e) Rough (f) Dislike

Figure 4: Box plots of the results about the image of “blue sky”

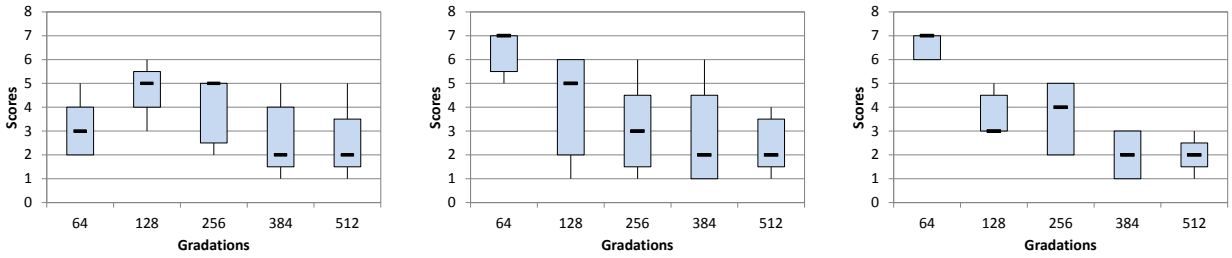


(a) Cherry blossoms (b) Blue sky (c) Corridor

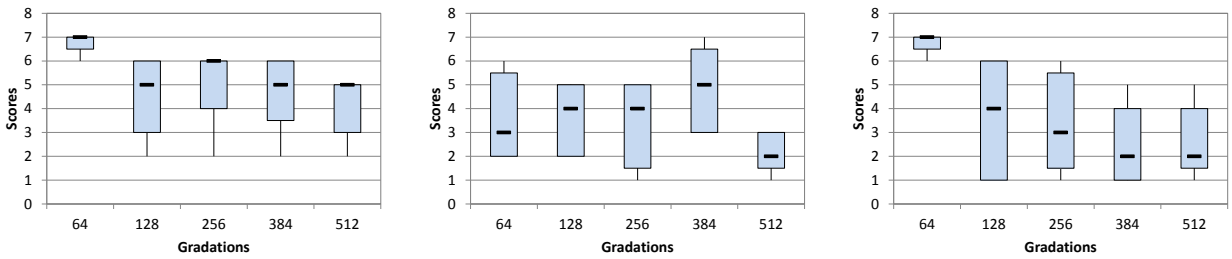


(d) Sunset (e) Hand (f) Balloon and cube

Figure 5: Box plots of the results about “smooth”



(a) Cherry blossoms (b) Blue sky (c) Corridor



(d) Sunset (e) Hand (f) Balloon and cube

Figure 6: Box plots of the results about “rough”

3. CONCLUSIONS

In this paper, we examined the impression change that results from increasing the gradation number and found that the image impressions improved as gradation numbers increased. In addition, it was determined that impressions tended to stabilize above the 256- or 384-gradation levels. In our future studies, we intend to quantitatively examine the relationship between gradation number increases and image content features using a larger sample size and a much wider selection of image types. In addition, because only gray-scale images were used in this assessment, it will be necessary to perform assessments using color and moving images in the future. Through our continued studies, we hope to indicate qualitatively effectiveness of high-gradation display devices in the general field.

ACKNOWLEDGMENTS

This work was supported by Grant-in-Aid for JSPS Fellows Grant Numbers 258965, JSPS KAKENHI Grant Number 24500251 and Utsunomiya University Center for Optical Research & Education, Intramural Grant-in-Aid Scheme.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Immersion Levels in Digital Interactive Environments

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Abstract: When discussing narrative in games, game designers and academics alike often ignore a very potent narrative component in favor of more traditional literary devices. The narrative component in question is the game world itself. Doug Church argued that the narrative within games refers to any narrative thread that binds events together and drives the player to complete the game. With this in mind, the game world is a very important part of the game narrative, as the player will be exposed to the game world for the duration of the entire game. It is for this reason that this paper aims to look at the narrative components of the game world. In the past, two definitions were established to describe the game world as a narrative component, namely narrative spaces and narrative descriptors. However, these two definitions prove to be insufficient for the scope of game worlds found in current day game. With this in mind, this paper aims to expand on those two definitions, by analyzing game worlds and deriving new definitions from those worlds and forming models based on those. On top of that, this paper seeks to validate these newfound definitions through the use of the Game Experience Questionnaire (QED).

Keywords: Game design, Interactive Design, Narrative Design, User Experience (UX).

1. INTRODUCTION

Most often, when talking about the presence of narrative within games, game designers and academics alike often refer to classic narrative elements. Even if they refer to in-game objects that have a narrative function, they refer to objects that can fill the role of a narrator.

Church argues that the game story does not necessarily mean “expository prewritten text,” but rather that it refers to “any narrative thread, whether design-driven or player-driven, that binds the events together and drives the player forward to the completion of the game.” (as cited in Huaxin, 2010) With this definition in mind, we can argue that the game world is able to be a narrative component as well. In fact, since the game world is the container to all elements that are needed for the player to complete the game in the first place, we might even consider the game world to be one of the most important narrative components within the game.

More than any other medium, users of games are continuously exposed to the game world. Not

only in terms of average game length, but because games are interactive by nature. Users can find themselves revisiting previous locales because the narrative demands it, the user feels there is still unfinished matters present within the locale, because users need to return due to a precious resource only available in particular locales, and so on. In fact, it could be argued that through most of the game, the user is actually not involved in advancing the plot of the game, but instead hard at work simply playing the game by immersing himself and interacting with the game's environment. This requires the user to take up the game world in greater detail, as it is a necessity in order to complete the game. More so than the worlds contained within traditional media such as movies or books, players find themselves involved with the world itself.

One could argue that these player actions are a part of emergent narrative, where the user's actions determine the shape of the narrative. However, before actions that build emergent narrative can take place, the locations in which these actions take place need to be established first to give players a reason to interact with them. The goal of this paper is to look at the game world as a narrative component and to form definitions and models through an extensive software survey. The validity of these definitions and models will be tested through their ability to immerse the player into the game world.

2. PRELIMINARY RESEARCH METHOD

2.1. Equipment

For most games that were surveyed, we used their respective consoles to analyze them. The consoles used were Nintendo, Super Nintendo, Nintendo 64, Gamecube, Wii, Gameboy, Gameboy Advance, Nintendo DS, Playstation, Playstation 2, Playstation 3, Xbox 360 and PC. For other games for which we either lacked the hardware or the ability to play, we used internet resources in the form of Let's Play's, which are video walkthroughs of games.

2.2. Protocol Design

For the software survey, we choose games in which the player had to control an avatar in order to interact with a digital game environment. Therefore, games that were more abstract in nature, such as puzzle games and rhythm games, were largely ignored.

Table 1: A selection of the games used for the survey

Platform	Title
Nintendo	Crono Trigger, Super Mario World, Tetris, The Legend of Zelda A Link to the Past, Terranigma, Lost Vikings, Little King's Story, Muramasa the Demon Blade, Illusion of Gaia, Golden Sun, Castlevania Portrait of Ruin, Banjo Kazooie.
Playstation	Wild Arms, God of War, Jak & Daxter, Ratchet & Clank, Prince of Persia, Uncharted, Folklore, Okami, Digital Devil Saga, Viewtiful Joe, Final Fantasy X.
Personal Computer	Dishonored, Super Meat Boy, Mark of the Ninja, Super Monkey Island, Day of the Tentacle, Psychonauts, Bioshock, Overlord, Deus Ex Human Revolution, Darksiders 2.
Xbox	Kameo Elements of Power, Blue Dragon, Final Fantasy XIII.
Sega	Sonic The Hedgehog, Skies of Arcadia.

2.3. Data Analysis

Games were analyzed on how the progression in the game was structured. Furthermore, the narrative spaces and narrative descriptors within the games were analyzed to find recurring themes among them. Lastly, we analyzed whether games had narrative that was not necessarily relayed to players in the game itself, but whose presence was either hinted at in the game or whose presence was further explained through other media, such as books.

3. PRELIMINARY RESULTS

3.1. The game world as a narrative component

When looking at the game world as a narrative component, Salen and Zimmerman (2004) defined two properties that could define the world as a narrative component, namely narrative spaces and narrative descriptors.

- Narrative space is the 2D or 3D space in which a game takes place.
- Narrative descriptors are the representations within the narrative space that help players understand the activity in the game within a larger narrative context.

Unfortunately, the issue with Salen and Zimmerman's definition of those elements is that it is too simplistic. The example they used to explain their definitions, namely the game Asteroids, is a game that consists out of only one screen with very few elements. While their definitions may hold true for a game of this scope, when looking at games of a broader scope, their definitions fall flat. Therefore, building on these definitions as a base, we sought to expand these definitions.

3.2. Encompassing Narrative

One thing that Salen and Zimmerman's elements do not take into account is the massive amount of background information that is present in today's games. Case in point is the game World of Warcraft, as well as antecedent games in the franchise. These games have a vast lore regarding its universe, including novels to explain history that took place before the timeline in the games. This lore is not necessarily disclosed to the player in the game itself, but it serves as important guidelines to shape the world of the game.

The encompassing narrative consists out of all the base information that is needed to build all the locales within the game; it gives form and identity to the narrative spaces and descriptors present in the game world. This includes, but is not limited to, the game world's history, the races that inhabit the world and the sociological properties of the game world. The encompassing narrative is generally not communicated directly to the player, at least not in its entirety.

3.3. Narrative Spaces

Narrative spaces are the containers that hold all of the descriptors. They can be considered the game's locales. They serve as the basic forms that the descriptors will take and are therefore more abstract in nature. Whereas the encompassing narrative contains information that is not necessarily present within the game itself, the narrative content of the narrative spaces are all available to players.

3.3.1. Narrative HUB

The narrative HUB differs from a normal narrative space in that it has a central role. While narrative can be present within a narrative HUB, it is limited compared to a normal narrative space. It is made to connect a wide variety of narrative spaces together so that players can easily (re)visit those spaces.

A common incarnation of the narrative HUB used in the Japanese role playing games is the so

called world map. In the world map, the player wanders across a miniature version of the entire accessible universe of the game. On the world map exists icons of locales, such as tows or caves. These icons serve as the entrances to new narrative spaces.

3.4. Narrative Descriptors

Descriptors are the smallest quantifiable part of the visual design of a game world; they are the building blocks that give meaning to the narrative space and communicate their role and the role of the narrative space to the player. There are four kinds of descriptors that can be present within a narrative space.

3.4.1. Narrative Descriptor

Narrative descriptors are descriptors that primarily fill a narrative function and they serve as the most basic of descriptors. They serve no to limited interactivity to the player and serve to establish the role of the narrative space they are located in. Through their presentation, they can also provide the player with information regarding the history of the locale and the relation of the locale to that of others.

3.4.2. Functional Descriptor

Functional descriptors do not necessarily communicate the narrative role of the narrative space to the player. They serve to give the player a point of reference from a game-play perspective.

In the game Alundra, the player will encounter pot-like objects throughout the entire game world. From a narrative perspective, these objects are completely out of place and should not exist, as it is unfathomable that someone would travel the world on a regular basis just to make sure these pots are in order. Not to mention that these pots exist in places that are generally not accessible by average people, further casting doubt on why these pots exist. However, from a game-play perspective, these objects serve to tell the player that the player has to use a particular item called “Magic Bean” in that spot. When used correctly, the pot will produce a spring-loaded plant which will launch the player to higher spots.



Figure 1: The game Alundra, with the titular main character using a “magic bean” on a pot.

3.4.3. Narrating Descriptor

Narrating descriptors are narrators within the game with whom the player can interact. They generally serve to either tell the player something directly about the game world at large, or to give the player directions to new possible goals. Narrating descriptors in that sense do not have to be humanoid; any object that relays text to the player after interaction is a narrating descriptor.

It should be noted that when referring to narrating descriptors, we refer specifically to those descriptors the player can choose to interact with. Narrators that narrate store to the player through

means the player does not have any control over should be considered normal narrators and not narrating descriptors.

3.5. Linear and Open Model

Before creating the model based on the definitions that have been established in this paper, a closer look at how game-play is structured within a game is needed. The reason for this is that the type of game-play can have an effect on the way the narrative world needs to be structured as well. We can distinguish between two types of structures; the linear and open structure.

3.5.1. Linear Structure

The linear structure has the player going from one point to another until the player has beaten the game. The player visits each narrative space in succession and has little to no control which narrative spaces the player can visit. For that reason, descriptors are mostly limited to what information they can convey to the player. On one hand, the descriptors can be more focused on expressing narrative, but on the other hand the player's exposure to them is only very short, since players cannot get back to previously visited locales.

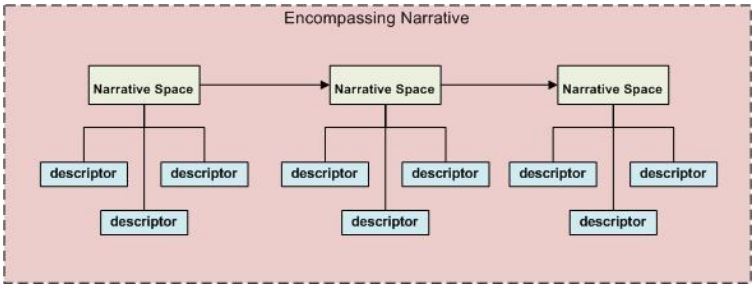

Figure 2: Linear Model

3.5.2. Open Structure

As opposed to the linear structure, the open structure gives the player the ability to revisit previously visited locales. This in turn has an effect on how the narrative components need to be established, as the player needs to aware of their existence. This is due to the nature of the open model, which allows the players to visit narrative spaces of their own choosing. Players need to be aware to the functions of narrative spaces and the elements within them in order to gain a reason to return to them. In order to accommodate tan open structure, the open model has a need for one or more narrative HUBs in order to connect the narrative spaces together.

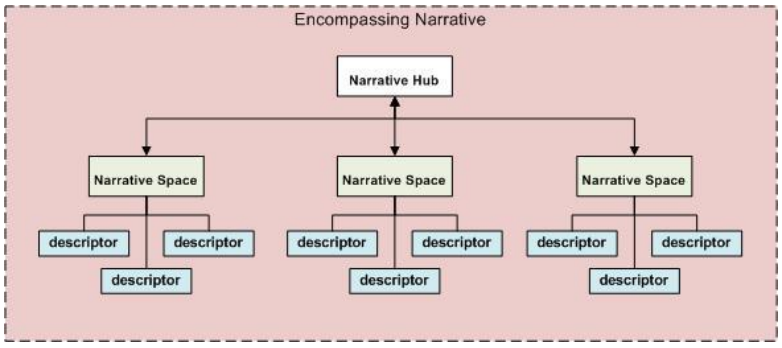

Figure 3: Open Model

4. VALIDATION METHOD

4.1. Participants

There were a total of 15 participants, of which 9 were male and 6 were female. The average age was 27.4 years with a standard deviation of 7.06. 8 participants were of Japanese nationality, whereas the other participants had varying nationalities.

4.2. Equipment

The computer used for the experimental game prototype was an Intel Core i5-2400 3.1GHz, with 4.0GB RAM and a AMD Radeon HD 6450 1.00GB. The operating system used was Windows 7 Enterprise (64bits). Additional hardware to control the prototype was used in the form of a Microsoft Wireless XBOX360 Controller for Windows.

4.3. Preparations

An experimental prototype to contain the stimuli was designed using the Unreal Development Kit July 2012 Beta. The prototype takes the form of a side scrolling action type game, where the game camera is always fixated to the side of the environment. The user is able to move left and right, run, jump, crawl, descend or ascend staircases as well as enter doorways. Two stimuli, divided into 3 stages each, where prepared for the experiment. Each stage of the stimuli shows more details of the environment (see table 2).

Table 2: Stimuli Setup

Stage	Stage contents
Stage 1	Basic geometric shapes, no descriptors.
Stage 2	Basic descriptors to establish basic identity of the narrative space.
Stage 3	Full narrative descriptors and narrating descriptors.



Figure 4: Stimulus 1, with stage 1 to 3 (from left to right).



Figure 5: Stimulus 2, with stage 1 to 3 (from left to right).

4.4. Protocol Design

Users were first expected to complete a tutorial stage, to get the users accustomed to how to play the prototype. During this stage they were verbally guided by the examiner. After that, the users were required to play through the stages in a fixed order. After every stage the user had to fill in the in-game module of the Game Experience Questionnaire (QED) before they could continue to the next stage. After completing all the stages, the users were required to complete the core module of the QED.

4.5. Data Analysis

For the data analysis, we used the core module and the in-game module of the QED. The social presence module was ignored since the experimental prototype did not contain any interactions with other players. Furthermore, we decided to forego the post-game module in exchange for the core module, as the post-game module did not test immersion in-depth. Out of the 7 components of the QED, we focused on sensory and imaginative immersion, flow, tension/annoyance, negative aspect and positive aspect. The other two components, namely competence and challenge, was not necessary for this particular research. Due to the limitations of the experimental prototype, we were unable to validate the functional descriptor, which is therefore not included in the data analysis.

5. VALIDATION RESULTS

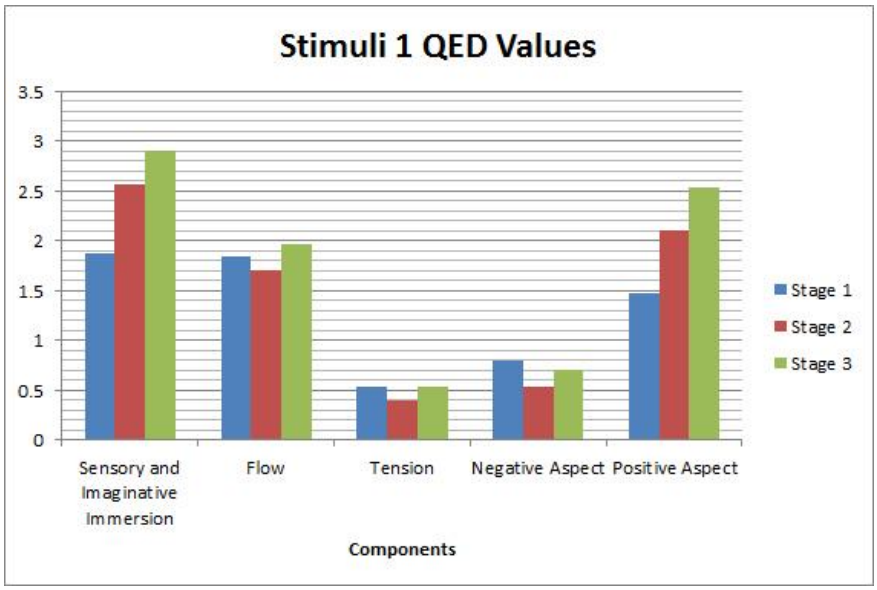

Figure 6: Stimuli 1 QED in-game module values.

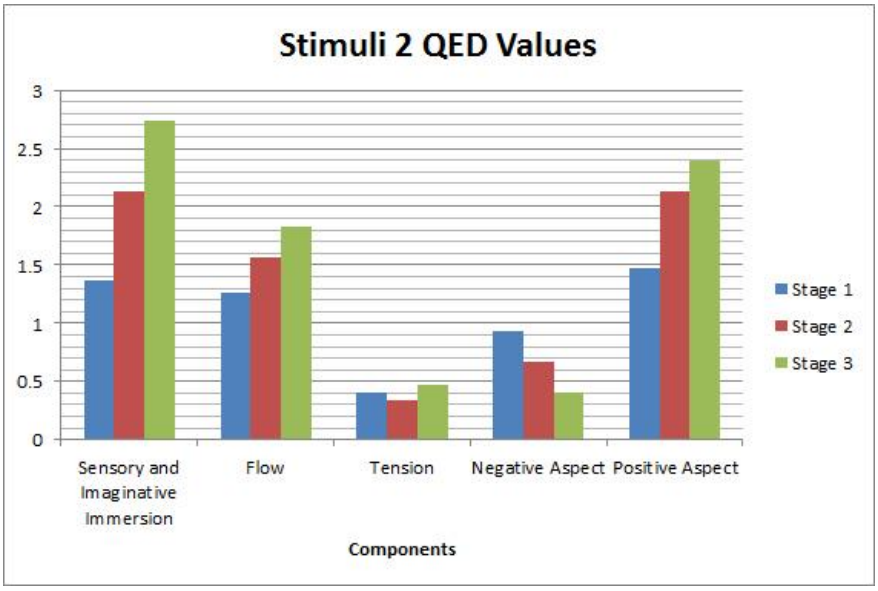

Figure 7: Stimuli 2 QED in-game module values.

Table 3: Significance values stimuli.

Component	Stimuli 1	Stimuli 2
Sensory and Imaginative Immersion	0.0003	0.0000
Flow	0.6227	0.0300
Tension	0.7521	0.7982
Negative Aspect	0.5137	0.2014
Positive Aspect	0.0021	0.0114

Figure 5 and 6 show that when participants played the stages in the stimuli, the stages that contained the biggest variety of narrative descriptors and narrating descriptors scored significantly higher than the areas who did not. Furthermore, the positive aspect module also showed distinct differences between the areas. There was a minor decrease in negative aspect when compared the first stage against the second stage, but the difference was not significant enough to give it any attention. Flow requires further testing. Tension scores were insignificant as well, though it can be argued that tension relates more to challenge rather than immersion, which was not the goal of this experiment.

6. LIMITATIONS

Due to the nature of the experiment, the development of the stimuli takes a long time. A limitation of this study was that due to the allotted timeframe, we were only able to develop two stimuli. However, due to the size of the stimuli, we feel the result is still relevant, though a few elements (such as the flow component) require further validation.

7. CONCLUSION

Games become bigger and bigger as each generation of software passes. The possibilities of the

present, with games containing large sprawling 3D worlds full of life and color, as compared to those of the past, with games being severely limited by hardware and only able to convey the most necessary of information, are vastly different. Whereas in the past the major motivation to play game arguably came from gameplay, nowadays games have become very capable of immersing players.

As the game industry continues to innovate, so will the worlds in which the games take place continue to grow bigger and more expressive. However, with game worlds growing to the sizes they are these days, it also becomes necessary to try and understand them. How can we create a world that the player will be able to successfully immerse himself in? How can we use all of the available resources without confusing the player with too much information? In order to answer questions such as these, we first need to understand the game world itself. It is at that moment that the definitions such as those in this paper become necessary.

Using the definitions and models as defined by this paper, we will become able to understand the narrative properties of the game world itself. Furthermore, we will become more successful at immersing players into the game world.

8. FUTURE WORKS

We wish to analyse how much narrative can be relayed to players of games through using the definitions as defined in this paper. More specifically, we want to find out to what extend narrative descriptors as well as narrative descriptors are able to relay narrative, since they are the most important elements when it comes to giving the game world a narrative purpose.

Furthermore, we wish to continue analyzing game worlds, so that if there is a need we can expand upon the already existing definitions with new ones. We are of the opinion that further analysis is necessary so that more distinctions can be made in the various elements in the narrative world models.

ACKNOWLEDGMENTS

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Color Scheme Search: A Statistics-Based IEC Method

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Abstract: This paper presents a statistics-based interactive evolutionary computation (IEC) method for color scheme search. Color schemes are utilized in an enormous range of items such as websites, clothing, advertising media, and housewares. However, people who do not have sufficient skill or knowledge of colors need to devote considerable time and effort to a creating color scheme. Currently, artists' color schemes are freely available from websites. However, obtaining an appropriate color scheme from a large data set is difficult for novice users. To overcome this problem, we rely on a statistics-based interactive genetic algorithm (IGA). Use of this IGA is expected to reduce computing costs compared with conventional IEC approaches and to take overall color scheme impressions into account. These contributions enable to realization of the *kansei*-based color search system in real time. In addition, we introduce four similarity search (SS) functions (hue, saturation, brightness, and color differences) to facilitate the convergence of a color scheme search. The combination of a statistics-based IGA and four SS functions allows users to easily and effectively find their desired color schemes. To investigate the performance of the proposed method, we conducted two experiments and confirmed that the implemented application allows users to obtain a desired color scheme in less than 48 s. In addition, we also confirmed that the proposed method can provide some favorable recolored illustrations in less than 52 s.

Keywords: Color Scheme Search, Interactive Evolutionary Computation, Statistics, Color Transfer.

1. INTRODUCTION

A color scheme is a significant element in most designs. Recently, some color websites, such as COLOURlovers[1] and Adobe® Kuler[2] have been available for general use. These websites allow

[1] COLOURlovers, http://www.colourlovers.com/ (accessed in January 2014)

users to share artists' color schemes and utilize them freely. However, finding their desired color schemes from a large dataset is difficult for novice users. Hence, people who do not have sufficient skills or knowledge of colors need to devote more time and effort to obtain their favorite color scheme.

In previous studies, an interactive evolutionary computation (IEC) has been applied to some color support systems for color scheme creation or color design. Existing IEC-based color schemes generating systems provide users with several suggested color schemes (Inoue et al., 2009; Tobitani et al., 2012). Other existing systems support color design for clothing, interior accessories, and products (Sugahara et al., 2008; Ito et al., 2009; Miki et al., 2011; Hsiao et al., 2013). An IEC-based approach gives users various color scheme candidates by changing color patterns; hence, users can find their favorites among all candidates. Furthermore, this method uses some human inputs; consequently, it is possible to gradually narrow the candidates based on user *kansei* (sensibility, preference, and aesthetic). Conventional IEC-based systems directly encode all color data in RGB, HSB, or L*a*b* color space; thereby, these approaches incur increasing computational costs with the number of target colors increases. In fact, most previous studies did not target more than three colors. Because of this limitation, a color scheme search method using the conventional IEC method typically does not handle more than three colors.

To overcome this limitation, we adopt an IEC method based on statistics. This new approach has two advantages. First, it decreases the computing cost compared to conventional IEC-based approaches because the proposed approach fixes the number of data; second, it maintains overall color scheme impressions. Previous studies have reported that people respond similarly to specific colors or color schemes (Kobayashi, 1992; Matsuda, 1995; Chijiiwa, 1999; Ou et al., 2004). The common responses or impressions are related to combinations of hue, saturation, and brightness. The statistics-based approach enables the overall impressions to be changed by using the statistics of a color scheme. In contrast, conventional IEC-based approaches do not consider the overall color scheme impressions. The proposed method enables users to find a desired color based on the user's *kansei*.

As mentioned previously, the features of the proposed method realize the *kansei*-based color search system in real time. In addition, this system introduces four similarity search (SS) functions based on hue, saturation, brightness, and color differences. Consequently, we expect that the combination of the proposed IEC method and four SS functions will enable users to find their desired color schemes based on their *kansei*.

2. RELATED WORK

Color is an effective graphic design element and can change the impressions of almost all advertising media. To fully utilize the effects of color, color harmony is significant because an appropriate combination of colors enables people to convey information efficiently and effectively. Moon & Spencer summarized a color harmony theory and quantified it as an aesthetic measure (Moon & Spencer, 1944a; 1944b; 1944c). Matsuda has created a color harmony model by summarizing some forms, schemes, and relationships in a practical color coordinate system developed by the *Japan Color Research Institute* (Matsuda, 1995). Previous studies were able to model or theorize color harmony. By referring to these outcomes, other studies have reported some color support methods for color transfer, color scheme creation, and other applications.

[2] Adobe® Kuler, https://kuler.adobe.com/create/color-wheel/ (accessed in January 2014)

2.1. Color support methods

O'Donovan et al. and Lin et al. used a similar approach to investigate color compatibility or color impressions (O'Donovan et al., 2011; Lin et al., 2013). This approach uses large color datasets or data of user experiences. By analyzing these large datasets, O'Donovan et al. studied color compatibility theories and Lin et al. proposed two methods: a probabilistic factor graph model for coloring and a method for extracting color themes from images using a regression model. These methods allow users to utilize colors effectively. However, people also use an inharmonic color scheme intentionally to attract attention in advertising material. Therefore, our proposed method also considers inharmonic color schemes.

2.2. IEC-based color support methods

Inoue et al., Kinoshita et al. and Tobitani et al. have presented IEC-based color creation methods (Inoue et al., 2009; Kinoshita et al., 2006; Tobinatani et al., 2012). In particular, The method of Kinoshita et al. incorporated Moon and Spencer's color harmony equations. Sugahara et al., Ito et al., Miki et al., and Hsiao et al. have proposed colorization methods for Japanese kimonos (Japanese-style clothing), t-shirts, office space design, and product color design, respectively (Sugahara et al., 2008; Ito et al., 2009; Miki et al., 2011; Hsiao et al., 2013). The advantage of IEC is the incorporation of human evaluations into the results. Thus, IEC-based method makes it possible to obtain a desired result.

3. STATISTICS-BASED IEC METHOD FOR COLOR SCHEME SEARCH

Conventional IEC-based color support systems do not consider the characteristics of colors. Previous studies have introduced an objective function to adjust color scheme candidates based on color harmony theory (Kinoshita et al., 2006; Troiano et al., 2009; Tobitani et al., 2012). This is a good solution for the creation of harmonious color schemes; however, the use of the object function becomes a hindrance when obtaining a favorite color scheme. In addition, it is difficult for novice users to take color harmonics into consideration when generating a desired color scheme.

To overcome these issues, we utilize enormous color scheme dataset available from color websites. Consequently, the effective color scheme search method is required. This section describes our proposed statistics-based IEC method for color scheme search.

3.1. Statistics data of color scheme in IEC

Our proposed statistics-based IEC uses basic statistics: average values, standard deviations, or coefficient of variations in a color scheme. We focus on the overall color scheme impression. The impression is related to hue, saturation, and brightness. For example, when a user wants a warm color scheme, he/she will look for a reddish color scheme. We consider the statistics of overall impressions for color schemes. Human perception of colors is an important factor when choosing color schemes. Generally, HSV and HLS color models are utilized for hue, saturation, and brightness values. However, these models do not consider human perceptions. L*a*b* color space is a well-known perceptually-based color model. Color difference in L*a*b* indicates the Euclidean distance in the color space, and this distance corresponds to human perceptions. We uses L*c*h* values, which are represented in L*a*b* color space. L*c*h* means brightness, saturation, and hue values respectively. Note that $c^* = \sqrt{(a^*)^2 + (b^*)^2}$ and $h^* = \arctan(b^*/a^*)$, L^* are calculated in L*a*b* color space. To consider human perception as much as possible, this study adopts the perceptually-based saturation $S = \sqrt{a^* + b^*}/\sqrt{a^* + b^* + L^*} \times 100\%$ reported by (Lübbe, 2010) instead of c^*. Therefore, we adopted the average values L^*_{ave}, S_{ave}, h^*_{ave}, the coefficient variations

Table 1: GA parameters and genetic operations

Population size	Number of elites	Selection method
9	2	Roulette Selection Elite Selection
Crossover	**Crossover rate**	**Mutation rate**
Uniform Crossover	1.0	0.3

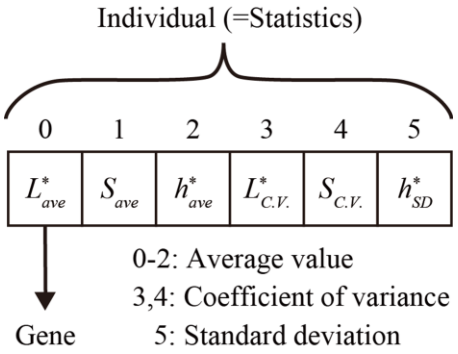


Figure 1: Configuration of an individual

$L^*_{C.V.}$, $S_{C.V.}$, and the standard deviation h^*_{SD}.

3.2. Interactive genetic algorithm for a color scheme search

In this study, we adopted an interactive genetic algorithm (IGA), which is a commonly used IEC method. Next, we describe the statistics-based IGA for color scheme search. The IGA processes are described in the following seven steps. GA parameters and the genetic operations are shown in Table 1.

STEP 1. Generate initial population

Statistics for an individual are provided in Figure 1. An initial population of IGA is strongly associated with IGA search performance. In this study, the search space is a dataset of color schemes; therefore, all generated individuals are color scheme data in the color scheme database (DB). The IGA used here utilizes probability distributions of each cluster to generate various candidates in the initial population. The process of generating the initial population is as follows.

The first process uses multidimensional scaling (MDS) for the color scheme DB. Then the color scheme DB is visualized as a 2D map.

The next process applies a k-means clustering technique to categorize the 2D map. Note that the number of neighboring clusters is set as $k = 9$ based on the dendrogram result. Figure 2 shows the results of k-means clustering. Each point is a color scheme in the DB. The coincident colored points have same cluster ID. Nine black points indicate the center of gravity of each cluster.

Final process assigns nine probability distributions on the basis of the Euclidean distances between each point and its center of gravity. The upper right portion of Figure2 shows the probability distribution of the brown cluster. The gradation colors show the probabilities. The reddish color denotes color schemes that have higher probabilities, and the bluish color denotes color schemes that have lower probabilities. A candidate is selected from the color scheme DB based on

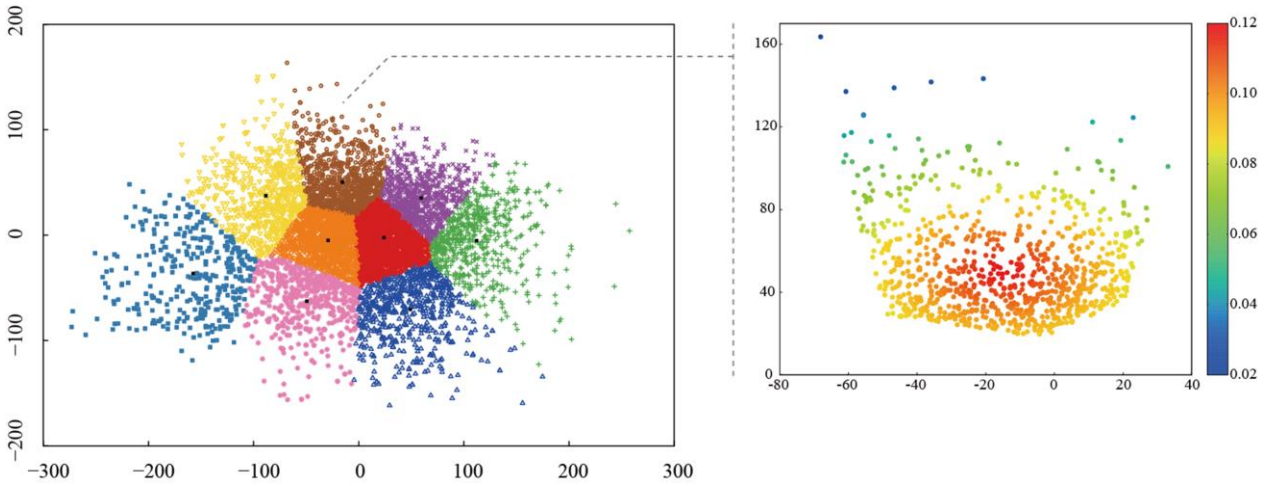


Figure 2: Result of k-means clustering and upper right portion is an example of a probability distribution

a probability distribution. Hence, nine candidates are stochastically chosen from the color scheme DB based on the probability distributions of each cluster as the initial population.

STEP 2. Replace all genes

General IGAs are used to generate fonts or musical content by combining parameters (genes). In this study, the IGA does not generate color schemes; it displays color scheme candidates. This method replaces each gene of an individual color scheme with each statistic of the color schemes in the DB. First, the fitness value is calculated by comparing an individual with each DB color scheme. Then, all genes of the individual are replaced with the set of statistics that has the maximum fitness value among the dataset in the DB. The fitness value F is defined as follows:

$$F = 1.0 - \sum_i \omega_i A_i / \sum_i \omega_i,$$
$$A = \{\Delta L^*_{ave}, \Delta S_{ave}, \Delta h^*_{ave}, \Delta L^*_{C.V.}, \Delta S_{C.V.}, \Delta h^*_{SD}\} \quad (1)$$

Here ω is a weighting parameter and A is a set of the difference values between the current selected color scheme and a DB color scheme with each statistic. In this study, all weighting parameters are set to $\omega = 0.2$ $(i = 1,2,\ldots,6)$. In the future study, appropriate weighting parameters determined by user feedback will be investigated.

STEP 3. Display candidates

Nine candidate color schemes are displayed. These candidates are determined by each individual after the readout of the color schemes from the DB.

STEP 4. Evaluate candidates by user

A user evaluates the displayed candidates by choosing a candidate that is close to their desired color scheme. This method accelerates IGA search because the user performs an evaluation at each iteration (Kimura et al., 2008). If the user finds a desired color scheme, the process is terminated.

STEP 5. Select individuals

Here, the IGA uses Elite Selection and Roulette Selection as individual selection methods. In Elite Selection, the selected individual in STEP 4 (Elite *A*) and the individual with the maximum fitness (Elite *B*) become elites. In Roulette Selection, seven individuals are selected stochastically based on Eq. (2).

$$P_i = \frac{S_i}{\sum_{i=1}^{N} S_i} \quad (2)$$

Here s_i is the fitness value between Elite *A* and each individual i. N is the number of all individuals excluding Elite *A*. This study sets N = 8. Note that Elite *A* remains a selected individual each time.

STEP 6. Crossover

The IGA has adopted the uniform crossover technique. This technique exchanges the corresponding statistics. In this IGA, four pairs of individuals are selected from all individuals including the two elites. This process considers color compatibility on the basis of hue and tone (brightness and saturation) (Kobayashi, 1992; Matsuda, 1995; Cohen-Or et al., 2006; O'Donovan et al., 2011). Thus, for brightness and saturation, an average value and a coefficient of variation are paired. Two pairs exchange the statistics with each value. For hue, the average value and the standard deviation are exchanged individually. Note that the probability of exchange is 50% for each statistic item.

STEP 7. Mutation

The mutation process also considers color compatibility. This process has three replacement target patterns: statistics in brightness and saturation, statistics in hue, and all statistics. Note that the replacement target pattern is determined by a one-third probability. This mutation process randomly chooses a color scheme from the DB. Each statistic value of an individual is replaced with each corresponding statistic of the chosen color scheme. Note that the probability of running this process is determined by the mutation ratio.

4. COLOR SCHEME SEARCH APPLICATION

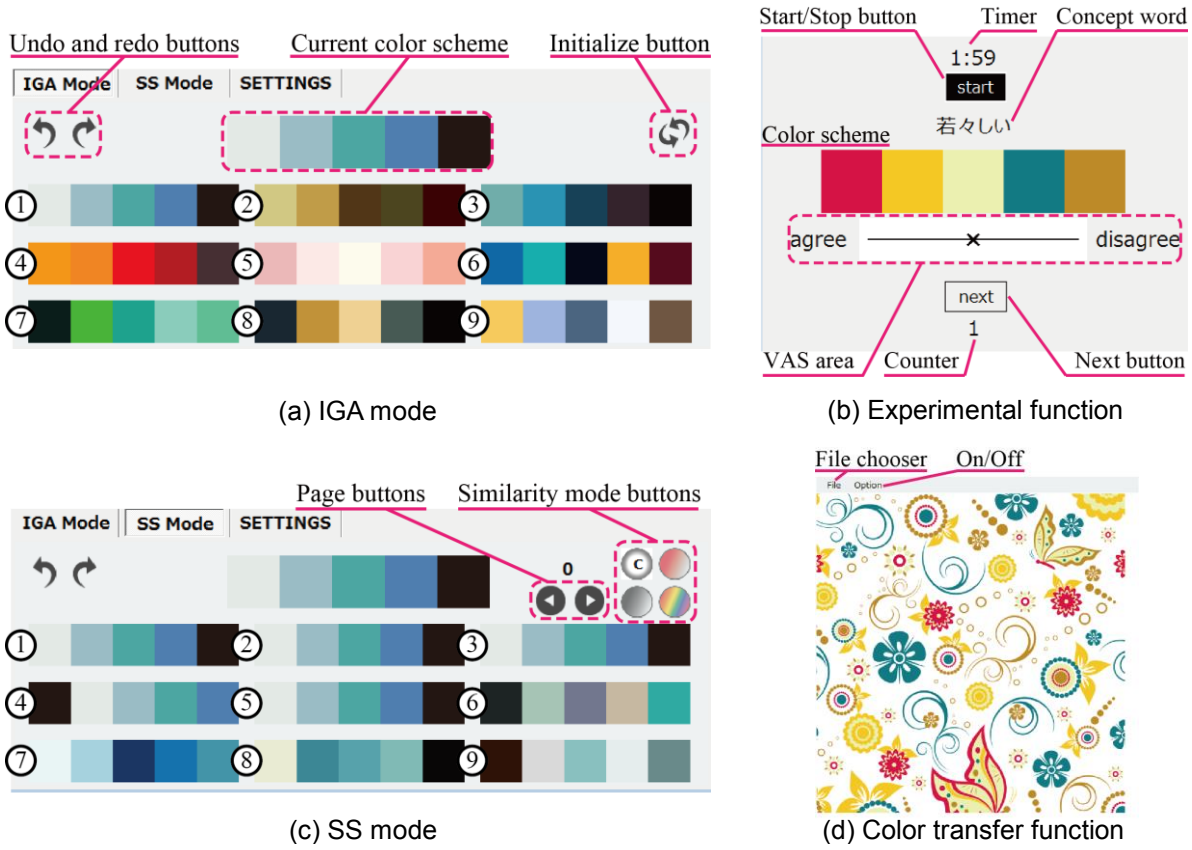
A color design support application has been implemented by using the proposed method. Furthermore, this application incorporates four SS functions. The combination of the proposed method and the four SS functions improve the search performance. This section describes the application and the details of the four SS functions. In addition, this application has a color transfer function. This section also illustrates the process flow. Figure 3 shows screenshots of each function in the implemented application.

4.1. IGA mode: the color scheme search function

Figure 3 shows a screenshot of the color scheme search function, named IGA mode. The IGA mode applies the proposed statistics-based IGA. The statistics-based IGA enables searching of a color scheme based on an impression of overall color scheme. Thus, the various color scheme candidates can be displayed. Normally, users use this mode to search for various types of color schemes as a global search. This system consists of undo and redo buttons, the display area for each color scheme, and an initialize button. This mode simultaneously shows 10 color schemes. The biggest color scheme shown in Figure 3(a) indicates the currently selected candidate. The other color schemes are the selectable candidates. This system displays various color scheme candidates based on user evaluation, and the displayed candidates are gradually narrowed with each iteration of the user selection operation. The evaluation is performed by clicking on a favorite color scheme. When the user chooses a candidate, the system presents other candidates.

4.2. SS mode: four similarity search functions

Figure 3(c) presents a screenshot of the SS mode. The SS mode has four different SS functions. One function is based on the color difference in L*a*b* color space. This similarity is a minimum



(a) IGA mode

(b) Experimental function

(c) SS mode

(d) Color transfer function

Figure 3: Screenshot of the color design support application

value among a set of the sum of values of color differences for every color scheme and each DB color scheme. This SS function shows results in ascending order. The other functions are based on hue, saturation, and brightness. These SS functions also shows results in ascending order, respectively. In addition, we set two constraint parameters φ^A and $\varphi^B$to preserve overall color impression. φ^A is relative to the average values of hue, saturation, and brightness (L^*_{ave}, h^*_{ave}, and S_{ave}), φ^B is relative to the coefficient variations of saturation and brightness, and the standard deviation of hue ($L^*_{C.V.}$, $S_{C.V.}$, and h^*_{SD}). For example, in the case of brightness, the SS function candidates fulfill the following condition; the SS function candidates fulfill the following condition; $|\Delta h^*_{ave}|^2/|\varphi^A_1|^2 + |\Delta S_{ave}|^2/|\varphi^A_2|^2 \leq 1 \cap |\Delta h^*_{SD}|^2/|\varphi^B|^2 + |\Delta S_{C.V.}|^2/|\varphi^B|^2 \leq 1$. The same constraint is employed for hue and saturation. Note that φ^A_1 is set for hue and φ^A_2 is set for saturation and brightness. We set these parameters as $\varphi^A_1 = 18$, $\varphi^A_2 = 5$, and $\varphi^B = 0.1$.

4.3. Color transfer function

This application has a color transfer function that changes the color pattern of a scalable vector graphics (SVG) image. SVG images do not deteriorate by color transfer processing and can be rendered most web browsers. The color scheme search function targets five colors. However, some SVG images are composed of more than five colors. Thus, a color reduction process is required for color transfer processing. The color reduction process continues to merge a pair of colors with the smallest color difference until the number of colors becomes five. This process is based on a process presented in (Kondo et al., 2000) shows a screenshot of this function. The color reduction process applies the specified SVG image. When the user chooses a color scheme using the color scheme search function, this color transfer function changes the color pattern of a SVG image based on the chosen color scheme. Each color assignment is determined by the color difference of

CIEDE2000. The function computes the sum of color differences for all assignment patterns, and the assignment pattern with minimum value is applied.

5. EXPERIMENTAL EVALUATION

The proposed color search method can search a desired color scheme without the user having any knowledge or skills regarding colors. We considered that setting a user's desired color scheme is difficult for novice users because the desired color scheme is often unclear in the user's mind. Furthermore, the user may frequently change the desired color scheme during the color scheme search. Therefore, it is impossible to evaluate whether the user can actually obtain a desired color scheme. Section 1 described some common impressions that people characteristically have of specific colors and color schemes. We conducted an experiment that focused on this characteristic. In addition, we also conducted an experiment using the color transfer function. The goal of the second experiment was to investigate the effectiveness of the practical use of the proposed method.

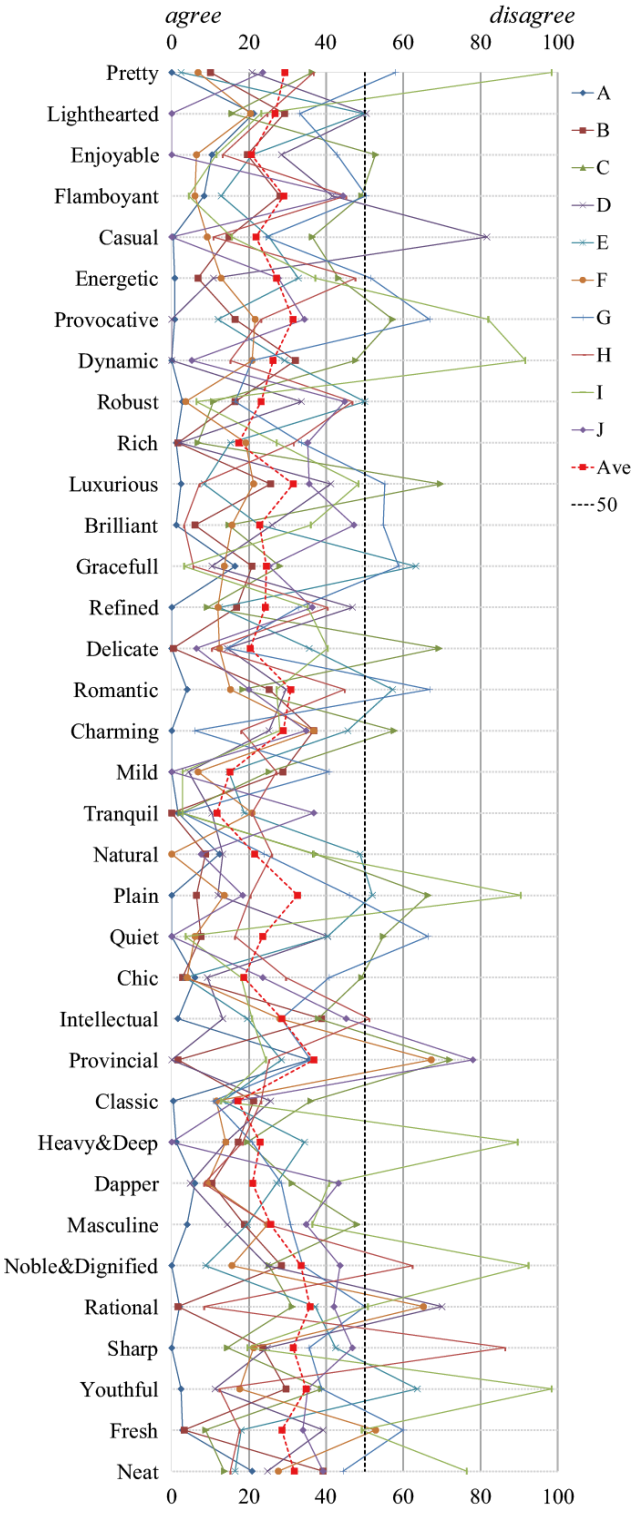
5.1. Details of the two experiments

The task of first experiment was to find a suitable color scheme for some concept words. Figure 3(b) shows the experimental function. This function has a start and stop button, a timer, a display area for a concept word, a display area for the selected color scheme, a visual analog scale (VAS) area (an evaluation area), a counter, and a next button. First, the participant searched for a suitable color scheme for the displayed concept word using the color scheme search system. If the participant found the best color scheme or exceeded the time limit, the experiment was terminated. The evaluation method adopted a VAS (Cox & Davison, 2005). The evaluation item of this experiment was “agree-disagree” scale. Thus, the participants were required to evaluate whether the color scheme gave the same impression as the concept word. The evaluation range of the VAS was from 0 to 250.

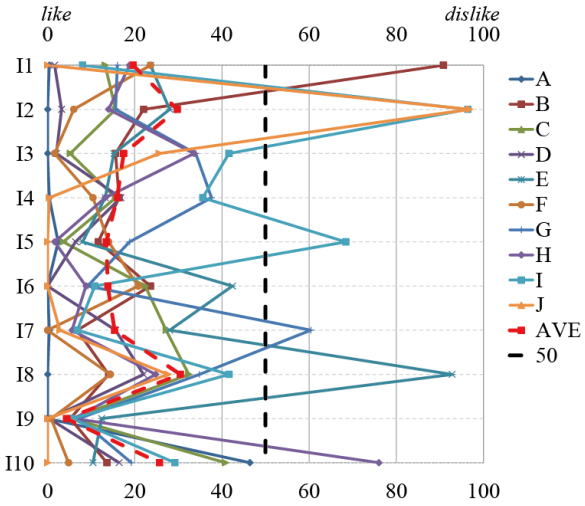
The task of the second experiment was to determine the preferred color pattern for some SVG images. The participants could change the color pattern of each SVG image using the proposed color scheme search method. If the participant found the best color scheme or exceeded the time limit, the experiment was terminated. The participant evaluated the recolored SVG images using the VAS with a “like-dislike” scale. The SVG images were displayed sequentially, as is shown in Figure 3(d). The size of the display area was fixed at 500×500 pixels, and each SVG was scaled to fit in the entire display area.

In both experiments, the time limit was 2 min. Ten male graduate students in 20s participated in the experiment. The experimental equipment included the LCD monitors (FlexScan M1950-R, Size: 19 inch, Resolution: 1280×1024) and PCs (Intel Core i7 2.3GHz, 8GB RAM). In some cases, different equipment of equal performances was used. The color of the LCD monitor was adjusted by using the following values: color temperature, 6500K; contrast, 50; brightness, 30. The distance between each participant and the LCD monitor ranged from 40 to 50 cm. All participants performed this experiment in the same room. The first experiment used 35 concept words described by (Kobayashi, 1995). The second experiment used 10 vector images selected from a website[3]. The DB was constructed by using 7850 color schemes from COLOURLovers.

[3] ALL-free-download.com, http://all-free-download.com/ (accessed in January 2014)



(a) Results of the first experiment



(b) Results of the second experiment



(c) Selected color schemes for “Tranquil”



(d) Recolored images for “I9”

Figure 4: Experimental results

5.2. Experimental results

We recorded all evaluation items and operation times for both experiments. Figure 4 show the results of the first and second experiment.

In both results, the letters are the participants ID. The red dashed line indicates the average values of the experimental results. The black dashed line indicates the center value. Note that all



(a) Example A (ID: I1, I2)



(b) Example B (ID: I9, I10)

Figure 5: Examples of recolored images

evaluation values are normalized in the range [0, 100]. In the first experiment, 0 indicates “agree” and 100 indicates “disagree.” The results are shown for each concept word. In the second experiment, 0 indicates “like” and 100 indicates “dislike.” IDs, such as “I1,” indicate each illustration (examples are shown in Figures 5 and 6). The average time for the first experiment was 47.30 s. The average time for the second experiment was 51.97 s.

In the first experiment, all average values indicate “agree.” The results for the concept word “Tranquil” strongly indicate an “agree” response. Figure 4(c) shows examples of the selected color schemes for “Tranquil.” These examples have two features. Some color schemes consist of (1) similar tone (saturation and brightness) patterns and (2) similar hue patterns. The results indicate that the statistics-based approach works effectively.

This result indicates that the proposed method allowed users to obtain a desired color scheme based on concept words. Furthermore, the average operation time was 47.30 s. In the experiment discussed by (Inoue et al., 2009), which targeted three colors, the average operation time was approximately 1.5 min. However, the proposed method targeted five colors, and the operation time was less than that of the existing method proposed by (Inoue et al., 2009).

In the second experiment, all average values indicate “like” responses. The results for “I9” strongly indicate “like” responses. Figure 4(d) shows examples of recolored images for “I9.” The common feature is that the silhouette regions (castle and bats) are darker colors. We suppose that the castle and the bats in the image gave the specific meaning as “silhouette,” thereby the participants fixed a darker color. From this assumption, the participants would focus on the other four colors in their color choice. Consequently, the participants could determine a favorite color pattern more easily and efficiently.

The operation time was only 3 s slower than the first experimental result. The participants could obtain a favorable colored illustration using the color scheme search. Therefore, we assume that the proposed method has an acceptable level of practical usability. Figures 5 and 6 show some



Figure 6: Examples of recolored illustrations (ID: I3 -I8)

examples of the recolored illustrations. Note that the ID numbers corresponding to Figure 4(b).

6. CONCLUSION

This study aims to find a desired color scheme without any requiring the user to have special skills or knowledge regarding colors. To achieve this goal, we proposed a color scheme search method using a statistics-based IEC method. The proposed statistics-based IEC method considers overall color scheme impressions. The proposed method provides the suggestions for various types of color scheme candidates and gradually narrows the candidates based on user evaluations. A color support application was implemented for experimental evaluations. This application introduced four SS functions and a color transfer function. To investigate the effectiveness of the proposed method, two experiments were conducted.

The experimental results confirm that the implemented application allows users to obtain a desired color scheme in less than 48 s. Relative to operation time, the proposed method is superior to the existing method proposed by Inoue et al. In addition, the results of the second experiment indicate that the proposed method enables users to obtain some favorable recolored illustrations in less than 52 s. Therefore, we consider that the proposed color support method is valid for practical use. In future, we will improve the proposed method by including the ability to respond to gradational color combinations and texture combinations.

ACKNOWLEDGMENTS

This work was supported by JSPS KAKENHI Grant Number 23500256 and 25・10750.

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Changes of Impression in the Animation Characters with the Different Color and Thickness in Outlines

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Abstract: Recently the several colors such as brown and reddish brown are used as the outlines in animation characters in some TV animation. To examine the effects on impression in the animation characters by the differences of color and thickness in outlines, the impression in the original animation characters was measured using SD method with varying the colors and thickness in outlines. In the results, the effects with the outlines can be represented by the impression to “naturalness”, “potency”, and “activity” of three dimensions in the animation characters from factor analysis based on the subjects’ evaluation. It is found that the colors and thickness of outlines affect the impression to naturalness and potency in the animation characters.

Keywords: Animation character, outline, color, thickness, impression.

1. INTRODUCTION

Most of animation characters in TV animation (i.e. anime) are originally drawn by black outlines. On the other hand, in some anime, recently the several colors such as brown and reddish brown are used as the outlines in animation characters as well. Also, the thickness of outline in animation characters is changed in some of anime. From the survey of studies on animation characters, although there are some studies for investigating the effects in terms of eye and face [Kawatani et al. (2010) and Kawatani et al. (2008)], there is no study focused on the outline in animation characters.

In this paper, the purpose is to examine the effects on impression in the animation characters by the differences of color and thickness in outlines. It is necessary to investigate these effects to understand how to design animation characters from practical point of view.

2. METHODOLOGY

2.1. Animation characters

Figure 1 shows four animation characters used in this experiment. They are drawn so that they do not impress similarly. Figure 1 (a) and (b) represent the male animation characters (MA and MB), and Figure 1 (c) and (d) are the female animation characters (FA and FB), respectively. The background of the all is painted by white. The outlines of each character are drawn using the pen tool without the effect of pen pressure in the drawing software.

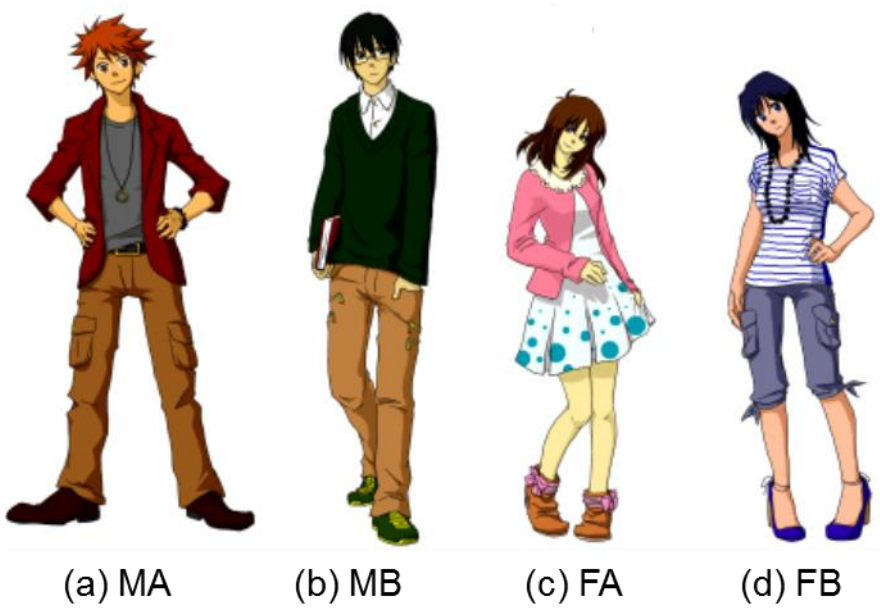


Figure 1: Animation characters used in this experiment.

2.2. Outlines

Table 1 shows luminance and chromaticities of colors and the pixels of thickness in the outlines of each animation character used in this experiment. Including without the outline, there were ten types of the outlines. In the black outlines, they consisted of four types with the different thickness at constant color. Five types of the outlines in chromatic colors were reddish brown, pale brown, green, blue, and red colors at constant thickness. The total of the stimuli was forty. Figure 2 show the examples of the stimuli of No.1 - No.5 in Table 1 for FA in Figure 1 (c).

Table 1: Luminance and chromaticities of colors and the pixels of thickness in the outlines.

No.	color				thickness (px)
	name	luminance (cd/m^2)	*x*	*y*	
1	without outline	-	-	-	-
2	black 1	0.30	0.2549	0.2646	0.5
3	black 2	0.30	0.2549	0.2646	1
4	black 3	0.30	0.2549	0.2646	3
5	black 4	0.30	0.2549	0.2646	5
6	reddish brown	11.39	0.5552	0.3405	1
7	pale brown	51.09	0.4320	0.3843	1
8	green	73.12	0.2141	0.4792	1
9	blue	30.08	0.1843	0.1055	1
10	red	65.71	0.6149	0.3111	1

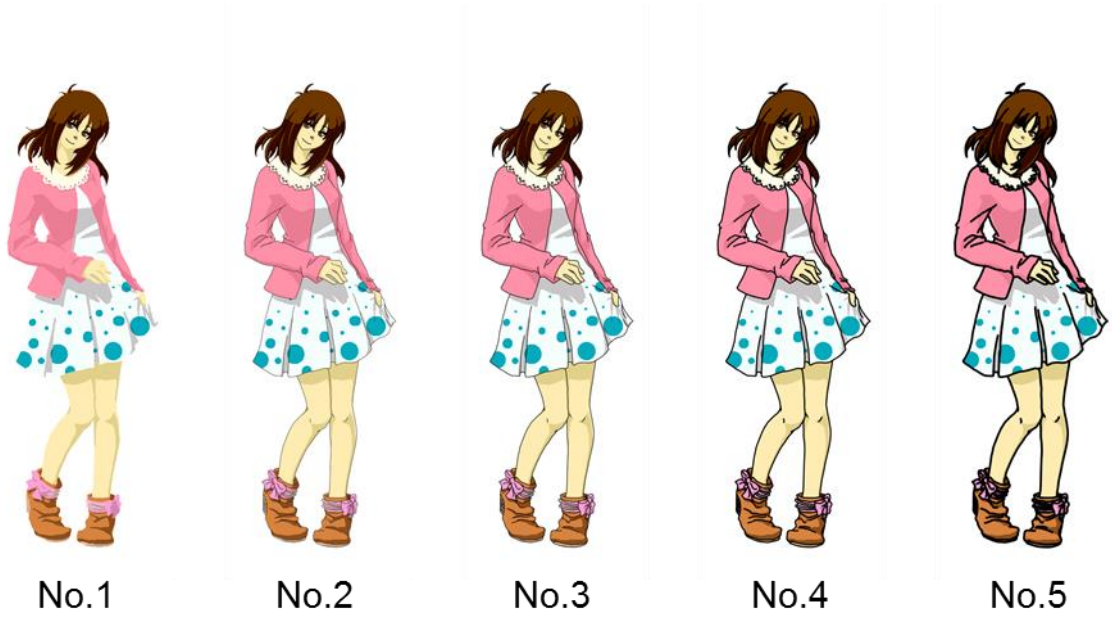


Figure 2: Examples of the stimuli of No.1 - No.5 in Table 1 for FA in Figure 1 (c).

2.3. Apparatus

Figure 3 shows the apparatus in this experiment. The stimuli were presented by the 24-inch display (EIZO, FlexScan SX2462W) placed on the table in the dark room. The subject sat on the chair in front of the display and the viewing distance was 900 mm. The subject was asked to evaluate the presented stimulus using the evaluation sheets placed on the table in the right side of the subject.

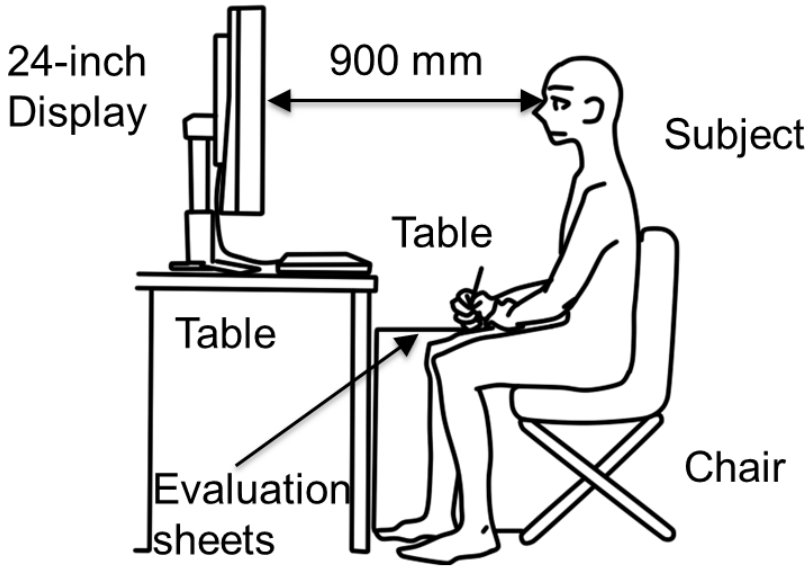


Figure 3: Apparatus.

2.4. Procedure

Prior to the experiment, it had an enough time to practice. The stimulus was randomly presented then the subject evaluated the impression of the presented stimulus using semantic differential method (SD method). In SD method, eighteen bipolar adjective-pair were used as shown in Table 2. It was the seven-rank scales for each bipolar adjective-pair (i.e. for example, 1: extremely dark, 2: very dark, 3: dark, 4: neither bright nor dark, 5: bright, 6: very bright, 7: extremely bright).

Table 2: Eighteen bipolar adjective-pair in SD method.

No.	bipolar adjective-pair			No.	bipolar adjective-pair		
1	darty	-	clean	10	quiet	-	active
2	unfriendly	-	friendly	11	fidgety	-	calm
3	unnatural	-	natural	12	cool	-	hot
4	complicate	-	simple	13	dark	-	bright
5	burly	-	stylish	14	roundish	-	sharp
6	flaccid	-	magnificent	15	dislike	-	like
7	weakly	-	powerful	16	common	-	unique
8	heavy	-	light	17	realistic	-	fantastic
9	burrly	-	clear	18	unimpressive	-	impressive

2.5. Subjects

Sixteen subjects participated in this experiment. They were thirteen males and three females. The average age was 22.6 years old (S.D. 3.8).

3. RESULTS AND DISCUSSIONS

3.1. Factors from factor analysis

In the results of factor analysis from the evaluation values in all the subjects, cumulative contribution ratio is 81% with three factors. Table 3 shows the results of factor loading in these factors. The row and column indicate eighteen adjective-pair and the values from the first to third factor loading, respectively. As shown this table, the value of the first factor loading is that the value of “unnatural vs. natural” is highly positive and that of “common vs. unique” is highly negative, mainly. In the second factor loading, “weakly vs. powerful” is highly positive and “heavy vs. light” is highly negative as well. The third factor loading represents highly positive value of “dark vs. bright”. In this paper, the first, second, and third factors are called “naturalness”, “potency”, and “activity”, respectively.

3.2. Naturalness, potency, and activity on animation characters

Figure 4 shows the distribution of factor score for each stimulus on the planes from two of factors. Figure 4 (a) and (b) represent its distribution on the naturalness-potency and naturalness-activity planes, respectively. Each symbol indicates each animation character in Figure 1. In Figure 4 (a), each ellipse represents the distribution of each outline in Table 1. In Figure 4 (b), each ellipse represents the distribution of MA and MB in Figure 1.

As shown in Figure 4 (a), each ellipse is distributed with the different outlines regardless of the animation characters. It means that the impressions to naturalness and potency are affected by the colors and thickness of the outlines rather than the design of animation characters. On the other hand, in Figure 4 (b), two ellipses are obtained on the upper and bottom regions, respectively. It means that the impression to activity is related to the design of the animation characters without the effects of outlines.

In Figure 4 (a), for the impression to naturalness, the colors of black, reddish brown and pale brown in the outlines are mainly distributed on positive value region and others are negative one. It is considered that the use of color close to human skin color in the outline give animation characters natural impression, as well as the use of black. Also, the impression to potency increases with an

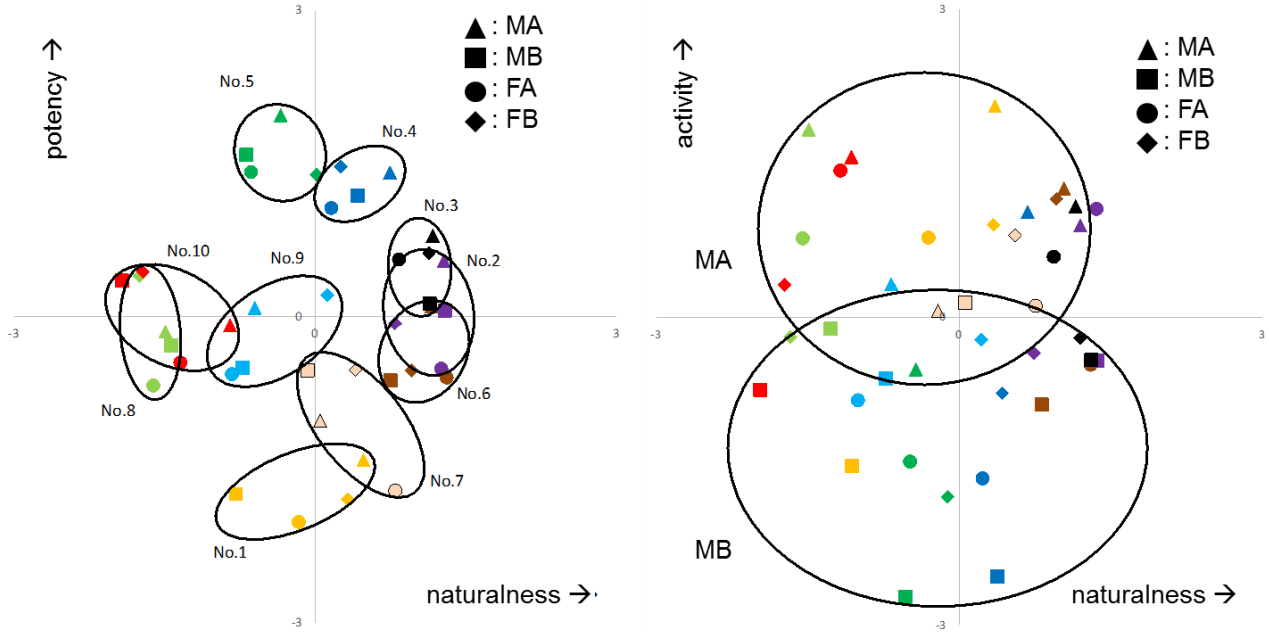
increasing with the thickness in the outline. And the use of colors of reddish and pale brown decreases the impression to potency compared with that of black despite the same thickness in the outline. It is suggested that the thickness of outline affects the impression to potency and its impression increases with the thickness of outline in animation characters. The use of brown colors gives animation characters usual impression. Thus, it is suggested that this is a reason why the brown color of outline is used in animation characters recently. It seems to give animation character more natural and usual impression reducing that to potency by using the brown color of outline. Although it decreases usual and natural impression for them, the impression to potency increases with the thickness of outline in animation characters.

Table 3: Results of factor loading in these factors from Factor Analysis.

bipolar adjective-pair	factor loading		
	first	second	third
unnatural - natural	**0.972**	0.151	-0.100
dislike - like	**0.969**	0.027	0.016
unfriendly - friendly	**0.945**	0.225	0.022
complicate - simple	**0.838**	-0.271	0.031
darly - clean	**0.887**	-0.237	0.143
common - unique	**-0.909**	-0.144	0.278
realistic - fantastic	**-0.833**	-0.320	0.346
unimpressive - impressive	-0.405	**0.720**	-0.087
weakly - powerful	0.043	**0.968**	-0.061
flaccid - magnificent	0.201	**0.932**	0.001
quiet - active	-0.109	**0.755**	0.609
heavy - light	-0.143	**-0.742**	0.640
dark - bright	-0.131	-0.046	**0.853**
fidgety - calm	0.655	-0.343	-0.612
burrly - clear	0.356	0.664	-0.309
roundish - sharp	0.070	0.016	0.288
cool - hot	-0.147	0.649	0.539
burly - stylish	-0.111	-0.392	0.667

4. CONCLUSION

To examine the effects on impression in the animation characters by the differences of color and thickness in outlines, the impression in the original animation characters was measured using SD method with varying the colors and thickness in outlines. In the results, the effects with the outlines can be represented by the impression to naturalness, potency, and activity of three dimensions in the animation characters from factor analysis based on the subjects' evaluation. It is found that the colors and thickness of outlines affect the impression to naturalness and potency in the animation characters. It is suggested that it gives animation characters more natural and usual impressions by using the brown color of outline in animation characters of recent anime.



(a) Naturalness - potency plane. (b) Naturalness - activity plane.

Figure 4: Distribution of factor scores for each stimulus on the planes from two of factors. (a) Naturalness - potency plane, (b) Naturalness - activity plane.

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KEER2014, LINKÖPING | JUNE 11-13 2014
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Analyses of Local Mascot Characters and Proposal of Automatic Creation System Using *Kansei*-words

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Abstract: In this paper, first, analyses of local community mascot characters are carried out to obtain knowledge to be the popular ones. Next a mascot characters automatic creation system is proposed using these findings. As for the analyses, we used 200 (top 100 and low 100) local community mascot characters selected from 2,258 characters. Many interesting findings could be obtained such that short limbs or dark-round eyes tend to contribute to be popular as a mascot character. The proposed system utilizing these findings can create a mascot character reflecting a user's image inputted by *Kansei*-words. Many parts having degrees of *Kansei* images are prepared in the proposed system and are combined to form a character using Rough Sets Theory and an Interactive Genetic Algorithm framework. We performed evaluation experiments. Many mascot characters satisfying user's image were created and remarkable results were obtained through subjective evaluations. For example, by using the extracted rules from the analyses and Interactive Genetic Algorithm, the proposed system can create much favorable mascot characters. Moreover, we found some interesting tendencies of the color used to paint characters. One of them is that the *cheerful* characters are often painted in warm colors with high saturation.

Keywords: local mascot characters, automatic creation, Interactive Genetic Algorithm, Rough Sets Theory.

1. INTRODUCTION

There are a variety of mascot characters around us —from commercial characters such as Disney (Disney) and Sanrio (Sanrio) to anime ones such as Pikachu (Pokémon company) and local community ones. The market, as large as 1.6 trillion yen, is said to be invulnerable to recession and to have a promising future (Koshikawa, 2013). Recently, "Kumamon", Kumamoto Prefecture's local mascot community character, has advanced overseas, making one of current topics. The Japanese mascot character business is on the rise, with its goods being sold in Europe,

America and Asia and the articles concerning it have often appeared in major newspapers (W. S. Journal, 2012, December).

A mascot character reflecting the image of a product, a company, or a local community is considered to have a potential to activate the target. Therefore, the design of a mascot character is a crucial issue to effectively convey the image of the target. However, there is little knowledge about the design: in most cases the characters are designed manually or by designers.

There are some researches on analyses of mascot characters. In (Shiizuka, 2012, April) it is reported that mascot characters popular in Japan were mostly expressionless. Ref. (Ito, Yamanaka, et al., 2007, September) reports that characters with short legs are suitable for “healing” that many people nowadays are seeking for in mascot characters (Miyashita, 2001), (Yamada, 2008).

Some researches treated some elements in a character. Ref. (Kiya, Yamanaka, et al., 2009) focuses on the color of a character. Effects for impression and preference by the shape of the eyes are analyzed in ref. (Ito, Yamashita, 2012).

We have proposed a 3D character automatic generation system (Ogura, Hagiwara, 2012). This system, however, aims at creation of only *Kawaii* (cute) girls. As a result, fields of the application are very limited.

This paper treats much more general and popular character, a mascot character. First, many local community mascot characters are collected and analyzed and obtained knowledge or rules concerning popular mascot characters. Second, a mascot characters automatic creation system is proposed using these findings.

This paper is organized as follows. In section 2, analyses of many mascot characters are carried out. Section 3 proposes an automatic creation system using *Kansei*-words. Evaluation experiments and the results are shown in Section 4. Finally, we conclude the paper in section 5.

2. ANALYSES OF MASCOT CHARACTERS AND DETERMINATION OF PARTS

Figure1 shows the flow of the proposed method. First, rules expressing popular mascot characters are extracted by analyses of many mascot characters. Then, *Kansei* space is defined in order to determine *Kansei* words used as the system input. Next, the degree of *Kansei* image for each part to create a mascot character is estimated by preliminary experiment.

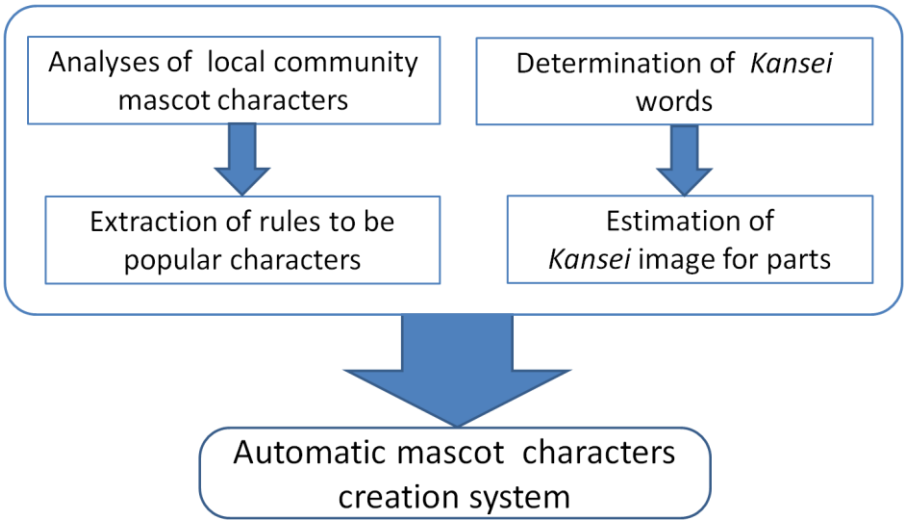


Figure 1: Flow of the proposed method.

2.1. Analyses of mascot characters

We collected and analyzed 200 mascot characters from 2,258 characters in “Catalog of local mascot characters” (TINAMI Co.,Ltd.). Among 200 characters, 100 are top 100 ones, and remaining 100 are low 100 ones in the 2,258 characters. We defined the popularity degree as follows,

$$Popularity = \frac{Number\ of\ \ favorite\ users}{Number\ of\ \ access\ to\ the\ character\ \ page} \quad . \tag{1}$$

Here, $Number\ of\ \ favorite\ users$ means the number of users who registered the character as his or her favorite in “Catalog of local mascot characters” web page (TINAMI Co.,Ltd.). Since the data for the character getting a small number of accesses to the character page are considered to be low reliability, we treated the character obtaining more than 3,000 accesses. Figure 2 shows the elements of analyses and Table 1 shows the elements and their values.

Analyzing item	
Proportion of the head to the body	A
Shape of the body	B
Proportion of the length to the width of the face	C
Shape of the eyes	D
Proportion of the black to the white of the eye	E
Configuration of the black and the white of the eyes	F
Presence or absence of the nose	G
Presence or absence of the cheek	H
Shape of the mouth	I
Presence or absence of the ears	J
Length of arms	K
Length of legs	L
Animal used in the mascot character	M

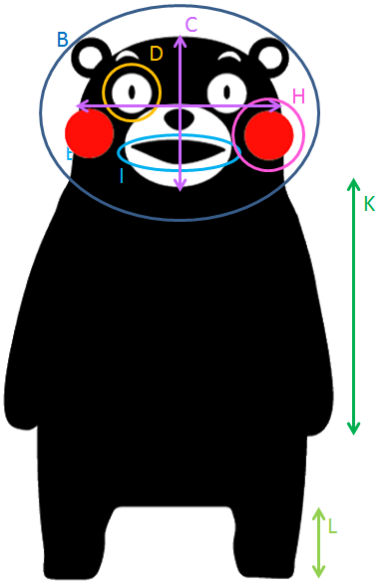


Figure 2: Elements of analyses.

Table 1: Elements of analyses and their values.

Analyzing item	Values
Proportion of the head to the body	positive real values
Shape of the body	circle, ellipse, square, tunnel-like
Proportion of the length to the width of the face	positive real values
Shape of the eyes	circle, vertically long, horizontally long, up-angled eyes, droopy eyes, almond-like, parabola
Proportion of the black to the white of the eye	positive real values
Configuration of the black and the white of the eye	black in white eyes, white in black eyes, black eyes
Presence or absence of the nose	presence of the nose, absence of the nose
Presence or absence of the cheek	presence of the cheek pattern, absence of the cheek pattern
Shape of the mouth	negative, neutral, positive
Presence or absence of the ears	presence of the ears, absence of the ears
Length of arms	absence of arms, short, long
Length of legs	absence of legs, short, long

By observing the data, we found the following tendencies for a popular character.

1) A tunnel-shaped form
2) Black colored eyes without white part
3) Short legs
4) Emotionless mouth rather than smiling mouth

2.2. Rule extraction by Rough Sets Theory

We employed Rough Sets Theory (Inoue, Harada, et al., 2009) to extract rules considering the combinations of several elements. As mentioned above, top 100 and low 100 characters were used for the analyses.

Figure 3 shows an example of rule extraction using Rough Sets Theory. In this case, the shape of the eyes and arrangement of the black part of the eye and white part differ between the character 1 and character 2. As a result, the following rules were extracted.

We obtained many rules and extracted 30 rules having higher C.I. (Covering Index) values. C.I. expresses the degree of contribution for the rule in Rough Sets Theory. These rules are used in the proposed automatic creation system. The followings are some examples:

If (form is tunnel-shaped) *and* (eyes are black color only) *and* (legs are short) *then* popular.

If (eyes are circular) *and* (no cheeks) *and* (mouth is neutral) *then* popular.

If (form is square) *and* (white pupil in the black iris) *then* unpopular.

2.3. Selection of *Kansei* words for the input of the proposed system

Selection of words is one of the important elements in the proposed automatic creation system, because they are used as the system input.

First, we defined a *Kansei* space for words. To be more precise, 180 *Kansei* words in the Language Image Scale (NIPPON COLOR & DESIGN RESEARCH INSTITUTE INC.) were vectorized and mapped into the space as follows:

1) 19 axes used in *Kansei* expression database (Takahashi, Asano, et al., 2009) were used. Table 2 shows them.

	Shape of the body	Shape of the eyes	Configuration of the iris and the white of the eye	Evaluation
1	tunnel-shaped	circle	black	popular
2	tunnel-shaped	vertically long	white in black eyes	not popular
3	squre	circle	white in black eyes	not popular

If {(eyes are circular) *or* (eyes are black only)} *and* {(form is tunnel-shaped) *or* (configuration of the black and the white of the eyes is black only) *then* popular.

==> *If* (eyes are circular) *or* {(eyes are circular) *and* (form is tunnel-shaped)} *then* popular.

Figure 3: An example of rule extraction using Rough Sets Theory.

2) *Kansei* value for each axis was calculated using the relatedness value considering common attributes (Araki, Okumura, et al., 2007, October), (Watanabe, Okumura, et al., 2006). Using these values, 180 Kansei words were expressed by 19-dimensional vector.

3) Principal component analysis was applied and 19-dimension was reduced to 3-dimension. Here we obtained the following three components.
   1st component: since the relations "new-old" and "dynamic-static" are dominant, this component can be considered as "cheerfulness".
   2nd component: "beautiful-ugly" and "gaudy-plain" are dominant, this component can be considered as "gaudy".
   3rd component: "warm-cool" and "soft-hard" are dominant, this component can be considered as "softness".

4) Log-scale was used because the range of the relatedness value was very large.

5) *K*-means algorithm (MacQUEEN, 2008) was applied for clustering and 180 *Kansei* words were formed 8 clusters.

6) We performed a preliminary experiment to collect *Kansei* words suitable to express the impression of the characters.

7) Considering the number of *Kansei* words in a cluster, we selected following 9 *Kansei* words shown in Figure 4. They are used for the input of the automatic creation system.

2.4. Structure of a character

Here we explain the structure of a character. Table 3 shows a list of elements to construct a character and their variations. Figure 5 shows some examples of elements to construct a character.

In the proposed system, coloring is carried out manually by the user. This is because effect of color is considered to be very large. For example, the impression of a character would be changed largely if coloring is different.

Each part is attached 9-dimensional *Kansei* words shown in Figure 4 based on the preliminary experiment.

cheerful, simple, amiable, humorous, gentle, innocent, cute, gorgeous, carefree

Figure 4: Selected 9 *Kansei* words.

Table 2: 19 axes of *Kansei* expression.

	(+) Polar expression (-)		(+) Polar expression (-)
1	beautiful <--> ugly	11	simple <--> complicated
2	amiable <--> not amiable	12	dynamic <--> static
3	quiet <--> noisy	13	stable <--> unstable
4	new <--> old	14	soft <--> hard
5	artificial <--> natural	15	thick <--> thin
6	open <--> closed	16	feminal <--> manlike
7	safe <--> dangerous	17	warm <--> cold
8	strong <--> weak	18	light <--> heavy
9	big <--> small	19	blight <--> dark
10	showy <--> plain		

Table 3: A list of elements to construct a character and their variations.

Parts	Values
Shape of the body	55
Shape of the eyes	21
Size of the eyes	5 (20*20, 22*22, ... , 28*28 [px])
Distance between eyes	16*16, 18*18, 20*20, 22*22, 24*24 [px]
Mouth	12
Size of the mouth	6 (35*35, 38*38, ... , 50*50 [px])
Hight of the mouth	16*16, 18*18, 20*20, 22*22, 24*24 [px]
Pattern of the cheeks	3
Accessory	8

Image size is 280*280 px

3. PROPOSED AUTOMATIC CHARACTER CREATION SYSTEM

Figure6 shows the flow of the proposed automatic character creation system.

3.1. *Kansei* words input

A user selects some of the *Kansei* words suitable to the image of a character the user wants to create from Figure 4.

3.2. Selection of parts

Next, the proposed system selects parts to create a character. The selection is carried out stochastically based on the attached 9-dimensional *Kansei* words for each part.

3.3. Composition of mascot characters

The proposed system composes 8 mascot characters by selecting parts stochastically at each generation.

3.4. Selection of mascot characters for display

The proposed system selects 4 characters based on the scores using the extracted 30 rules. Characters applied more rules having higher C.I. values are selected with a high probability.

3.5. Evaluation of mascot characters by a user

The user evaluates the displayed characters by 4 levels: 1. Excellent; 2. High; 3. Medium; 4. Low. Figure 7 shows an example of the interface window.

3.6. Interactive Genetic Algorithm

Interactive Genetic Algorithm (Hagiwara, 1994) is employed in the proposed system. Selection is based on roulette method and uniform crossover is used.

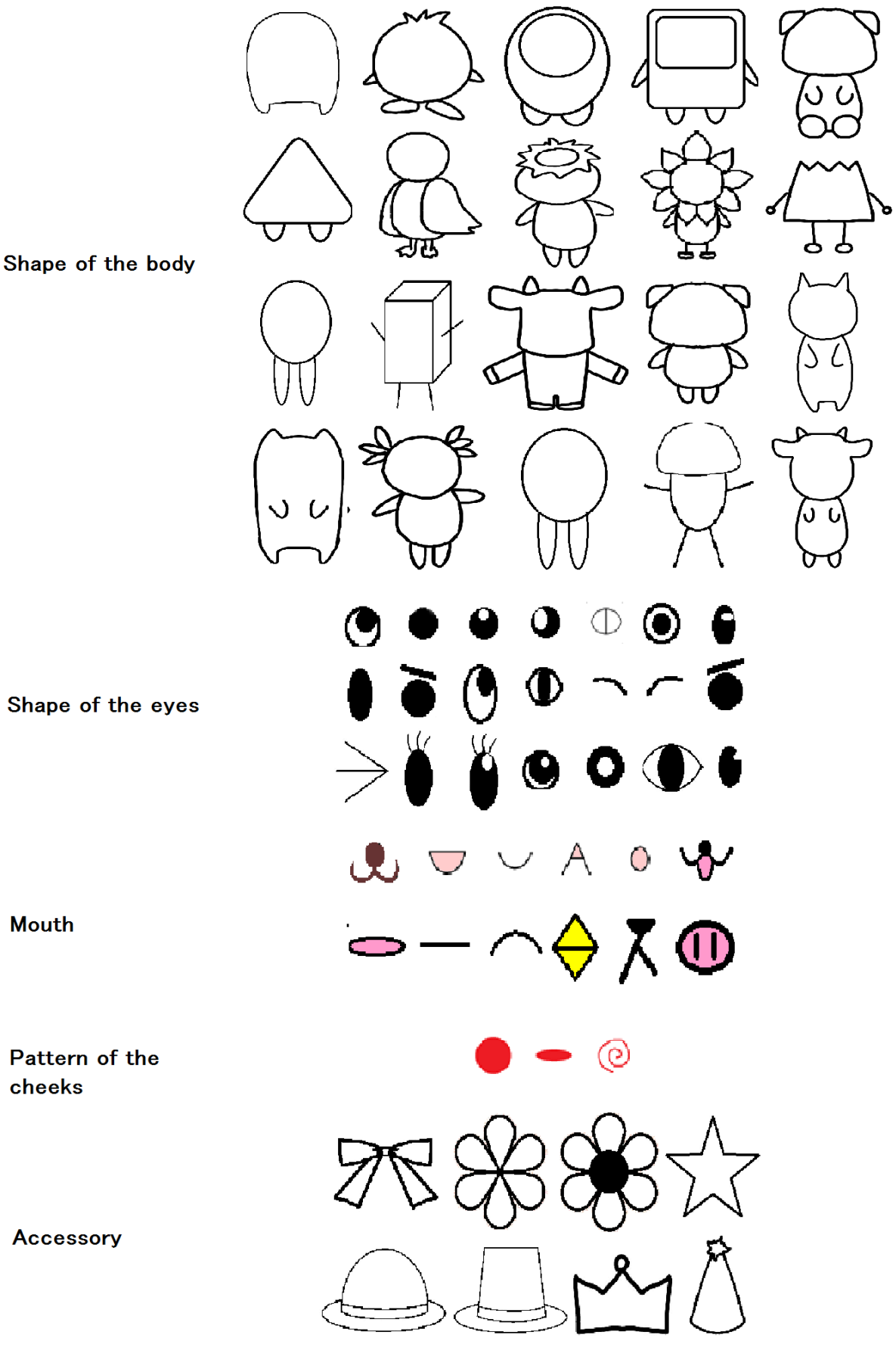


Figure 5: Examples of elements to construct a character.

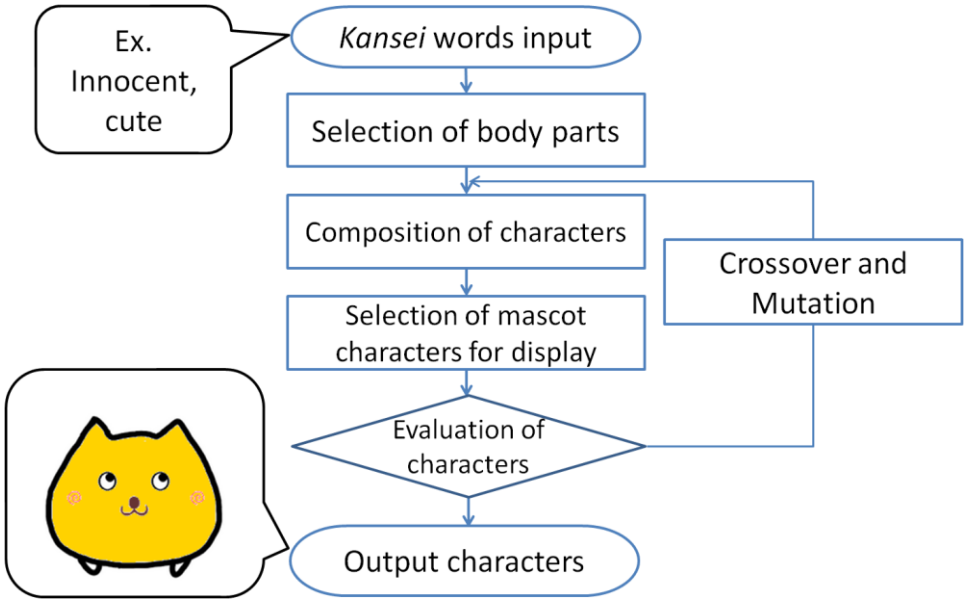


Figure 6: Flow of the proposed automatic character creation system.

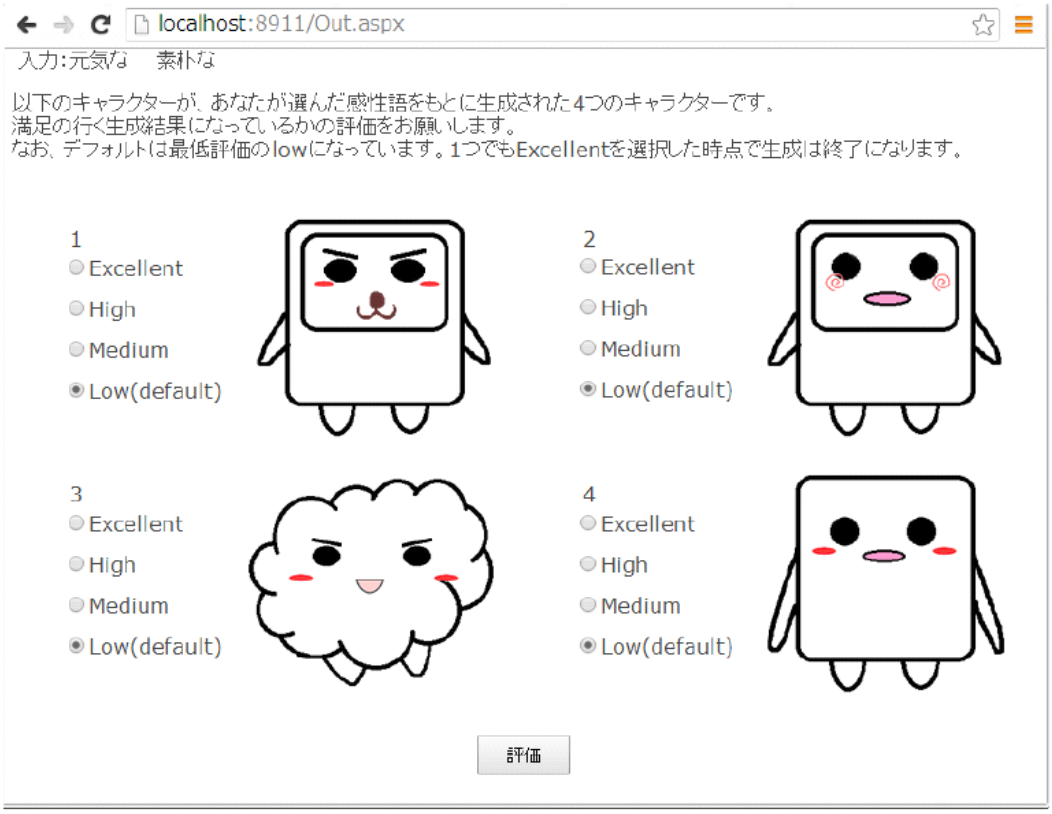


Figure 7: An example of the interface window.

4. EVALUATION EXPERIMENTS

We carried out three kinds of experiments. The first one is a subjective evaluation of the output of the proposed system and the second one is an objective evaluation of that, and the last one is an experiment about the *Kansei* image of the color.

4.1. Experiment 1 (Subjective evaluation of the output of the proposed system)

We asked 15 subjects, university students in their 20s(M:12, F:3), to create 32 characters in the following three ways and evaluate them. The first way is the usage of the proposed system, the second one is that without using the extracted rules, and the third one is the baseline system in which parts are selected randomly. Then comparison experiments are carried out. Figure 8 shows some examples of the created mascot characters by using the first way (proposed system).

Table 4 summarizes the results of the reflection degree of created characters to the input *kansei* words. It can be observed that the proposed system shows the highest evaluation values for all of the *kansei* words. In addition, significant differences ($p < 0.05$, difference of t-test) are detected between the proposed system and the others for all of the *kansei* words. One of the reasons might be usage of the rules extracted from analyses. The averaged reflection degree to input words of the proposed system was 4.4.

Table 5 shows the results concerning the favorability of the created characters. The values of *gorgeous* and *carefree* are not high. The reason concerning *gorgeous* can be considered as follows. *Gorgeous* is inherently difficult to express because the this kind of characters are not gorgeous. Another reason might be lack of gorgeous accessories such as hair jewelries, fur coat, and so on. As for *carefree,* the low value may be caused by their eyes. Almost all of the shape of the eyes we prepare are bright and circular forms which might not give the impression of *carefree*. If there are more various kinds of shape of the eyes, the value would be improved.

4.2. Experiment 2 (Objective evaluation of the output of the proposed system)

We carried out an objective evaluation experiment for the characters created by the proposed system. In this experiment, 10 subjects, university students in their 20s(M:9, F:1), evaluated the characters created by the other subjects.

Table 6 shows the results. The values are lower than the subjective experiment shown in Tables 4 and 5. The reason can be considered as follows. *Kansei* and the preference differ person by person. Therefore, even if someone likes a character very much, the character is not necessarily liked by the other people.

As for *cute*, it can be observed that the variance of the reflection degree to input the word and the favorability are both relatively small. It means that people tend to have more common images about *cute*.

4.3. Experiment 3 (Evaluation of the painted characters and unpainted ones)

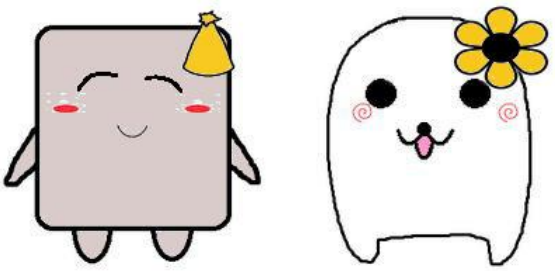
We compared the painted characters with those of the unpainted characters. The evaluators were 15 subjects, the same people as the subjects of the 1st experiment.



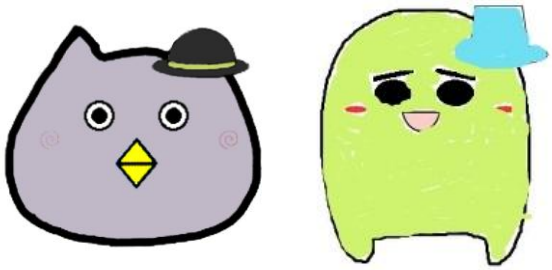
(a) cheerful



(b) simple



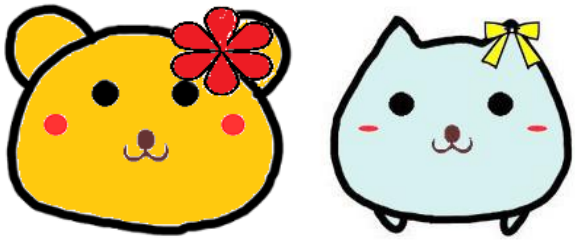
(c) amiable



(d) humorous



(e) gentle



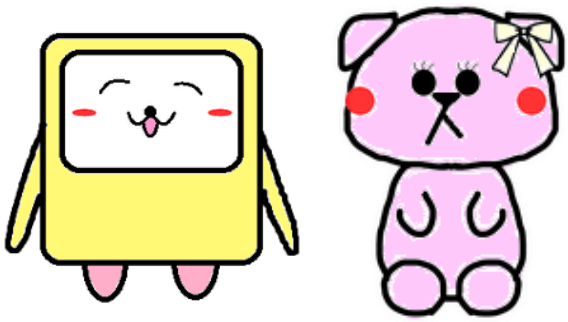
(f) innocent



(g) cute



(h) gorgeous



(i) carefree

Figure 8: Some examples of the created mascot characters.

Table 4: Evaluation of the reflection degree of created characters to input the word.

	Reflection degree to input words		
	Proposed system	Without rules	Baseline
cheerful	**4.8**	3.9	3.3
simple	**4.5**	4.2	3.2
amiable	**4.3**	3.7	2.8
humorous	**4.7**	3.8	3.3
gentle	**4.2**	4.2	3.0
Innocent	**4.6**	4.1	3.1
cute	**4.8**	4.3	2.3
gorgeous	**4.0**	3.7	3.0
carefree	**3.8**	3.2	3.6

Table 5: Evaluation of the favorability of created characters.

	Favorability		
	Proposed system	Without rules	Baseline
cheerful	4.2	4.8	3.8
simple	4.5	3.9	3.5
amiable	4.3	3.7	3.0
humorous	4.7	4.3	4.0
gentle	4.2	4.2	3.3
Innocent	4.4	3.9	3.7
cute	4.0	4.0	3.3
gorgeous	3.8	3.8	3.3
carefree	3.6	3.4	2.8

Table 7 summarizes the result. Because of addition of colors, the reflection degree to input words was increased by 0.59 and the favorability was by 0.65. This shows that colors have large influence on people's impression and *kansei*.

Then we analyzed the influence of color: the relation between colors and the influence on *kansei* such as *cute* and *cheerful*.

We focused on the painted characters and investigated the tendency of the employed colors. As a result, it can be found that *amiable, cheerful, or gentle* characters tend to be painted in warm colors. Especially, *cheerful* characters tend to be painted in colors with high saturation, while *gentle* characters tend to be painted in colors with high luminosity. On the other hand, various kinds of colors are used to paint *humorous* characters. It can be considered that the colorfulness may be one of the essential features for *humorousness*.

Table 6: Objective evaluation experiment for the characters created by the proposed system.

	Reflection degree to input words		Favorability	
	Ave.	σ^2	Ave.	σ^2
cheerful	3.4	0.73	3.3	1.60
simple	3.7	0.81	3.5	0.81
amiable	3.4	0.52	3.2	1.00
humorous	3.4	0.81	3.0	1.10
gentle	3.7	0.80	3.5	0.89
Innocent	3.8	0.81	3.4	0.77
cute	3.6	0.64	3.3	0.69
gorgeous	3.1	0.89	3.0	0.58
carefree	3.5	0.75	3.2	0.81

Table 7: Evaluation of the painted characters and unpainted ones.

	Painted	Unpainted
Reflection degree to input words	4.34	4.21
Favorability	3.75	3.56

5. CONCLUSIONS

In this paper, first, we analyzed 200 local community mascot characters and obtained knowledge to be the popular ones. In the analyses, many interesting findings were obtained such that short limbs or dark-round eyes tend to contribute to be popular as a mascot character. Next a mascot characters automatic creation system has been proposed using these findings. The proposed system can reflect a user's image and favorability by usage of *Kansei* words for input and Interactive Genetic Algorithm.

We have performed three kinds of evaluation experiments. In the 1st experiment, many mascot characters satisfying user's image were created and remarkable results were obtained through subjective evaluations. For example, by using the extracted rules from the analyses and Interactive Genetic Algorithm, the proposed system can create favorable mascot characters. In the 2nd experiment, it can be observed that people tend to have more common images about *cute*. In the last experiment, we found some interesting tendencies concerning colors used in painted characters. One of them is that *cheerful* characters are often painted in warm colors with high saturation.

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5A - Evaluation 3

Investigating the Role of Kansei Engineering for Affective Aspects of Empathic Design, a Report of a Case Study

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Abstract: This paper tries to seek possibilities and challenges of applying Kansei Engineering method as a tool to investigate affective aspects of Empathic Design. This trend has been introduced strongly as a holistic approach in Design Studies and there were some proposals for Functional Aspects of This trend, such as activity theory. However design researchers claim that affective aspects are not well considered in this new approach and tools and techniques are needed. In this paper the case study was chosen from children for blood sampling test procedure in the medical centers. The emotional aspect was assessed through Kansei Engineering. Four series of questionnaires were distributed toward them. Their choice and their emotional reactions were gathered and recorded. In one of them, Likert rating was also used for assessing the role. Based on such data gathering procedure, some precious verbal protocols could be generated from users .Also some cartoon characters were more inspiring for children. The results were applied in designing a new service experience for blood sampling procedure for children, and some preliminary responses are included for further investigation. The value of this paper would be helpful for researchers in Empathic design approach, for emotional aspects of such a trend.

Keywords: Kansei Engineering, Activity Theory, Empathic Design, Affective Aspects.

1. INTRODUCTION

Recently Empathic design is known as a holistic approach in design studies and some new proposals have tried to offer best thinking tool to cover both Functional and Affective Aspects of user experiences for empathic design approach. Postma et. al., have examined a variety of

frameworks to select the best one for analyzing user experience. They found activity theory as a scaffold of context that can make best proportion between designer's need and framework's output. As finding of this research, "activity theory addresses emotions merely implicitly, whereas emotions are at the forefront of empathic design." (Postma et al: 2012). They mentioned that "the role of emotions in activity theory needs to be further explicated when using activity theory as a thinking tool in future empathic design projects." According to this finding we hypothesized while in the design process the functional part was supported through activity theory, the emotional aspect could be assessed through Kansei engineering. Can we apply Kansei engineering method as a tool to investigate affective aspects of Empathic Design? To answer this research question, this paper has been structured as follows. We begin by presenting relevant literature, after which we address our research methodology and discuss the results.

2. LITERATURE REVIEW

2.1. Empathic design

"Empathy" is an imaginative projection into another person's situation. (Koskinen, et. al., 2003). It tries to take its emotional and motivational qualities into account. In the traditional design processes, design methods depended on the designer's personal experience whereas empathic design is to understand how the user sees, experiences and feels some object, environment or service in the situation in which he or she uses the object (Koskinen, et.al, 2003, Chen, 2012). Empathic design was first stated by Leonard and Rayport in 1997, they noted how designers could know the potential needs of customers as a process of a design method (Shu-huei and Shyh-huei, 2010)." Empathic design was presented as a process that involved observation, data collection and analysis, and iterative prototyping. Most significantly, the discipline was identified as a way to uncover people's unspoken latent needs and then address them through design (Battarbee et al, 2014)

The goal of empathic design is to capture users' needs and desires, particularly those needs which users, themselves, are not aware of. Even though the product problems can be discovered by the users, they will not have design knowledge to resolve them. (Chen, 2012) The problem of understanding the user and his or her experience has an important role in human-centered design and several tools and methods have been offered to support designers to be in user's shoes in order to design products that fit the user experiences (Kouprie and Visser, 2009).

3. METHODOLOGICAL PROCEDURE

3.1. Choosing the case study

One of the most unpleasant procedures for the recovery and treatment of children, are needle-related procedures in medical centers. Fear and stress of them arise when the sharp needle is supposed to insert into their skin. More than 80 percent of children under age 7 and more than 50 percent of school-aged children scare of needle (Humphrey, et. al., 1992). According to Sarah Gaskell, et al. research result, in 2005, number of children who referred to hospital with fear of needles, in the surgery/hospital treatment and blood testing was more than the other referrals. Therefore, the results of related previous researches emphasize on more attention to needle-related procedures such as blood sampling. Thus we chose blood sampling test procedure as case study.

3.2. Research process

As mentioned, blood sampling procedure was selected as case study and survey research performed for children hospitalized in Children Medical Center of Tehran and students of a painting class in Tehran. Therefore, during repeated visits to the laboratory and surgery department of the hospital and painting class, required data were collected in two separate phases. In the first phase, research based on activity theory, laboratory of the medical center has been chosen as a similar environment for the initial evaluation of blood sampling activity. The procedure of blood sampling for children aged 7-12 was observed and recorded for several cases. In the second phase (Kansei engineering), the sample was chosen from 17 subjects who were children between 7 to 12 years old, 10 subjects were hospitalized in Surgery Department of Children Medical Center of Tehran. Four series of questionnaires were distributed toward them. Their choice and their emotional reactions were gathered and recorded.

3.3. Kansei Engineering as an Affective Tool

3.3.1. Choice of domain

In order to applying Kansei engineering as an affective method, we had to achieve emotional data from focus group (children aged 7-12). Thus some researches have been studied related to service experience design and design for children. One of our limitations was that children cannot understand the meaning of the words exactly. Therefore only one experience factor (physical) was considered as service components to measure through Kansei engineering. One of the available sources related to different aspects of service experience is John et al. research in 2009. Based on their classification, service for user experience is composed of parameters including: Service benefits, People, Physical, Process, Perception, Emotional theme & Participation Activities. Finally, according to the available limitations associated with focus group, two parameters of color and theme/character as physical factor associated with sight sensory were considered.

Table 1: Experience factor (physical) and services component

Experience Factor	Services component
Physical	Sensory Design Sight, Sound, Touch Smell, Taste Physical clues Signs, Symbols, Artifacts

3.3.2. Spanning the semantic space

Collection of Kansei words (emotional adjectives) were selected through previous Kansei studies for children (Tharangie et. al., 2008, 2009) and from interviewing children related to their favorite things.

3.3.3. Spanning the space of properties (colors and theme)

Spanning the space of properties was based on, field research, previous Kansei studies for children and the results of previous research with similar object (Coad, 2008). The field research was conducted through interviewing vendors of games and animated series for children as well as teachers of children. The result was a list of 12 most favorite themes of children.

3.3.4. Questionnaire

Planning the questionnaires was based on the space of semantic and properties (color and themes). Five series of questionnaires were prepared. Elements were consisted of Color, Cartoon Characters and a sample of natural elements such as visions of see or mountains. One of them was composed of children favorite themes in A3 size, and the others were included the colors in A4 size. In one of them, Likert rating was used for assessing the role. The sample was chosen from 17 subjects who were children between 7 to 12 years old, 10 subjects were hospitalized in Surgery Department of Children Medical Center of Tehran and the other were students of a painting class in Tehran. The questionnaires were distributed toward them and their choice and their emotional reactions were gathered and recorded. One sample of questionnaires is here:



Figure 1: Questionnaire of themes/characters

4. RESULTS AND DISCUSSION

Inferential analysis was done by SPSS software using binomial test, Pearson chi-square test and Spearman's rho on the data. The results are explained in following. In order to rate happiness of 8 different colors (Violet, yellow, green, sky, blue, red, blue, orange and pink) using Likert scale, we examined the feeling of being happy using binomial test because the data were qualitative and our aim was to test a single sample. According to the results of table 2, the degree of happiness test, for blue, yellow, sky blue colors is significant.

Table 2: Binomial test results for happiness degree of colors

Parameters	mean	Std deviation	Observed prop	Test prop	Exact sig (2-tailed)
Violet happiness degree	3.29	1.10	Group1 0.53 Group 2 0.47	0.5	1.00
Yellow happiness degree	3.94	1.08	Group1 0.18 Group 2 0.82	0.5	0.013
Green happiness degree	3.12	1.49	Group1 0.47 Group 2 0.53	0.5	1.00
Sky blue happiness degree	4.12	0.928	Group1 0.24 Group 2 0.76	0.5	0.049
Red happiness degree	3.65	1.22	Group1 0.29 Group 2 0.71	0.5	0.143

Blue happiness degree	2.65	0.931	Group1 0.82 Group 2 0.18	0.5	0.013
Orange happiness degree	3.53	1.12	Group1 0.53 Group 2 0.47	0.5	1.00
Pink happiness degree	4.06	1.08	Group1 0.41 Group 2 0.59	0.5	0.629

Table 3: Happiness degree of colors (considering P-Value)

Violet happiness degree	
Yellow happiness degree	
Green happiness degree	
Sky blue happiness degree	
Red happiness degree	
Blue happiness degree	
Orange happiness degree	
Pink happiness degree	

Yellow and sky blue are happy, violet, green, red, orange and pink are not happy not sad and blue is sad. The next tests was done on the colors of happiness, sadness and anger (chosen by children) in terms of physical conditions (healthy and the sick) that was evaluated Spearman correlation test. The table of Spearman correlation coefficient among happiness, sadness and anger and 8 colors has shown in following.

Table 4: Spearman correlation value among happiness, sadness, anger and the colors. (The numbers in the parantesis are P-Value.)

Color	**Correlation value**		
	Anger	**Sadness**	**Happiness**
Violet	-0.06 (0.82)	0.54 (0.02)	0.06 (0.82)
Yellow	-0.22 (0.23)	-0.27 (0.29)	-0.15 (0.56)
Green	0.03 (0.90)	0.12 (0.66)	0.37 (0.14)
Sky blue	0.18 (0.49)	-0.18 (0.50)	0.18 (0.49)
Red	0.22 (0.40)	0.07 (0.78)	0.41 (0.10)
Blue	-0.25 (0.34)	-0.09 (0.73)	-0.51 (0.03)
Orange	-0.49 (0.04)	-0.20 (0.44)	0.11 (0.67)
Pink	-0.08 (0.75)	-0.32 (0.21)	0.43 (0.08)

According to the above table, there is an inverse relationship between blue and happiness(correlation=-0.51, sig=0.03) that is not significant. orange and Anger(correlation=-0.49, sig=0.04) and also a significant relationship between violet and sadness (correlation=0.54, sig=0.02), happiness and pink (correlation=0.43, sig=0.08). The following is cross-tabulations test to examine the relationship between the child's first favorite color and her/his feelings toward it. Firstly, we examined that the relationship was significant, or not.

Table 5: Results of Pearson chi-square tests of the favorite color of children and their feeling

	Value	Degree of freedom	significance level
Pearson chi-square	32.371	25	0.148
Likelihood ratio	26.004	25	0.407
Number of valid samples	17		

According to the table of Pearson chi-square test, significance level of chi-square test is 0.148 thus the null hypothesis that is “There is no relationship between first favorite color and feelings” is not rejected. Therefore, the test is not significant, and there is no correlation between the feelings and first favorite color. All samples had a different feeling toward their favorite colors. Consider the following diagram:

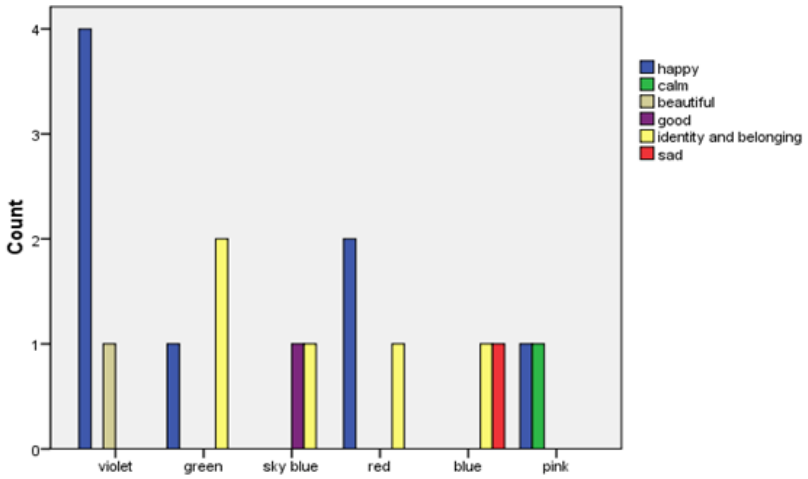


Figure 2: Children’s feelings toward the favorite colors

The following is cross-tabulations test to examine the relationship between the child’s first favorite theme/character and her/his feelings toward it. Firstly, we examined that the relationship is significant, or not? Consider the table of Pearson chi-square tests. According to Chi-square table, significance level equal to 0.272 and the null hypothesis will be rejected. Therefore, the test is not significant, and there is no correlation between children’s favorite theme/character and their feelings. All samples had a different feeling toward their favorite theme/character. Consider the following diagram: Based on such statistical analysis, this precious result generated; Sky Blue color was assessed by children as quite happy. Also Yellow, Red and Pink could be categorized in the happy range for children. Also some cartoon characters were more inspiring for children, such as Sponge Bob.

Table 6: Pearson chi-square tests of the most favorite theme/character of children and their feeling

	Value	Angel of freedom	significance level
Chi-square Pearson	28.817	25	0.272
Likelihood ratio	21.389	25	0.671
Linear-linear relationship	0.424	1	0.515
Number of valid sample	14		

Table 7: Symmetry measurements

	value	Approx. on of sign. level (3)	2T approximation	Asymptotic standard error(1)
Pearson'R distance-distance	-0.181	0.537	-0.636	0.198
Spearman's rank-rank correlation	-0.042	0.887	-0.145	0.286
Number of valid sample	14			

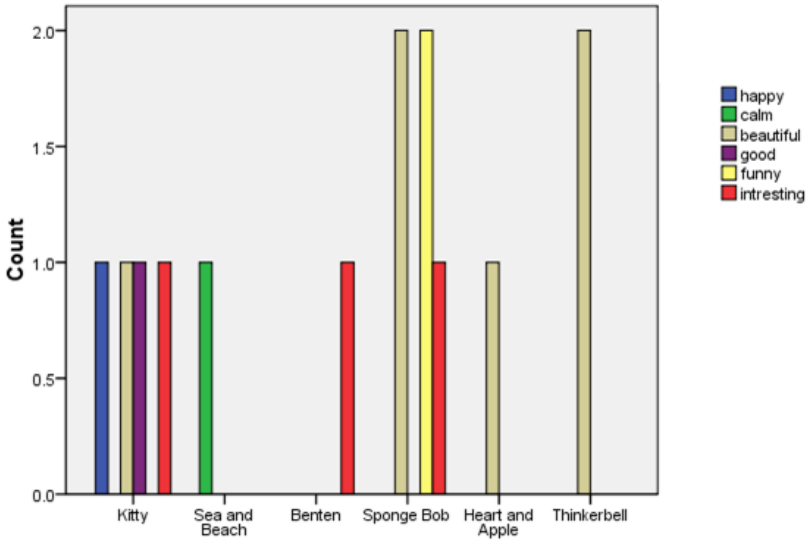
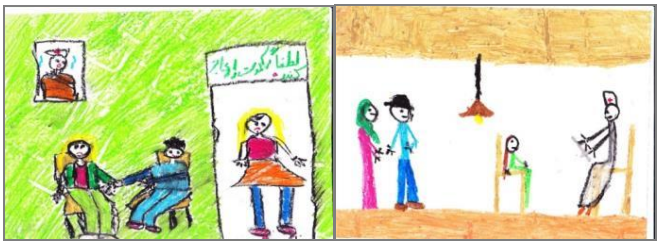


Figure 3: Children's feelings toward the favorite theme/characters

5. CONCLUSION

As this study was service-based research, in order to understand the user and create the ideal experience through Empathic approach, Scenario as a tool was used in design phase. As we know, personal experience is an important element in Empathic design especially related to services. Theatre play design could apply to service situations than originally thought (Stuart and Tax, 2004). Children's creative theater and paintings was considered as a basis source for inspiration in the design phase to better understand how children feel and behave in that situation. Some of children's paintings are in following: Four Scenarios was created through inspiration of close observation of the blood sampling process, watching children favorite animations and cartoons, creative theatres and paintings. The results of using activity theory in this study was also considered, models such as Engstroem Triangle Model were mixed with Semiotic Analysis, meaning Paradigmatic and Syntagmatic layers of an Activity.



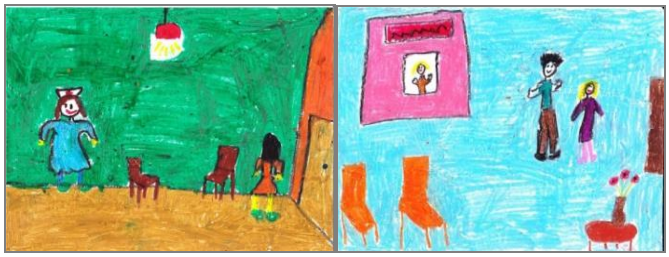


Figure 4: Children's paintings

Regarding Bruno Latour terminology the role of children in this procedure was changed from an actant to actor, meaning that they became able to affect the medical procedure. Also the protocols resulted from Kansei engineering was applied in these scenarios. In order to developing the scenarios consultation with industrial designers was done. Finally, one scenario was selected and transformed in to a new service experience for blood sampling procedure for children, and some preliminary responses are included for further investigation. The result will generate some positive results, such as decreasing the level of reaction toward pain; also the level of fear and stress in medical procedure will be decreased as well.

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BIOGRAPHY

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Mood Change Caused by 'Active Art' that Encourages Touching and Grasping Movements

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Abstract: The objectives of this study are to practice and evaluate a program that can be brought about through touching and grasping, with a focus on the psychological effect of 'Active Art'. For the purposes of this study, 'Active Art' is defined as art works and art creations that encourage the movement to touch. The work program with 'Active Art' we created is 'Let's draw fireworks!', by touching an electronic panel and squeezing a rubber air pump to create art works which can then be printed on postcards. The work brings about a desire to do more, and induces movement of touching, grasping and squeezing. I analysed ratings of the subjects' mood by using a shortened version of POMS. The POMS measure of mood after 'Let's draw fireworks!' stimulation revealed a reduction of 'Tension – Anxiety', 'Depression – Dejection', 'Anger – Hostility', 'Fatigue', and 'Confusion', and a maintenance of 'Vigor'. Subjects' mood after the program was confirmed to have improved significantly in comparison with their mood before the program.

Keywords: Active Art, Touching, Grasping, Mood, POMS

1. INTRODUCTION

Art galleries and museums are increasingly offering participatory art appreciation and art workshops where visitors can touch or create art themselves. It is thought that touching and creating art in addition to visually appreciating it can further stimulate people's sensibility.

'Active Art' which encourages touching the art and participating in creation of art, stimulates sensibility by inducing self-expression. In this study, we define art works that encourage touching

and grasping art as ‘Active Art’.

As a qualitative evaluation based on encouraging active movements such as participation in creation and visual effects by appreciating art works, we have studied how mood is affected by picture appreciation and painting activities and confirmed their effectiveness [Note 1,2]. The POMS measure of mood after appreciation of photographic images stimulation revealed a reduction of ‘Tension – Anxiety’, ‘Depression – Dejection’, ‘Anger – Hostility’, ‘Vigor’, ‘Fatigue’, and ‘Confusion’. On the other hand, painting activities stimulation increased ‘Vigor’. Subjects’ mood after painting activities stimulation, compared with that before appreciation of photographic images stimulation, exhibited a continued reduction of ‘Tension – Anxiety’, ‘Depression – Dejection’, ‘Anger – Hostility’, ‘Fatigue’, and ‘Confusion’.

Focusing on tactile perception, grasping and squeezing, the present study used the Profile of Mood States (POMS) to analyze the effect of the ‘Let’s draw fireworks!’ program based on ‘Active Art’, which encourages movement such as touching a computer touch panel or squeezing a rubber air pump. POMS is a psychological evaluation approach with high reliability for measuring states of temporary mood and emotion and has been widely used to evaluate mood change in expression techniques and stress examination [Note 3-7]. Thus, it is appropriate for this study’s measurement and analysis of mood change from specific stimulations. The program aims to improve patients’ quality of life (QOL) during palliative care by both improving mood and maintaining physical function (rehabilitation) through touching and grasping.

2. OBJECTIVES

This study evaluates changes in mood caused by operating the ‘Let’s draw fireworks!’, a program based on ‘Active Art’, which stimulates actions such as touching a computer touch panel or grasping and squeezing a rubber air pump, with a focus on touching and grasping actions. Differences in mood between before and after the actions are compared by using a shortened version of POMS.

3. EVALUATION OF MOOD AFFECTED BY THE ‘LET’S DRAW FIREWORKS!’ PROGRAM BASED ON ‘ACTIVE ART’

3.1. Dates, Place, Subjects, and Investigation methods

The experiment was conducted on August 2, 2013. in Laboratory B234 of the Building of the School of Art and Design, University of Tsukuba. The space was about 25 m^2 and quiet. The only equipment in the room was the ‘Let’s draw fireworks!’ system. Subjects were 14 university students (male: 8, female: 6) between the ages of 19 and 43.

After operating the ‘Let’s draw fireworks!’ program for 10 minutes, participants’ mood before and after the activity were examined by using a shortened version of POMS. The results on T scores were obtained by gender and age group from the gross score based on six scales, i.e., ‘Tension – Anxiety’, ‘Depression – Dejection’, ‘Anger – Hostility’, ‘Vigor’, ‘Fatigue’, and ‘Confusion’ for 30 evaluation items in the shortened version of POMS.

3.2. Details of program

Using a 15.6 inch desktop touch screen monitor for the computer touch panel screen, seven types of work screens were displayed in sequence by touching the screen: operating instructions,

selection of background, selection of firework pattern, creation of fireworks, and printing. A monitor embedded on the top (inclination of 15°) of a table with a width of 700 mm, depth of 500 mm, and height of 700 mm was set up to allow operation by a person seated on a chair that was 45 cm from the floor. On the creation screen, a firework appears and spreads at a position designated for its placement by the operator touching the screen before squeezing the rubber air pump. When a still image is displayed indicating completion of the work, that image can be printed out to create a picture postcard by selecting the “create a picture postcard” icon, and the screen returns to the first screen. If the operator selects the “do not print” icon, the screen directly returns to the first screen of the program. It is an interactive creative program capable of creating a landscape with fireworks by operations such as touching and grasping (Fig. 1, 2).

Seven participants were randomly assigned a task to create two sheets of picture postcards within 10 minutes and the other seven participants were assigned a task in which they did not create postcards. The time required for the experiment was approximately 15 minutes per person.



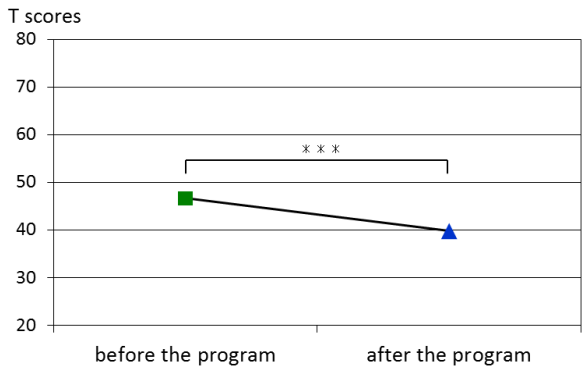
Figure 1: ‘Let’s draw fireworks!’ program



Figure 2: In Laboratory B234

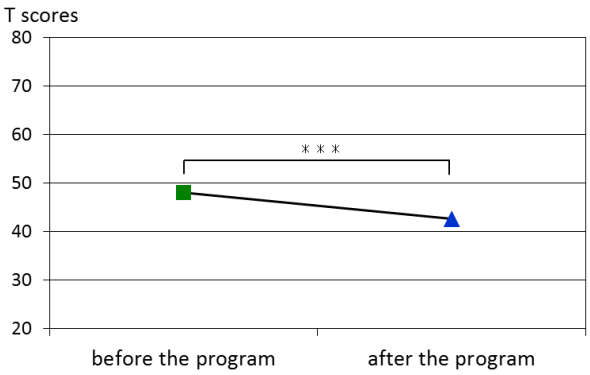
3.3. Results

For the T scores based on the six scales of the shortened version of POMS, two-factor two-level analysis of variance was conducted for participants who performed the task creating picture postcards and those who performed the task without creating the postcards, both before and after operating the program. No interaction was observed.



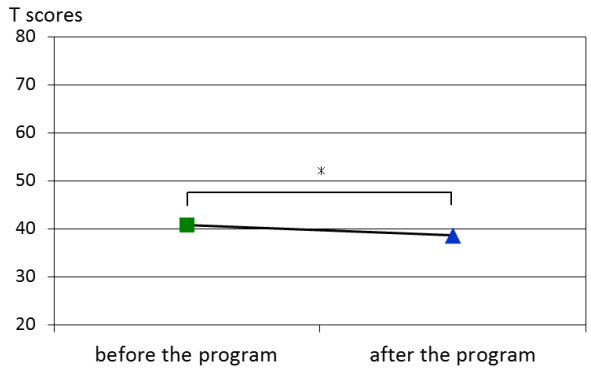
*** p<.005

Tension – Anxiety



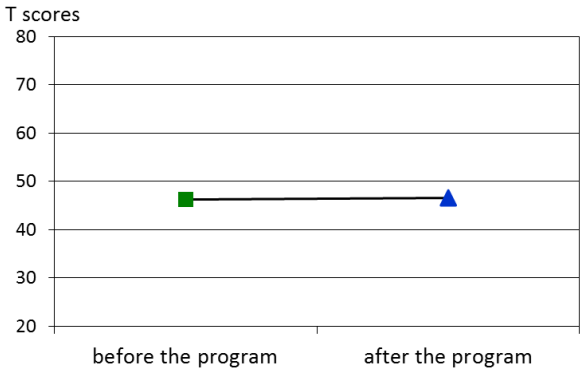
*** p<.005

Depression – Dejection

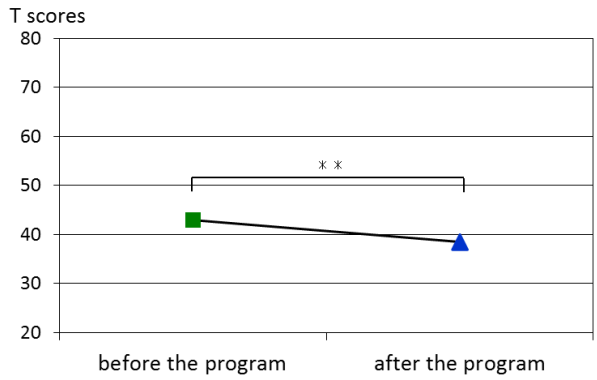


* p<.05

Anger – Hostility

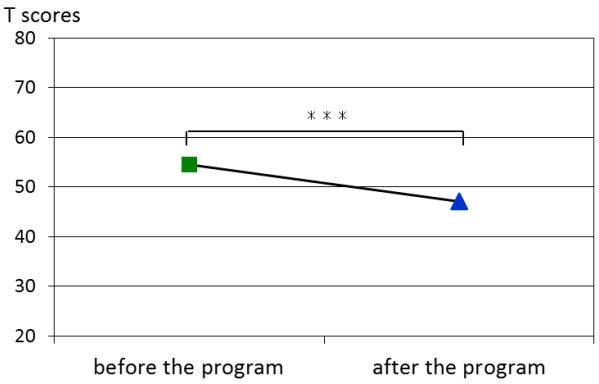


Vigor



** p<.01

Fatigue



*** p<.005

Confusion

Figure 4: The transition of T scores (POMS) before and after the 'Let's draw fireworks!' program operation

A significant difference was observed for T scores in ‘Tension – Anxiety’ ($F(1,12)=17.80$, $P<.001$), ‘Depression – Dejection’ ($F(1,12)=13.12$, $P<.004$), ‘Anger – Hostility’ ($F(1,12)=6.70$, $P<.023$), ‘Fatigue’ ($F(1,2\ 3)=9.84$, $P<.009$), and ‘Confusion’ ($F(1,12)= 11.91$, $P<.005$) scales between participants’ states before and after operating the program. T scores in ‘Tension – Anxiety’, ‘Depression – Dejection’, ‘Anger – Hostility’, ‘Fatigue’, and ‘Confusion’ after implementation of the ‘Let’s draw fireworks!’ program significantly decreased compared with those before operating the program. A significant difference was not observed in the ‘Vigor’ scale. In addition, a significant difference was not observed in the T scores of participants whose task involved creating picture postcards and those whose task did not involve creating picture postcards before and after program operation.

The transition of T scores on the six scales of the shortened version of POMS before and after the ‘Let’s draw fireworks!’ program operation is shown in Fig. 4.

3.4. Discussion

Considering the results of mood evaluation from operating the ‘Let’s draw fireworks!’ program, using the shortened version of POMS, we performed the following analysis.

T scores in Tension – Anxiety’, ‘Depression – Dejection’, ‘Anger – Hostility’, ‘Fatigue’, and ‘Confusion’ scales on the POMS scales significantly decreased by operating the ‘Let’s draw fireworks!’ program using Active Art to stimulate actions of touching a computer panel, grasping and squeezing a rubber air pump. A significant difference was not observed in the ‘Vigor’ scale. Therefore, these results mean that mood is improved when the ‘Vigor’ score is maintained and scores in ‘Depression – Dejection’, ‘Anger – Hostility’, ‘Fatigue’, and ‘Confusion’ are lowered by operating the ‘Let’s draw fireworks!’ program that encourages touching and grasping. This result, it is possible to confirm previous study [Note 1,2].

The absence of any difference between the T scores of participants whose task involved creating picture postcards and those whose task did not involve creating picture postcards before and after program operation demonstrates that operating the ‘Let’s draw fireworks!’ program improves mood regardless of the presence or absence of picture postcards as a work product. The results thus suggest that performing a creative task such as drawing pictures on a screen by stimulating the actions of touching and grasping may correlate with change in mood.

4. CONCLUSION

From the study’s results, we evaluated mood affected by operating the ‘Let’s draw fireworks!’ program that is based on ‘Active Art’. These results mean that mood is improved when the ‘Vigor’ score is maintained and scores in ‘Depression – Dejection’, ‘Anger – Hostility’, ‘Fatigue’, and ‘Confusion’ are lowered by operating the ‘Let’s draw fireworks!’ program. In addition, the results suggested that operating the ‘Let’s draw fireworks!’ program improves mood regardless of whether picture postcards are obtained as a work product or not.

As a practical application, operation of an ‘Active Art’ program associated with mood change and stimulating actions such as touching and grasping may improve the mood of palliative care patients, their family, and medical staff, resulting in improvement in QOL during palliative care. In addition, the movement of touching and grasping are the movement of the basic occupational therapy. An ‘Active Art’ program is considered useful in maintaining patients’ physical function (rehabilitation)

with the stimulation of such actions.

We intend to examine evaluations of patients' mood by implementing the 'Let's draw fireworks!' program in hospitals. The results in this research are effective for proposal to practice in hospitals. Further, we will attempt to clarify the effects of 'Active Art', which is physical function (rehabilitation) by stimulating a positive mood for "want to act more", for QOL improvement in palliative care for children.

ACKNOWLEDGMENTS

This work was supported by JSPS KAKENHI Great Number 24603001, and the Sasakawa Memorial Health Foundation.

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BIOGRAPHY

Dr. Yoshioka obtained a Ph.D. in Design Science at the University of Tsukuba in 2011. She was a researcher of the University of Tsukuba in Japan from April 2011 to March 2014, and an associate professor of Meisei University from April 2014. Her research area is Affective Design which is interaction of Design Science with the Science of Art, Cognitive Science, Psychology and Ergonomics. In addition, she holds effective Art Workshops.

The kitchen supply design based on Kansei engineering study for the elderly user of independent

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Abstract : The world's elderly population (Age over 60 years) rapid rise and to 22% of the total population and will more than children (under 15 years) population in 2050.The world Health Organization (2002) Active Aging concept, Promote the importance of maintaining the autonomy and independence of the elderly clarify. This study used inductive method such as lifestyle population surveys, focus group interviews, Kano model, and QFD (quality function deployment). The results show that important for having idpendent living for to study the possibilities of desiging kitchen supply for the independent aging. The most important design elements for ederly using kithen supply are to have the anti-hot pot body, fast heat conduction, heat dissipation, no ship handli, lightweight and easy to pick up, and in line with the hand.

Keywords: QDF deployment matrix, elderly user, independent living, active ageing, kano model

1. INTRODUCTION

1.1 Background

The aging population of the global is growing. According to United Nations, that the estimated global elderly population in 2045 for the first time beyond the children (under 15 years) population. This trend will produce huge social and economic burden, and have to be early to responsed. Many studies have confirmed that with independent living and regular physical activity can bring many health benefits. Effective physical activity to enhance the functionality of the elderly daily life, health, fitness and quality of life are of great help and also achieving pleasant living (Ming-Jen Yang, 2010). According to the concerned areas of research (including health, economic independence, the degree of independent living) it is also that founding elderly user living independently more positive attitude, the higher the degree of independence of living persons, higher life satisfaction (Lin Yi-shan, 2007).

1.2 Research purposes

This study aim is to promote the autonomy and independence of older people to maintain life, and the use of resources in the central region of the metal industry, the development kitchen supply of the elderly user. By kitchen supply research to improve the motivation of the elderly cook, help the elderly to live independently with dignity, and both self-maintenance and body healthy daily diet, creating a sense of pleasure and happiness. Also, the metal industry in central Taiwan for the vehicle, This study may change the traditional manufacturing and design thinking, then, increase sales target customer groups, enhance economic output, increasing company profits, and build their own brand in Taiwan.

2. LITERARY REVIEWS

In order to create and give elderly user that a satisfactory and enjoy life for kitchen supply design, Our research to find out from the literature with the "independent" about the elderly population and comprehensive of the all kinds of researchers definition lifestyle are summarized in Table 1. Overall, the life style is defined scope from the study of human habits, life, behavior, culture, etc., and to make inferences and classification of different ethnic approach.

AIO dimensional types more suitable for applications in large-scale surveys and quantity, and also the most widely adopted by most researchers approach. AIO Scale is divided into: (1) general lifestyle, and (2) certain of the lifestyle scale (Engel et al, 1978.), our study used the first general lifestyle scale, to overall understanding of elderly user in general lifestyle. Reynolds & Darden (1974) considered lifestyle (Table 2), including: (1) Activities (activities), (2) interest (interests), and (3) comments (opinions), but each study is bound to contain all the variables, so our study, depending on their research projects to select, filter or change variables needed. Our study was designed to classify the objects that meet "independence" ethnic characteristics, to serve as future visit. Taiwan in recent years, researchers measured using AIO for elderly user in various lifestyle which summarized in Table 3.

Table 1：Lifestyle definitions

Researcher	Definitions
Mei-Ling Yeh (2007)	Lifestyle with the residents or consumers grouping characteristics, and can reflect the specific behavior of individuals and ideas
Hawkins, Best, & Coney(2001)	Person's lifestyle is the concrete manifestation of the concept of self-caused, through past experience, inner thoughts and the prevailing situation, produce the combined effect of these three
Engel, Blackwell, & Miniard(1995)	Lifestyle is a form of human life and spend time and money, reflecting the activities undertaken by individuals, ornaments and opinions on various topics of interest.
Kotler(1991)	Lifestyle is to describe the situation of personal interaction with the environment
Assael(1987)	Proposed lifestyle is widely defined as a way of life, and this mode can be three ways to identify, has also become the main basis AIO scale: (1) how people use their time (activities); (2) What is their living surroundings of the important things (interest); (3) their perception of themselves and those around them (opinion)
William Lazer(1963)	Lifestyle is a system concept, is a group on the life and consumer has the characteristics to explain differences in the groups with other groups, so the lifestyle is the sum of culture, values, and legal forces caused
Kelly(1955)	Lifestyle is a person's cognitive architecture, rather than the social system, because everyone has their specific cognitive architecture, because everyone has a particular lifestyle.

Table 2： AIO lifestyle Scale

Dimensions	Definitions
Activity	Refers to a specific and distinct activities can usually be observed directly, however the reason it is difficult to directly measure
Interest	Refers to certain things, events or topics excitement level that allowing people to produce special and sustained attention
Opinion	Refers to the individual in question puncture under certain situations shock reaction, given oral or written statements, can be used to describe a personal explanation for things, expectations and assessments

Source：Reyonlds & Darden(1974)

Table 3：elderly user in all facets clustering literature review

Researcher	Topic	Clustering name
Zeng Bo Xun (2008)	Research retirement lifestyle satisfaction with the use of the park	Interest orientation Independence Leisure Leader
Wang Pei-Yun、Su Ja-Cho(2006)	Research using adult lifestyle relations with the media	Feeling of supremacy Self-centeredness Aggressive
Zhang L, Chen Guang-hua (2006)	Research elderly buying behavior Long-term care market in Taiwan	Traditional and conservative Aggressive Optimistic attitude to life
Liu Yan Ying, Wang Hui Xuan(2005)	Research middle-aged care retirement community for coherent attitude in the city	Opening and focus on brand Conservative, traditional and diligence Emphasis on health and not care substance Optimistic attitude to life
Guo zheng-De	Research seniors participating leisure, lifestyle factors and obstacles	Emphasis on the family Self calm Information access Self requirements

3. RESEARCH METHODS

Our study used four kinds of research methods include: (1) lifestyle scale, (2) Kano model (Figure 1), (3) QFD (Figure 2), and (4) focus group interviews. Products are metal products industries with growth potential in central Taiwan, while setting the kitchen supply as subjects and setting target customers over 65 years old, with an independent features in Taichung, Taiwan. Contents divided into several stages, the step shown in Figure1.

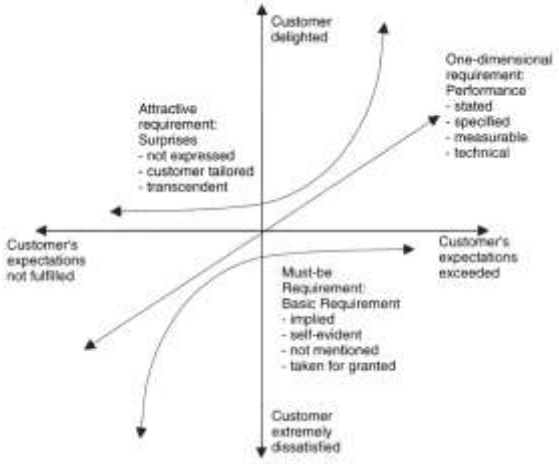


Figure 1：The Kano model of customer satisfaction

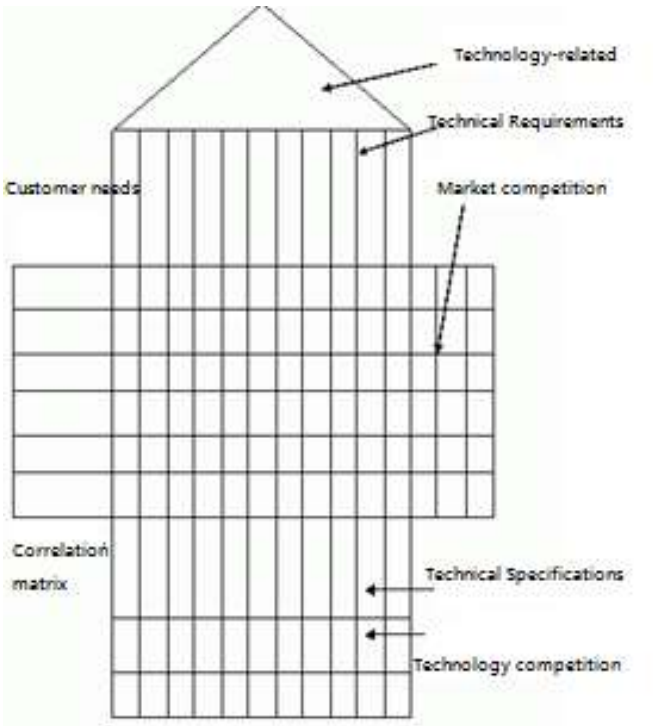


Figure 2：Schematic QFD

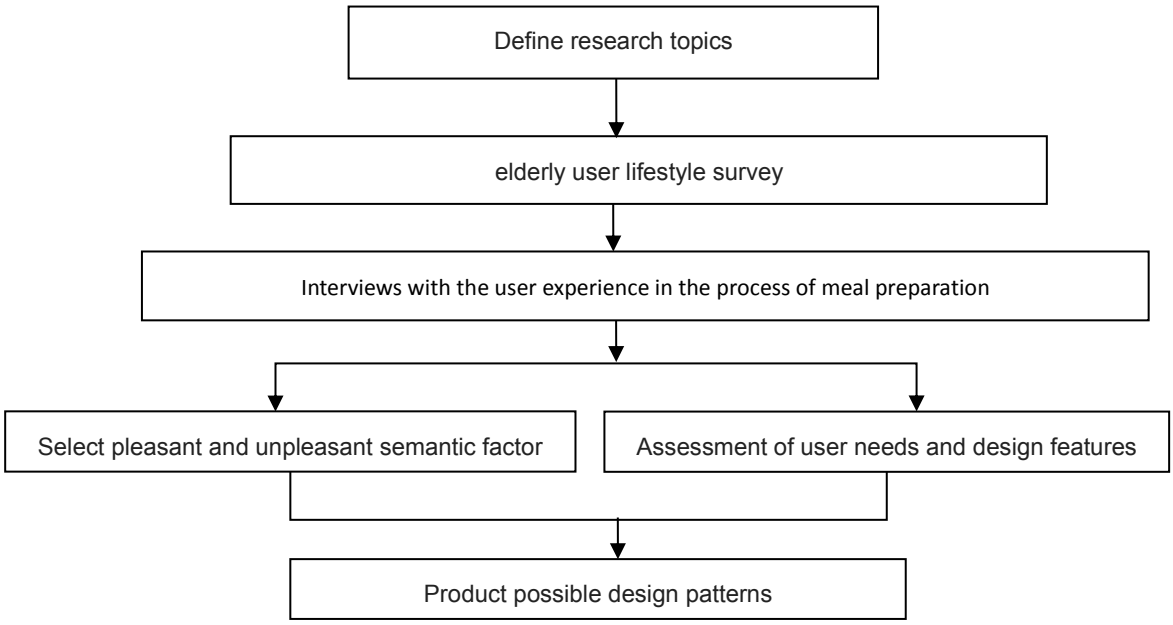


Figure 3：Research Steps

4. THE FINDINGS

Based on the number of people over the age of 65-74 (Table 1) for the 140,987 people in Taichung City. Experiments taken calculate 95% confidence lower (error is 5%). This study distributed 384 questionnaires that using Internet questionnaires and paper questionnaires survey.

The results of basic information, respondents were mostly women, age distribution between 65-69 years old, they live in urban areas the most, most married, spouse alive, almost illiterate, educated in high school the most, mostly in retirement status. Their favorite activities at home, there are usually at home cooking up a week 5-6 week, you can prepare your own meals independently

This study using factor analysis (chi-square test correlation is 2294.71, the significance level of p = .00; sampling suitability to KMO (Kaiser-Meyer-Olkin measure of sampling adequacy criterion value of 0.8, Luo Wenkun, 1986), Extraction elderly user lifestyle includes live and work, health and enjoyment, practical and authority, traditional and conservative, brand-oriented.

Select " live and work " and " health and enjoyment " as the representative of in-depth interviews, because this group has a healthy, positive, helpful, and pay attention to the characteristics of home life, and these are related to independence and enjoy life

From the " live and work " and " health and enjoyment " selected population scores higher, and the need is much higher than the overall average score of 384 for the elderly user that as the representative of focus (Table 4)

The first stage of the process enjoyable experience for meal preparation part, using in-depth interviews (in-depth interview) in the focus group interviews, the use of unstructured interviews (Wulz, 1990), the interview lasted two hours and a half, a break once divided for two echelon proceed. The results showed that:

1. Respondents cook one meal a day on average that mostly for dinner.
2. The pantry behavior includes washing, cutting, cooking, cleaning utensils
3. The findings pleasure vocabulary has 27 words, unpleasant words a total of 20, and the corresponding kitchen supply such as Table 28, and the findings focus on the most pleasurable feeling is wok

Table 4： Overview of focus group respondents in each grouping average

NO	NAME	live and work	health and enjoyment	practical and authority	traditional and conservative	brand-oriented
S1	Mr Zhang	3.88	2.43	2.60	3.00	0.67
S2	Mr Lin	2.38	3.43	2.40	1.33	1.67
S3	Miss Jane	3.75	1.57	1.60	3.00	0.67
S4	Miss Ye	2.13	3.00	2.60	1.33	2.33
S5	Miss Shi	1.88	2.71	2.20	2.67	2.00
The total average		3.03(234 people)	2.69(89 people)	2.83(15 people)	3.29(15 people)	2.81(7 people)
Total 360 people (Deduction across two or more ethnic groups)						

The second phase of the study user requirements and design features, the use of focus group findings arising from pleasure, to understand the needs of attractive, and be constructed QFD house (QFD) interviews. The results showed that:

1. Kano model Findings

(1) The pot body attractive (value> 18), including aperture size, fast heat conduction, easy to clean, basic functions, durable, non-stick pan, suitable size, material, member location, shape, heat, and can not afford to smoke qualities.

(2) The handle attractive (value> 18), including insulated、 lightweight and easy to get, easy to clean, in line with the hand.

2. QFD Findings

(1) pick out a user needs more than four points or more important factor (Figure 14)

(2) The most important body of the pot to prevent hot, fast heat fast, fast heat dissipation; handle the most important is not slippery, lightweight easy to pick up, in line with the hand.

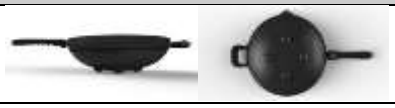
According wok set QFD findings from a new type to prevent hot as the main factor, therefore, consider reducing the heat transfer area, increase the cooling area, insulation materials, etc., to design and development of kitchen supply for elderly user.

This research compiled respondents and expert advice, this study is expected to conclude meet the the improved design of the elderly wok focus as follows(Table 5):

1. The wok heat groove design
2. The wor's bottom has thermal design
3. Addition wok pan edge design to facilitate pouring dish
4. Reduce the force of the weight of the wok support design

5. The wok's bottom has thermal display

Table 4：The design style of wok

Type 1	Type 2	Type 3
		

5. CONCLUSION

1. wok heat trench both beautiful and attainable cooling effect, it is recommended that the cooling rate of the related experiments
2. Testing the bottom pan angle and vertical position of the point to get the best position and angle to reduce the force is increased by granting the safety wrist
3. Recommended wok beak designed to operate that understanding the most suitable size diameter
4. Increase in the bottom of the wok thermal design (such as concave, bumps and vertical angle) that need for the size of the experimental gas stove.

Development new types kitch supply for elderly user was limited by the lack of knowledge and processing technology, and resulting in the concept of output is difficult, so still need help in different areas of professional technicians. In addition, the combination of different materials (e.g., wood and iron), with perhaps another possible starting material for the new design style.

ACKNOWLEDGMENTS

The study have to thanks for the assistance of many units, thank the following：

1. Thanks to funding support for Industrial Technology Research Institute.
2. Thanks to Survey for Elderly association in Taichung city.
3. Thanks to provide research environment for Asian university.
4. Thanks to help for the Department of Creative Product Design Asian university teachers and students.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Feature Analysis for the Design of Artifacts with Growing Practical Values and Spiritual Values

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Abstract: Value Growth Design is a design based on a new design paradigm, Timeaxis Design, which incorporates the viewpoint of the time axis into the theory and methodology of design. Value Growth Design enables an object to increase in its practical value, such as its usability, and in its spiritual value, such as affection, the more it is used. This is antithetical to value decay design, seen in artifacts of mass production and mass consumption, which show a decrease in value over time. If such artifacts were able to adapt to the change of environment and the change of value based on the theory of Timeaxis Design, it is expected that their practical values and spiritual values would increase. This can enable artifacts to become appealing to human Kansei and allow users to possess a single artifact over a long range of time with strong affection. However, there are only few studies which have considered the application of Value Growth Design to actual design. Thus, in this research, a case study of existing value growing cases is carried out, followed by a cluster analysis and a discussion of the results which produce nine factors of value growth.

Keywords: Timeaxis Design, Value Growth Design, Multispace Design Model, design science.

1. INTRODUCTION

1.1. Research background

1.1.1. Issues surrounding society

In recent years, as we shift towards a society dependant on mass production and mass consumption caused by the development of industry and the growth of population, environmental

issues due to mass disposal and energy waste have become crucial. In addition, there is a demand for spiritual richness rather than practical richness. Also, since the circumstances of artifacts such as the surrounding environment, and the diverse values of users such as one's preferences may change from to the point of purchase, there is a need to cope with these issues in the field of artifacts design.

1.1.2. Value Growth Design

In order to design artifacts that will meet the needs mentioned above, Value Growth Design, a design methodology which embodies Timeaxis Design, is proposed as an effective solution.

Timeaxis Design incorporates the viewpoint of time into the theory and methodology of design, enabling various conditions and values as well as changes over time to be considered. Other than Value Growth Design, the design of the transition period is also a methodology to embody Timeaxis Design. Value Growth Design allows an artifact to grow in its practical values and spiritual values. The design of the transition period can be applied to large-scale systems with long term transition periods of one state to another. Among such methodologies, Value Growth Design focuses not only on the change over time but also on the spiritual relationship between an artifact and its user, such as the affection and devotion towards an artifact.

When designing artifacts based on the concept of Value Growth Design, it is necessary to focus on the process of usage. This is because practical values and spiritual values of an artifact are expected to be nurtured through various experiences and interactions through the usage after purchase. This process can be clarified by studying the relationship between the user and the physical and mental elements of artifacts which change over time.

On the other hand, to clarify the elements considering the design of artifacts and their relationships mentioned above, a framework is needed for its comprehension. Design science, proposed by Matsuoka, is a framework aimed to elucidate the laws and knowledge concerning design. Furthermore, the Multispace Design Model, proposed based on design science, is a model which organizes the physical and mental elements and its relationships of a certain design object, and also explains the surroundings, the meaning, and value of a design object. The introduction of this model thus becomes valuable in this research.

1.2. Purpose of research

In this research, we clarify the factors of value growth based on the perspective of design science. This makes it possible to express the growth of value, and will become contributory to the application of Value Growth Design.

1.3. Method of research

First, we collected cases of existing value growth designs and organized its elements using the Multispace Design Model. Next, we analyzed the cases by a cluster analysis and applying the perspectives proposed in Value Growth Design. As a result, we were able to extract the factors of value growth.

2. PERSPECTIVES OF ARTIFACTS DESIGN INTRODUCED IN RESEARCH

2.1. Value Growth Design

As shown in figure 1, many existing artifacts have the highest value at the point of purchase and show a decay in value through usage due to the disability to adjust to changing circumstances and

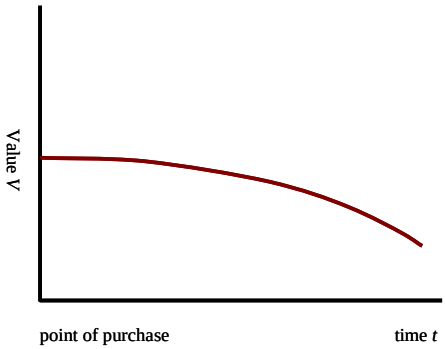

Figure 1: Value decay design

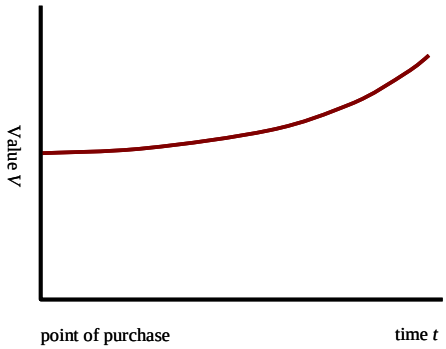

Figure 2: Value Growth Design

users' values. This can be described as a value decay design. An example would be a disposable pen. Opposed to this, Value Growth Design enables an object to adapt to changing circumstances and values, which results in an increased value over time, as shown in figure 2. An example of this would be a fountain pen. By applying Value Growth Design, the design of artifacts which are not only capable of long time usage, but are also focused on spiritual values in addition to practical values will become possible.

2.2. Multispace Design Model

To consider the elements of a design object and their relationships, we introduce the Multispace Design Model, shown in figure 3. The Multispace Design Model consists of knowledge space and thinking space.

Knowledge space consists of two categories: objective knowledge and subjective knowledge. Objective knowledge is comprised of generalities, theories, and methods in natural science, humanities, and social science. In contrast, subjective knowledge depends on personal skills and experiences.

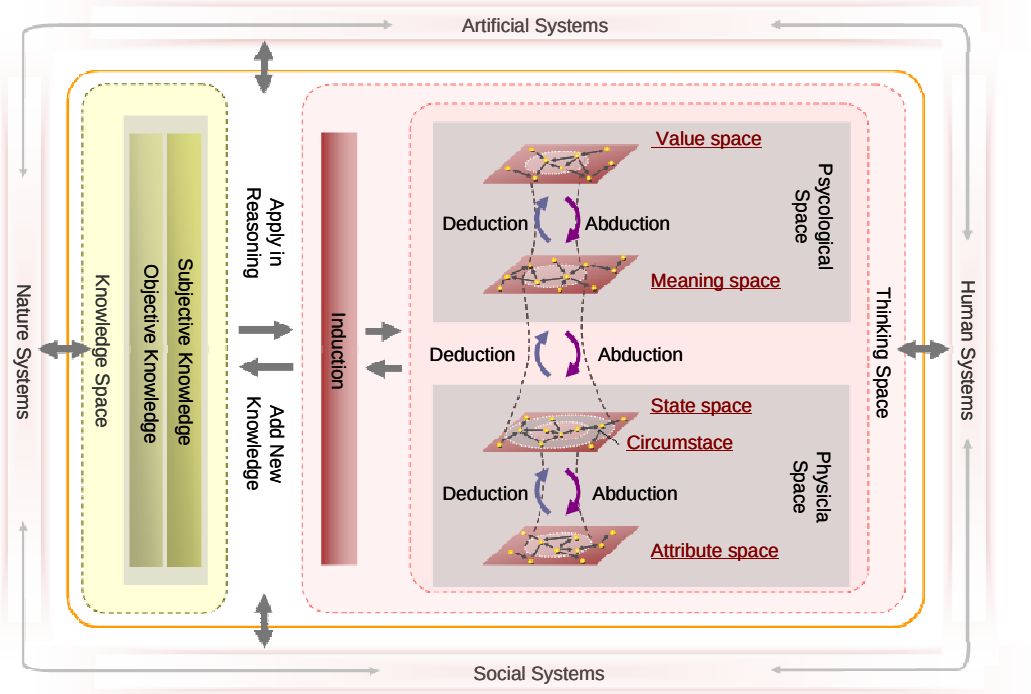

Figure 3: Multispace Design Model

Thinking space can be subdivided into value space, meaning space, state space, attribute space, and circumstance. Value space is a set of elements related to the value that a user gives an artifact (e.g., functional value, cultural value, etc.). The meaning space is a set of elements related to the meaning that a user places on an artifact, including function and image. State space is a set of physical quantities generated when an artifact is in a given condition, and includes stress and acceleration produced when an external force acts upon an artifact. Attribute state is a set of elements that describe the geometrical and physical properties of an artifact (e.g., dimension and material). The circumstance is the environment where an artifact is used, including time, the user, external force, etc. Below is a description of the procedure of employing the Multispace Design Model in the example of eyeglasses.

Eyeglasses are a very useful tool in daily life, and its consisting elements can be organized using the Multispace Design Model as shown in figure 4. Here, "provide comfortable daily life" is placed in the value space, and "fits the user's face" and "correction of vision" is placed in the meaning space as meaning elements that realize value elements. Also, physical qualities that are influenced by circumstance are described as "constriction of the frame" and "adjustment of focus" in the state space. In the attribute space, physical elements that are not influenced by circumstance are described as "color" and "hinge". Finally, as elements of circumstance that influence the four spaces, "the user's preferences", "the user's age", and "the user's skeletal features" are arranged.

The relationship between these organized elements can be explained as the following. First, state elements emerge from the relationship between the attribute elements such as "color" and "hinge" and elements of circumstance such as "the user's age" and "the user's skeletal features". Next, based on the state elements such as "constriction of the frame" and "adjustment of focus" and the user's experiences, meaning elements such as "fits the user's face" and "correction of vision" emerge in the meaning space. Finally, the user will discover the value of eyeglasses as "provide comfortable daily life" from the meaning elements. Eyeglasses can be described by its elements and can be placed in the 4 spaces and circumstance in this way. By doing this, it becomes possible to organize the elements of a design object and comprehend the relationship between elements and design knowledge.

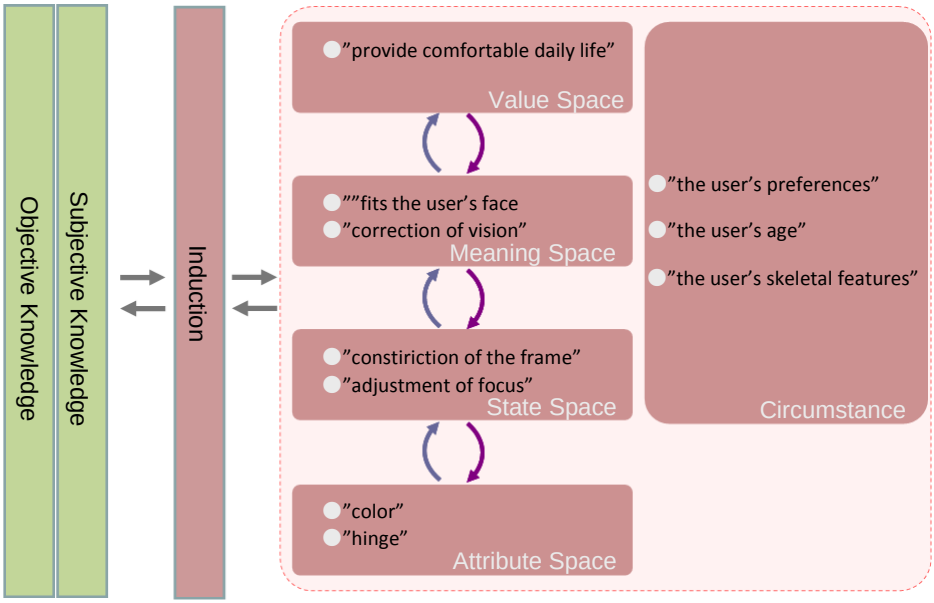

Figure 4: Elements of eyeglasses

3. CASE STUDY AND ORGANIZATION OF EXISTING VALUE GROWTH DESIGN CASES

3.1. Case study of existing Value Growth Design cases

3.1.1. Extraction of cases

The procedure of the case study carried out is shown in figure 5. To collect Value Growth Design cases, first, words strongly related to Value Growth Design, shown in table 1, were extracted. Second, artifacts, which exhibited the growth in value based on the extracted words, were collected via research on the internet and in documents. Third, related words were also extracted from these cases. Fourth, these related words were used to repeat the second step. As a result of this repeated operation, 84 cases were collected.

3.1.2. Selection of cases

Value Growth Design is a design that focuses on the change of value of an artifact from the point of purchase. Furthermore, the value referred to here includes composite values determined by an unspecified number of users and the surrounding environment. In this research, we analyze cases where a single user exists for a single artifact, and aim to consider composite values by expanding the results. From this viewpoint, out of the collected 84 cases, we selected cases which the point of its purchase is clear, cases whose value increases from the user's point of view, and cases where a single user could be identified. For example, a baseball glove corresponds to a single user, while the Tokyo Tower does not. Cases such as this were omitted at this stage. As a result, 14 cases were selected as Value Growth Design cases as shown in table 2.



Figure 5: Procedure of case study

Table 1: Words related to Value Growth Design

attachment	acquaintance	accustom	harmony	learning ability
customize	trust	time-passage	long-term	prediction
self-expression	taste	convenient	safety	...

Table 2: Selected 14 cases

AIBO	Paro	smart phone	car navigation	fountain pen	jeans	baseball glove
pongee	archer's glove	writing brush	leather shoe	lacquerware	copper-sheathed-roof	Nambu ironware

3.2. Organization of elements based on the Multispace Design Model and the Value Growth Model

3.2.1. Introduction of the Multispace Design Model

By organizing the elements of the 14 cases using the value space, meaning space, state space, attribute space, and circumstance, we are able to conduct the study from a unified viewpoint.

3.2.2. Observation of the change over time

The cases collected in this research are all involved in change over time. For example, the writing brush becomes accustomed to the user through repeated usage, enabling the user to write freely with their will. This is caused by the hair of the brush being strengthened through usage. Such characteristics can be seen in all the other selected cases, and it is considered that several phases exist in the process of a user using an artifact, in which their values grow.

3.2.3. Introdution of the Value Growth Model

In order to consider the change over time of the 14 cases, we introduce the Value Growth Model. Figure 6 shows the growth of value over time and the five phases of the Value Growth Model: value discovery phase, value realization phase, value growth phase, value establishment phase, and value tradition phase. In each phase, the practical value and spiritual value of an object change.

Period 0: Value discovery phase

The value discovery phase is when one discovers the value of an object or product through a brochure, advertisement, or trial period prior to purchasing. Since the user does not possess the object, the spiritual value mainly increases in this phase.

Period I: Value realization phase

The value realization phase is when a user uses an object or learns about its different functions. This is the phase when expectations and the actual usage of a product are reconciled, which lead to a significant change in an object's value. Due to the object's functions and usability, the practical value mainly increases in this phase.

Period II: Value growth phase

The value growth phase is when a user employs an object and becomes accustomed to its usage. The user also develops a sense of attachment to it. The value changes most in this phase,

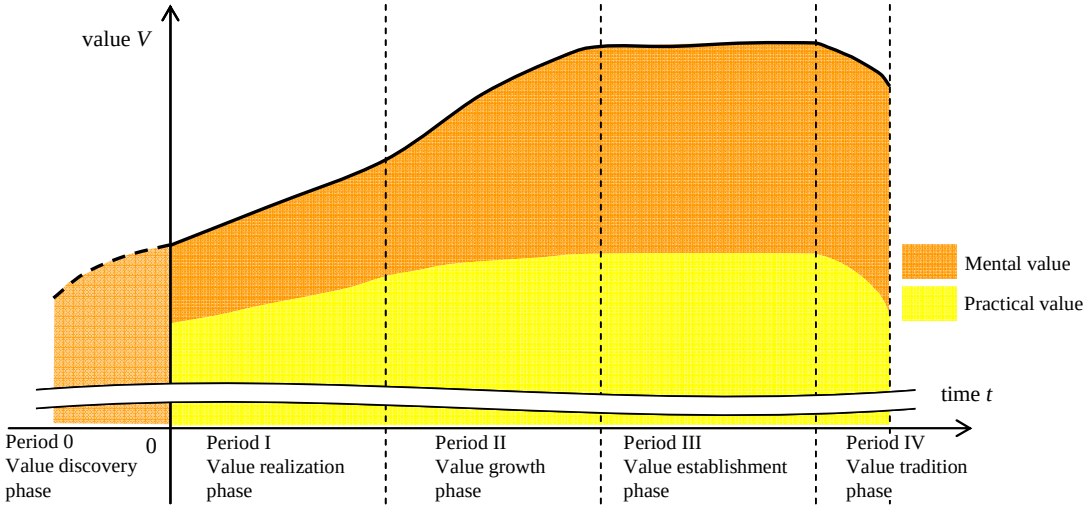

Figure 6: Value Growth Model

mainly due to the increase of spiritual value.

Period III: Value establishment phase

The value establishment phase is when the value on the whole eventually stabilizes. The user is able to obtain a stable value from the object. In this phase, the value that has been built up in the past phases is more significant than the growth.

Period IV: Value tradition phase

The value tradition phase occurs when the value of an object begins to decrease due to decay, and the object is replaced. An object is replaced, especially once it exceeds its life expectancy and when the value rapidly decreases. In this case, it is possible to transfer the value of the former object to the replaced object due to data transfer for example.

3.2.4. Organization of elements based on the two perspectives

Based on the Multispace Design Model and the Value Growth Model, the elements of each case were sorted due to the value space, meaning space, state space, attribute space, circumstance, value discovery phase, value realization phase, value growth phase, value establishment phase, and value tradition phase. While sorting, the possibility of each element's correspondence was considered by extracting elements from the descriptions of the artifacts and placing these elements into the corresponding spaces as shown in figure 7.

4. FACTOR ANALYSIS OF VALUE GROWTH DESIGN CASES

4.1. Cluster analysis

4.1.1. Introduction of means-ends

In order to clarify the patterns of value growth, we introduce the perspective of the means-ends of Value Growth Design. The means of Value Growth Design refer to bio-inspired technology and service technology, which are proposed to be effective in previous studies for the growth of value, which are the ends. The values that increase as a result of these means can also be divided into practical values and spiritual values. The details of this perspective are described below.

1. Practical values and spiritual values

The value elements extracted from the collected cases included practical values due to the object's functions, and also included spiritual values due to affection. The value elements could be divided into these two.

- examples of practical values
  "an indispensable information terminal of a traffic society"(car-navigation), "improvement of skill"(archer's glove)
- examples of spiritual values
  "healing the mind"(Paro), "originality"(jeans)

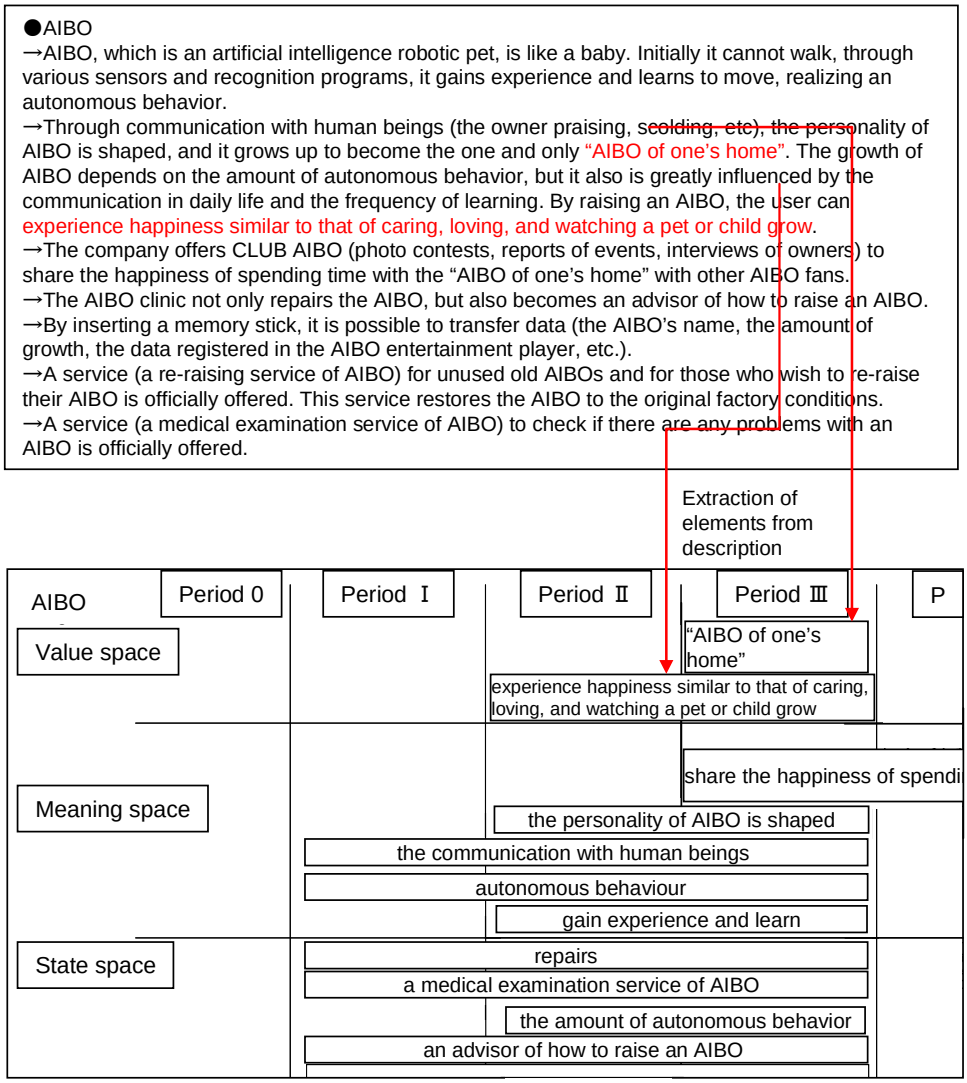

Figure 7: Organization of elements

2. Bio-inspired technology and service technology

The state elements extracted from the collected cases included changes occurring in the internal system and also in the external system of an object. The internal system of an object refers to the system composed of the elements of the object itself and its relationships, as shown in figure 8. The external system refers to the elements of the circumstances and its relationships. Bio-inspired technology and service technology act as causes of effecting change to these systems.

Bio-inspired technology aims to maintain and improve an object's value or functions by the improvement of the internal system through interaction between the external system. This follows

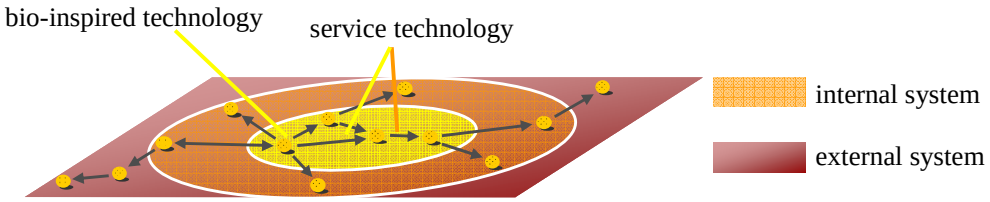

Figure 8: Internal system and external system

the system of living life. Service technology aims to maintain and improve an object's value or functions by applying service to the internal system and the external system of an object.

- examples of bio-inspired technology
  "growth speed of AIBO"(AIBO), "internal condition of Paro"(Paro)
- examples of service technology
  "appropriate care by the user"(leather shoe), "maintenance"(Paro)

Furthermore, service technology can be categorized into the following according to the target of change.

- change by the user (when the object changes due to the user)
- change by the artificial environment (when the circumstances change due to an artificial environment)
- change by the method of usage (when the circumstances change due to the method of usage)
  The cluster analysis was carried out based on the perspectives of 1 and 2.

4.1.2. Outline of the cluster analysis

To extract the features of value growth, a cluster analysis on the existence of elements in the four spaces and condition of the Multispace Design Model, the five phases of the Value Growth Model, and on the correspondence of practical value, spiritual value, bio-inspired technology, and service technology, was conducted. In this analysis, the Ward method (Nagata & Munechika, 2001) is used.

The Ward method combines clusters so that the sum of the squared deviation within a cluster is minimized. First, the squared Euclidean distance d_{ab} of cluster A samples a_1 and a_2 is determined as shown in formula (1).

$$d_{a_{12}} = \left(x_{a_1} - x_{a_2}\right)^2 \tag{1}$$

Here, x_{a1} is the coordinates of sample a_1 in the Euclidean space. Next, the sum of squared deviation S_l of cluster A is determined. When cluster A holds samples a_1~a_l, S_l is given as shown in formula (2).

$$S_l = \sum_{k=1}^{l} \left(x_{a_k} - \bar{x}_a\right)^2 \tag{2}$$

Here, $\bar{x}_a$ is the average of the distance between samples x_{a1}~x_{al}. Based on the Ward method, the clusters are generated and combined until all samples end up in one single cluster; the sum of the squared deviation within the remaining cluster is the minimum.

For each case, the existence of an element in a specific space for a specific phase was evaluated by two values.

4.1.3. Classification of cases based on cluster analysis

Figure 9 shows the results of the cluster analysis where the horizontal axis denotes the distance between clusters. Then the results were organized into four clusters, cluster A, cluster B, cluster C, and cluster D, as shown in figure 9.

The clusters differ by the presence of a value element, a meaning element, or a state element in period I, period II, and in period Ⅲ. Cluster A and B shows how value elements, meaning elements, and state elements all appear at an early stage. Although similar, the factors of cluster A and cluster B are different. For example, AIBO belongs to cluster A and possesses a learning function, enabling it to grow through interaction between its user. Smartphones, which is an example of

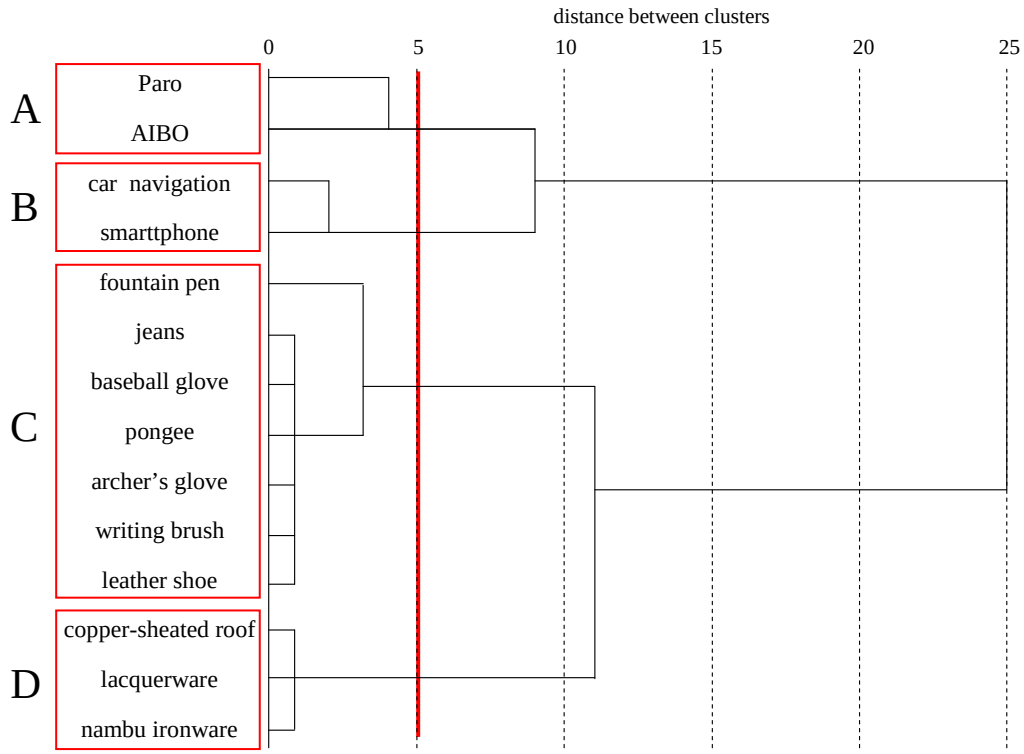

Figure 9: Cluster analysis results

cluster B, has various apps enabling its user to customize its functions to fit their needs. Therefore, cluster A is characterized by "learning", and cluster B is characterized by "customizing".

Cluster C shows how in phase I, value elements and meaning elements do not exist, while state elements exists, indicating that the value is just beginning to grow. Cases belonging to cluster C are leather shoe, writing brush, archer's glove, pongee, baseball glove, and jeans. The process of the user becoming accustomed to an object leads to the appearance of meaning elements and value elements in phase II. These changes are therefore due to care and repeated usage by the user, and cluster C is characterized by "accustomization".

Cluster D shows how elements do not exist in phase I, indicating that the value of the artifact grows suddenly, in period II. Cases belonging to cluster D are nambu ironware, copper sheathed roof, and lacquerware, which do not show a dramatic change during the early stages; consequently, phase I is absent. However, when these objects enter phase II, users are able to recognize the change through color or taste due to a chemical reaction caused by the surrounding environment. Therefore, cluster D can be characterized by "changing naturally".

4.2. Extraction of factors based on each cluster

The characteristics found in period I through period III is described as the following.

- period I

The user feels empathy due to elements such as "feeling of vitality" and "possess a learning function and takes action reflecting the user's senses", which mimic the features of pets. Users also are amazed to encounter elements such as "autonomous behavior", "able to follow latest trends". The user evaluates the object through senses of emotion based on these impressions.

- period II

The user evaluates the object comprehensively based on past experiences and elements such as "feel affection" and "preferences and personality is shaped" arise. This indicates how a

differential evaluation by the user is repeated and results in an integral evaluation.

- period III

The user is able to make full use of the object based on the accumulated information, and the surrounding environment is considered altogether. This appears in elements such as "stimulated conversation" and "update of map information".

When observing these characteristics, the perspectives below proposed to be effective in previous studies on each phase of the Value Growth Model may be valid.

period I-emotion theory

period II-integral evaluation and differential evaluation

period III-context model

In the emotion theory, emotion is created by amazement and empathy and the emotion theory effectively creates emotion. Amazement is due to an object’s novelty, while empathy is due to the user's understanding of a function.

Integral evaluation is due to a spur of the momentary evaluation. Therefore, objects are judged differentially at each time point. On the other hand, when an object is continuously used for a certain amount of time, reliability due to steady usage and affection due to long-term use both affect the object's value. Therefore, the value is evaluated integrally; that is, a product's value is built up over time.

The context model effectively explains the increase of shared information between two objects. Information shared within the context of the model is divided into two groups: a high context level and low context level. The high (low) context group consists of a large (small) amount of shared information. Thus, a user in the high context level group can effectively grasp the value of an object even if only a small amount of information is provided. An object's value may become stable as the shared information shifts from a low context level to a high context level.

As perspectives focused on the purchase of an object, the PEAM model proposed by Murakami(2012) describes the consumer's expectations towards a product and their emotional reactions due to purchase. There are also other proposed perspectives, but many focus only on a short time range, such as period 0 through period I. In this research, we consider the long time range of each object beginning from its purchase until its disposal. Thus, it is necessary to adopt perspectives that will cover a wide-ranged phase of value growth.

4.2.1. Factors of value growth in cluster A

We first consider cluster A, where value elements, meaning elements, and state elements all exist in period I(figure 10).

In period I of cluster A, the state elements are mapped to the meaning space, producing a meaning element. This is done by the user's original knowledge or new knowledge given from the external environment. For example, by looking at the "movement of the upper body and fins" of Paro, a meaning element "feeling of vitality" emerges based on the user's experiences or the information described in the operation manual. Moreover, in order for a value element to emerge by the mapping of a meaning element to the value space, a user must find some kind of value from the meaning elements. For example, the value element "healing the mind" emerges when the user finds the significance of meaning elements such as "interaction with people" or "possesses a learning function and takes action reflecting the user's senses". By applying the perspective of the

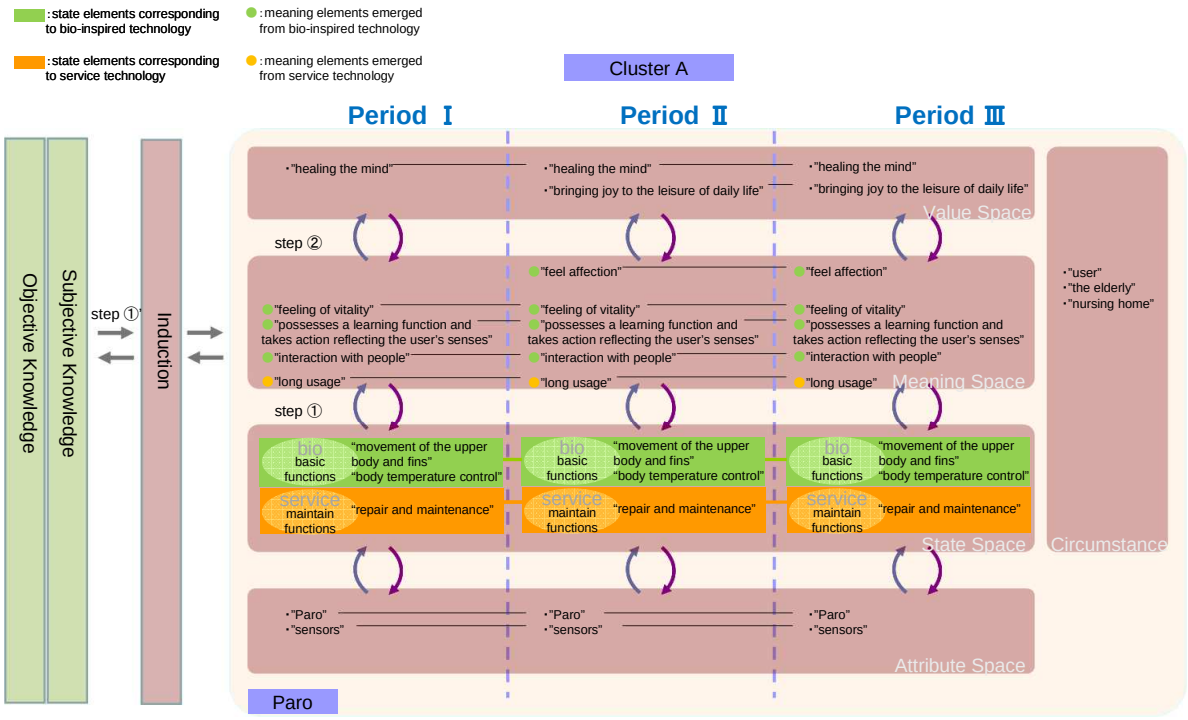

Figure 10: Elements of cluster A

emotion theory to the process, the following factors of value growth is proposed.

- the emergence of emotion due to bio-inspired technology and service technology ①

"Emotion emerges in period I due to the sense of empathy and amazement caused by service technology and mainly bio-inspired technology"

This mainly originates in the bio-inspired technology of AIBO and Paro.

In period II, value elements exist due to the existence of meaning elements and state elements, as in period I, but the process differs. In period II of cluster A, state elements which have emerged in period I and continuously exist in period II, and other state elements which have newly emerged in period II exist. Different value elements emerge from each state element. For example, "healing the mind" emerges from "interaction with people". This state element continuously exists in period II, allowing the same value element to emerge in period II. Opposed to this, "feel affection" a meaning element which newly emerges in period II, allows a new value element, "bringing joy to the leisure of daily life" to emerge in period II. By applying the perspective of integral evaluation and differential evaluation to the two processes, the following factor of value growth is proposed.

- the emergence of value due to differential evaluation

"Value increases in period II due to integral evaluation on the succession of value of emotion(memory)"

- the emergence of value due to integral evaluation

"Value increases in period II due to differential evaluation on the emergence of a new value"

In period III, state elements, meaning elements, and value elements all exist in all four clusters. Thus, all clusters reach the same state, which indicates how the value is stabilized by the growth of value reaching a steady state. By applying the perspective of the context model to the process, the following factor of value growth is proposed.

- establishment of value

"Value stabilizes in period III due to the continuous provision of value under small involvement of the user's knowledge"

In addition, the existence of a community consisted of users is also a difference seen between cases. A community is expressed by an element in the circumstances of an object. The meaning element changes in period III due to the change of circumstance caused by a community. Thus, the following factor is also proposed.

- sharing of value

"A new value emerges in period III due to mutual understanding and the sharing of information between users caused by the existence of a community"

4.2.2. Factors of value growth in cluster B

Figure 11 shows the elements in cluster B. In period I of cluster B, the following factor is proposed.

- the emergence of emotion due to bio-inspired technology and service technology ②

"Emotion emerges in period I due to the sense of empathy and amazement caused by bio-inspired technology and mainly service technology"

This mainly originates in the service technology provided by a company which realizes the object's bio-inspired technology.

In period II of cluster B, factors of cluster A can be proposed. For example, "evolving to match the user's tastes" emerges from "able to follow latest trends" of smartphones. This state element continuously exists in period II, allowing the same value element to emerge in period II. Opposed to this, "provision of accessories" a state element which newly emerges in period II, allows a new value element, "individual characteristic of the user" to emerge in period II. Finally, period III of cluster B shows the same features as those of cluster A.

4.2.3. Factors of value growth in cluster C

As shown in figure 12, in period I of cluster C, state elements such as "care" exist, but meaning elements and value elements do not.

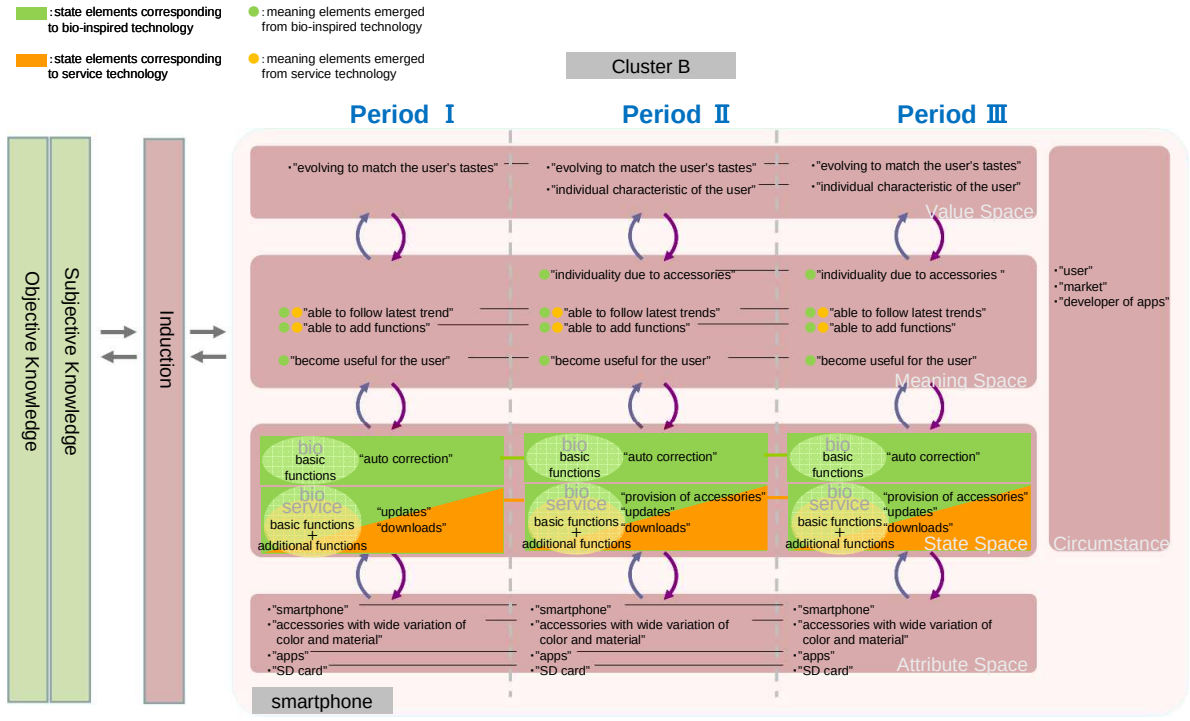

Figure 11: Elements of cluster B

The emotion theory applied to cluster A and B focuses on the meaning space and the value space of the Multispace Design Model(emotion is expressed by the multi-layer of the meaning space and the value space). Therefore, since cluster C does not correspond to the emotion theory, the consideration of its factors is done by focusing on the state elements.

The state elements such as "care" correspond to service technology. However, compared to cluster A where service technologies are also applied, meaning elements do not exist, and result in the absence of a value element. This indicates the existence of service technologies that lead to the emergence of meaning, and also technologies that do not. As explained earlier, service technologies can be divided into three according to the target of change. "a medical examination of AIBO" or "buildup of a database based on the users' experienced traffic jams and knowledge of short cuts", seen in cluster A, are categorized to "change by the artificial environment". On the other hand, "care", seen in cluster C, is categorized to "change by the user". In period I, the former allows the emergence of value, while the latter does not. Given the above, no factors could be extracted from this period.

In period II of cluster C, state elements, meaning elements, and value elements all exist. Like cluster A and B, state elements which have emerged in period I and continuously exist in period II, and other state elements which have newly emerged in period II exist. Different value elements emerge from each state element. For example, "something very important and personal" emerges from "care". This state element emerges in period I, and continuously exists in period II, allowing a new value element to emerge in period II. Opposed to this, "kneading" a state element which newly emerges in period II, allows a new value element, "improvement of archery skill" to emerge in period II. By applying the perspective of integral evaluation and differential evaluation to the two processes, the following factor of value growth is proposed.

- care

""change by the user" enables state elements such as "care" to continuously exist from period I to

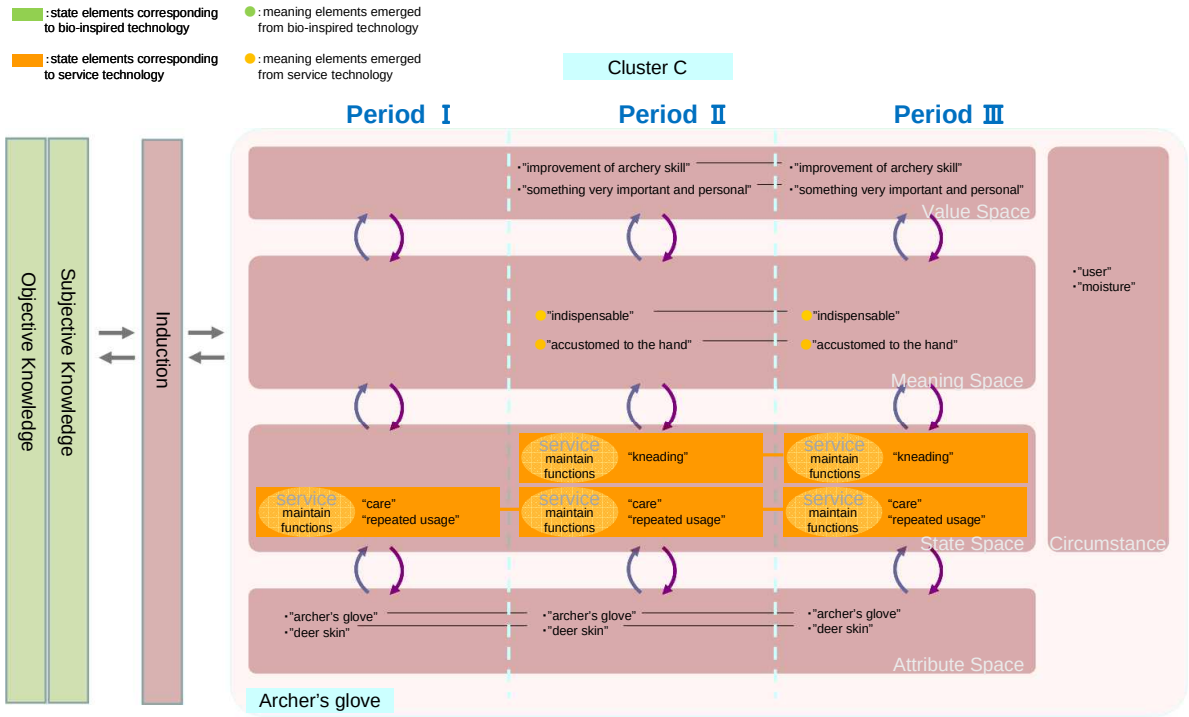

Figure 12: Elements of cluster C

period II. Value increases in period II due to affection and reliability caused by integral evaluation on the process"

- accustomization

"Value increases in period II due to change of the object's attribute elements caused by "change by the user ""

Finally, period III of cluster C shows the same features as those of cluster A.

4.2.4. Factors of value growth in cluster D

As shown in figure 13, in period I of cluster D, no elements exist. This is because no state elements exist which lead to meaning elements and value elements.

In period II of cluster D, the sudden emergence of elements in the state space, meaning space, and value space is characteristic. For example, the value element "good for the health" emerges from the state element "ferric ions are produced". Compared to the process of the emergence of value in clusters A, B, and C, this process differs in that it is affected by its circumstances. In the example of nambu ironware, elements such as "water" in the circumstances which exist from period I are strongly involved in the process of change in state. By applying the perspective of integral evaluation and differential evaluation to the process, the following factor of value growth is proposed.

- natural change

"Value increases in period II due to change of state caused by the accumulation of the influence of the natural environment"

Finally, period III of cluster D shows the same features as those of cluster A.

4.3. Factors extracted from each cluster

To summarize, a total number of nine factors were extracted from the four clusters, and are listed below.

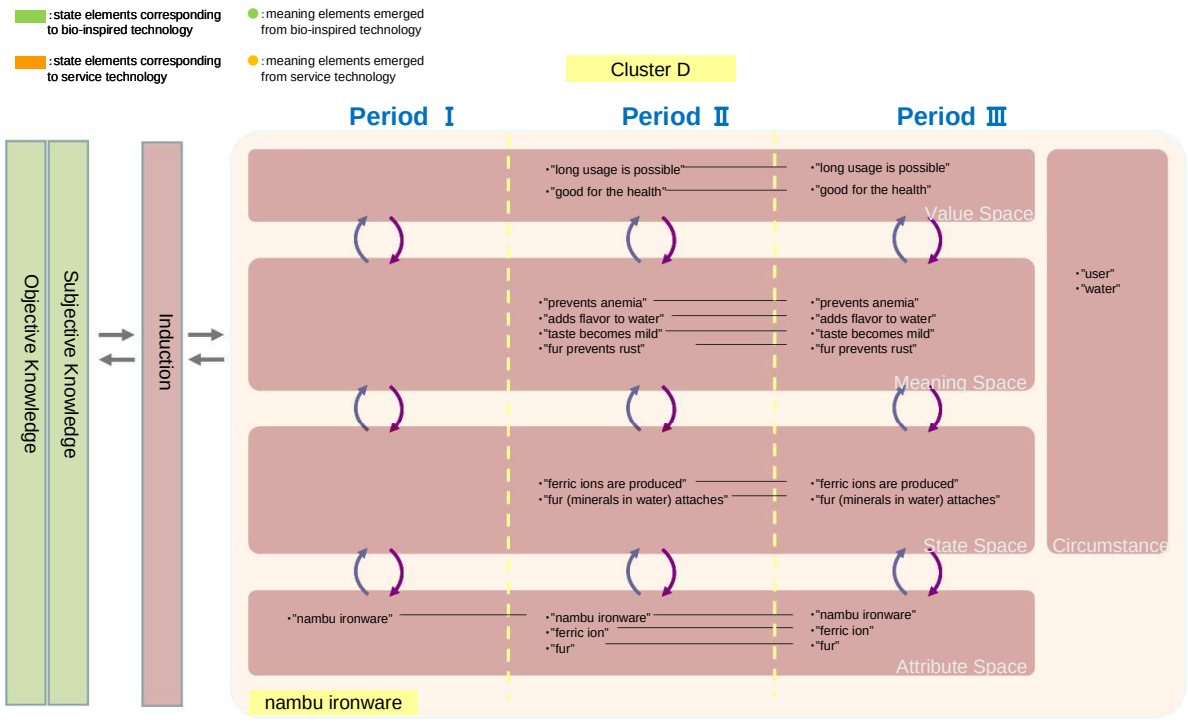

Figure 13: Elements of cluster D

- the emergence of emotion due to bio-inspired technology and service technology ①
- the emergence of value due to differential evaluation
- the emergence of value due to integral evaluation
- establishment of value
- sharing of value
- the emergence of emotion due to bio-inspired technology and service technology ②
- care
- accustomization
- natural change

These factors were extracted from different clusters and represent different patterns of value growth.

5. CONCLUSION

To clarify the factors of value growth, this paper conducted a case study of existing Value Growth Design cases and a subsequent cluster analysis to extract the factors of value growth. As a result, cases showing value growth from various genres were collected, and four patterns of value growth appeared. A detailed investigation of these patterns produced nine factors of value growth. In future research, the relationship between the factors should be analyzed in detail because their relationships may clarify the value growth mechanism, and become contributory to the application of Value Growth Design.

ACKNOWLEDGMENTS

This work was supported in part by the KLL 2014 Master's Program Research Grant provided by the Keio Leading-edge Laboratory of Science and Technology.

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KEER2014, LINKÖPING | JUNE 11-13 2014
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A Study on the Image of Wedding Gift Fortune Chicken

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Abstract：In the wedding ritual of Chinese culture, “Fortune Chicken” plays a major role in Han Ethnicity. As the time passes, the old way of wedding practices have evolved into a sign which is more visual based in order to be utilized as a means to disperse knowledge and here comes the ultimate product of “Fortune Chicken”. By using the homophone of the word “chicken” in Taiwanese language which resembles the phonic of “settle down” in Taiwanese, it can be a medium of nonverbal communication between parents and offspring as well as to achieve the purpose of sending out parents’ blessing to their children. This piece of work not only pursues the perfection of its design, but also seeks the significance of the design.

The “Fortune Chicken” product has taken place of live chicken in the wedding ritual of today as society continues to evolve. It is for display as well as for reproduction, in another words, it is in between abstract and figurative, performance reproduction with the body. This study experimentally designs identical stuffed “Fortune Chicken” with different colors in order to explore diverse effects in communication of aesthetic imagery. In this way, the “Lead the way Chicken” product is able to interpret the principles of Chinese art aesthetic which are “endless words”, “lively” and “Godlike”. In this study, the image scale is used to measure different colors and aesthetic imagery. Primitively, some common “Fortune Chicken” product samples were used to analyze the application of fabric, afterward, seven designs of “Fortune Chicken” were created so as to allow customers and manufacturers have

better understanding of the feeling that the fiber cloth made “Fortune Chicken” can bring.

The study aims at creating products for various consumers by combining dissimilar colors of fiber cloth with “Fortune Chicken” goods in order to achieve the new aesthetic concept. Furthermore, this elevates the interest of customers in purchasing the fabric “Fortune Chicken.” In the long run, this is expected to become a symbolic wedding gift in Taiwan. the study also discovers the difference between the designers and the subjects towards the sense of style, in the meantime, the study learns that based on aesthetic imagery, color red, blue with the design of big peony tend to be more popular in Taiwan’s wedding ceremony. The outcome of this study can be used as a reference for further production and design of “Fortune Chicken” moreover the new “Fortune Chicken” product can be the best gift in this constant merging, renovating and pervading Chinese wedding culture.

Keywords: Fortune Chicken, Aesthetic Imagery, Cultural Merchandise

1. Preface

This study aims to examine the customer’s perception towards the fabric design of the “Fortune Chicken” in the Taiwanese wedding custom. Among a great variety of products in the current market, the key is to design a product which will satisfy the need of customers. Above all, the way to maneuver the feeling of the customer has been an indispensable factor. In order to meet the need of customers, collecting and analyzing different samples of the “Fortune Chicken” from the market is the initial step, later, a further research into the appearance of the product by using distinct textiles is taken place. Through experiment, the outcomes of the “fortune Chicken” with different material are presented. The procedure starts with; design, draft, modification, suture and fabrication, after all, assaying the effect of aesthetic imagery which the “Fortune Chicken” will have combining with each and every different fabric. First, we utilize the greatness of “Geometry” onto the design of the chicken, then, apply “Sphere” which symbolizes happiness in marriage to the exterior design of the chicken to create a “Fortunate” fashion. The “Fortune Chicken”, an aesthetic orientation of symbolism and realism, in Chinese art, it is said that the imaginative feeling is greater than the intrinsic feeling. Therefore, Chinese art emphasizes on likeness instead of imitation, as for many creations, artists seek for likeness in their designs, not just the shape (Li, 1996). It is the “Imagery” of cultural and formal characteristics which was transformed. The “Fortune Chicken” product is easily to be correlated with “settle down” in a religious society. The relationship between the color of the cloth and the style is apprehended through the use of fabric. This merchandise must achieve the aesthetic feeling criterion and collect information to review whether it has met the characteristic

of “Aesthetic Beauty of Fortune Chicken”. This is to develop and alter a conventional product into a fashionable weeding product as well as providing a guideline for designers in which the psychological influence of the product toward customer should be taken into consideration when it comes to designing a wedding related product and the idea could be used extensively in the wedding.

2. History

In between the dusk of Ming Dynasty and the dawn of Qing Dynasty, most of Han people in Taiwan were from Fujian, Guangdong coast, but among those immigrants, majority were Hakka inhabitants who migrated south to Ho-Lo district. Since then, Ho-Lo culture had rooted and spread in Taiwan, Fujian and Guangdong where Hakka people clustered, owing to the long history of Hakka culture, the wide-spread population and the combination of various ethics, Hakka culture had incorporated some other local distinctions, but Ho-Lo culture, such as, respecting ancestor, attending prefecture and nurturing politeness is still the core, essence and foundation. Hakka people then emigrated to Southeast Asia, Europe and the rest of the world, despite residing in different parts of the world, Hakka people still bonded to their hometown “Central Plain”, until today, many Taiwanese and Hakka immigrants still addressed themselves as “Ho-Lo-Lang”.

In Taiwan, approximately 83% of residents are Han people and among those, 80% are Hakka immigrants from Ho-Lo district, they all call themselves “Ho-Lo-Lang”. In the wedding custom, there are several processes; from proposing, engaging to marring, and they all resemble to the custom in areas like, Taiwan, Ho-Lo and Central Plain which are solemn and complex! During the wedding, the ritual of “Fortune Chicken” is also known as “Consummated Birth”. Besides, in some provinces of China, such as , Quanzhou and even the people from Southeast Asia region named “Baba Nyonya” has the similar wedding ritual. Originating from the ancient time, chicken has always played a role as an important mascot. The usage of chicken in the wedding ceremony has transformed from a live one to a man-made art and merchandise with diverse materials and styles. The “Fortune Chicken” has been changing into different styles along with the times and the product has become more diversified. In Yuan, Ming and Qing Dynasties, the way people examine aesthetics were based on the act of fortune and wealth and the act of focused imagery. Focused Imagery act is form operating orientated, it focuses on opportune. The law of opportune is “cause and borrow”, according to the law, it respects the origin of the creation and it extends to “Analogy” and “Opportunism”. As for “Analogy”, it is “to allure a creative idea for item A by using part or all of item B” (Yang, 2011). The “Fortune Chicken” product has replaced a live chicken and the consisting of chicken family symbolizes the building of

a blissful family.

2.1. The implication of the fortunate aesthetic of the “Fortune Chicken”

The “Fortune Chicken” has played an important role in the traditional wedding ceremony, with the change of time, its value has been replaced by the cultural goods. An idea of aesthetic in I-Ching(the book of change) Ye, Lang (1993)summarized it with two phrases; “create to represent” and “observe to imitate”. These two phrases can be paraphrased as the affection and the idea inside cannot always be fully interpreted, but not with the help of image, as a result, the perceptions of “Image” and “Context” emerged. “Observe to imitate” explains the purpose of using the abstraction, “symbolic”, in order to create an art piece from objects we have seen in the real world (astronomical phenomena, the earth, the beauty of animals), things which the public are acquainted with, after all ideas have been fully expressed, the ultimate goal is to connect the relation between God and human(Yang, 2010). The “Fortune Chicken” implies “settle down” and the word “crest” in Chinese language is homophonic with the word “government official”, because of this, the chicken is used in the wedding to bring good luck to the newly wed. In Yangshao era, the trait of painted pottery was mainly on the shape and pattern of animals, especially the pattern of fish. The word “fish” in Chinese language means “prosperity” and it possesses the same magic symbol as the “Fortune Chicken”. The magic symbol can be defined as long live the family with tons of offspring. (Li, 1987) The “Fortune Chicken”, hopefully, can achieve “wordless”, “vivid” and “God-like” principles which have influenced Chinese arts for centuries. (Li, 1987) Moreover, the “Fortune Chicken” in Taiwanese language sounds similar to “The successful in birth of the bride”.

2.2. The application of “Fortune Chicken” in wedding

As the time changes, it’s getting tougher to have adequate space for keeping live chicken, also egg is fragile and not easy to maintain. The living condition and standard have also improved, it is no longer necessary to prepare a live chicken meal as nutrition supplement for the postpartum bride. Meanwhile, if the wedding ceremony requires long traveling, the chicken may be suffocated during the journey and it is definitely a bad sign for the newly wed. The wedding stores carry a wide range of “Fortune Chicken” products for the needs of customers, some can even be customized, it’s like what “Poetry” states “Endowment”, “Comparison” and “Enhancement” as principles of aesthetic and have impacted the art society for more than two thousand years. The most famous and popular explanation done by Zhu Xi is “Endower delivers the truth directly, comparer compares one with another, enhancer stirs the discussion by referring to other items.” “Poetry Glossary” ancient and modern people have more complicated views and definitions on it. Since “Endowment” is

simple and easy to understand, therefore, more discussions center around “Comparison” and “Enhancement”. It’s because only “Comparison” and “Enhancement” correlate with the expression of the affection in art. (Li, 1987) In addition, the “Fortune Chicken” tallies the modern artists’ inspiration derived from the interaction between the material and the body through playing games mentioned in the aesthetic theory of Adorno and the blessing and “psychological inclination” of the artist is created and instilled incidentally into the art piece. Interestingly, two identical “psychological inclination” collided once the customized “Fortune Chicken” was chosen by the parents and the pre-wed couples. Currently, a wide variety of “Fortune Chicken” is available in the market.

2.3. “Fortune Chicken” features distinguished

One of the motives which reintroduces the art and the history of the “Fortune Chicken” in an orthodox wedding practice through the cultural goods and promotes the development of traditional Chinese wedding ceremony is the reflection which the Western aesthetic had on the East. Without the new vision from the West, it would be unlikely for the conventional Eastern art to standout. The “Fortune Chicken” which possesses a cultural code and the significance of cultural and symbolic codes is evolved through ancient mythology, history and even daily routine. The cultural code not only owns an image, but also packs with a symbolic meaning. (Yang, 2010) The creation of the “Fortune Chicken” merchandise came from a live chicken strapped with 9 feet long red ribbon on its claws respectively and on both ends of the ribbons tied with a basket with the chicken claws inside. And this must be prepared personally by the mother of the bride. The true meaning behind it is to bless the bride and groom for a harmoniously marital life and long lasting love. Most importantly, the newly married could bear more kids, just like what the chicken could, this is called “Having a Good Life” in Taiwanese culture. Philosopher Kent once said “Thought without connotation is empty, intuitions without conceptions are blind.” And this proves the coexistence between aesthetic and art is inevitable. Therefore, how to transform the material used on the “Fortune Chicken” from fiber cloth to modern fabric and from a live one to an artifact is the key. Based on aesthetics, also known as perception, to establish the style with the use of modern fabric in the market and study the preference of Ho-Lo ethnic. In the meantime, the questionnaire was used in order to probe and analyze the “Fortune Chicken” distinguishable features so as to provide principles for future designs related to the “Fortune Chicken”. Red fabric is a type of Taiwanese fabric with brilliant red color and big Peony, it symbolizes fortune and noble, it is well represented in the wedding. Among the flowers which are used today, Peony resembles prestige, Plum flower resembles fortitude and Cherry resembles diligent, bravery and wisdom are the most welcomed by Taiwanese. There might have more

flowers which can bring a totally different feeling to the consumers, this study will examine the feeling of consumers toward various applications of fabrics on the "Fortune Chicken".

		
Red Peony	Blues Plum	Red Cherry blossom with white underlay

Figure 1: Applications of Color Fabrics on the "Fortune Chicken"

2.4. The aesthetic imagery of the "Fortune Chicken"

"Aesthetics" is the phenomenon of beauty as well as to study its nature and principle, this type of study can be traced back to ancient Greece. Plato was deemed to be the founder of aesthetics, but the conglomeration between aesthetics and philosophy took place in mid-eighteen century (Lu, 1993) The word "aesthetics" originated from the Greek word "aisthetikos", it can be interpreted as "sensitivity" and "the experience of sensory". It was first introduced to the world by the German Philosopher, Baumgarten, in 1750. The word "Imagery" was found back in the book called "I-Chuan", but the first time this word was created by Liu Xie in Northern and Southern Dynasty. (Ye, 1993) The so-called "Simplicity" of "Intention" and "Richness" of "Image" is the relationship between "Intention" and "Image", "Image is limited while Intention is unlimited". From the theory, it is how the foundation of philosophy was framed and how aesthetics commenced. The design of the "Fortune Chicken" generates an image of bliss and blessing, as for the aesthetic of the design, it will stir the emotion of the consumers while they are picking up the "Fortune Chicken" products. Chang Hung-Yu once stated in the book of "Composition Aesthetics" that the cause of people's aesthetics is the fluctuation of their emotions within, and the fluctuation often bursts along with the shape of the goods. Aesthetics attaches on certain goods perpetually (Chen, 2006). The plump design of the "Fortune Chicken" is being anticipated.

2.5. The transition of the intention of the "Fortune Chicken"

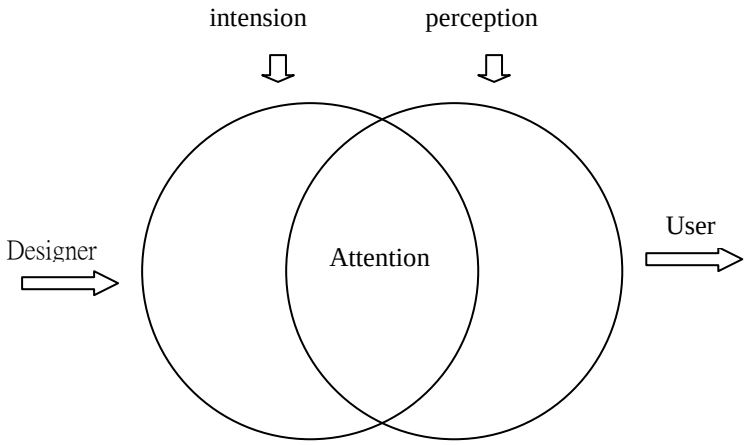

Figure 2: The transition of the intention of the “Fortune Chicken”(Ho, 2004)

“The cogitation of designer” exists deeply in every designer, through the transition of intention can their ideas be interacted and influenced.

The study aims at analyzing the productivity of the intention transition, validate the essence and criteria of the design, as well as any possible flaw and deformation. What standard must be met throughout the entire designing process? Does every design successfully deliver the intention? Is there any twisted, missed or over explanation? How to design a product which can meet the need, the intention and the value of both the designer and the consumer is a critical issue.

The identical “Fortune Chicken” moppet can be represented by diverse color fabrics, in the meantime, it can be used to transmit the intention, for example, the application of different flowers; Peony, Plum and Cherry and the shape of the “Fortune Chicken” can all be a guideline for the customers to apprehend more clearly about the intention which the designers try to pass through “Fortune Chicken” merchandise. In order to understand whether the consumers will accept the code and message and have and same “Intentional Figure”, the designers and the consumers must agree to use the same code.

The following are the factors which can determine the “Communicating” capability of the “Fortune Chicken”:

1. It can accurately deliver the phrase and the message of the designer.
2. It can express the perception of the designer by the application of different phrases.
3. It can exchange the experience between the designer and the end user.
4. It can earn mutual respect, understanding and recognition.

3. Real-life Testing

This study emphasizes on the research of the design element of the “Fortune Chicken”, the exploration of the visual intention of the consumer towards the “Fortune Chicken”, the analysis of relevant merchandise and the influence of fabric on consumer’s visual intention. Various measures on different color is executed in order to study the perception of consumer.

3.1. First, design the style of the chicken

“Consummate Marriage” and the body of the chicken must be plump. The crest, wings and tail represent wealth and their shapes resemble Gold Ingot. This experiment is conducted by using the same style of chicken sewed with different color fabrics and the total of 10 samples were created as followed.

The making of the moppet

There are 10 sets of handmade “Fortune Chicken” produced from designing to fabricating in this study and there are as followed in the table 1 below:

Table1: Experimental Samples

	Image	Characteristic of Imagery Intention		Image	Characteristic of Imagery Intention
A		Pink and indigo underlay，Peony Medium-saturation	F		White underlay, red and green cherry blossoms Medium-saturation
B		Maroon and yellow-green underlay, Peony High-saturation	G		Red and blue underlay, Cherry blossoms High-saturation
C		Red and blue underlay，Peony High-saturation	H		Black and red underlay, Cherry blossoms High-saturation
D		Pink and yellow underlay, Peony Medium-saturation	I		Light green and khaki underlay, Plum flowers Low-saturation
E		Diverse colors underlay, Peony Medium-saturation	J		Blue underlay, Plum flowers Low-saturation

3.2. Adjectives selected

This study uses 15 different adjectives to test the sensory perception and they are as followed; Joyful, lucky, beamish, blissful, nostalgic, warm, amatory, blessed, gracious, distinctive, lively, aesthetic, tactful, amiable, gorgeous.

Using 10 “Fortune Chicken” samples to conduct the image scale test based on a scale of 10, 10 as the strongest.

3.3. Testing procedure

This test conforms to the field setting method by displaying 10 sets of the “Fortune Chicken” samples and the questionnaires on the counter. 30 surveying objects were selected randomly with 15 male and 15 female. The procedures are; 1st, handing out the questionnaire, 2nd, illustrating the purpose of the test, 3rd, filling out the basic personal information and reminding the instructions for answering the questions, 4th, implementing the test, 5th, collecting the questionnaire, 6th, sorting and analyzing the data.

4. Outcome and Deliberation

4.1. This experiment is conducted based on the application of fabric on the “Fortune Chicken”, 30 of the surveying objects were selected randomly with 15 male and 15 female, among these 30 participants, 11 male and 12 female were from age 20 to 30 and 4 male and 3 female were from age 31 to 40. This is to examine the relationship among the “Fortune Chicken”, the adjectives and the designer by using the “Fortune Chicken” image scale. The outcome of the survey through the use SPSS21 statistical analysis is as followed.

Reliability=0.977, excellent reliability evaluation. Kmo value=.788, middling, appropriate for factor analysis. The analysis is shown on the table below:

The analysis of the “Fortune Chicken” combined with the Adjectives

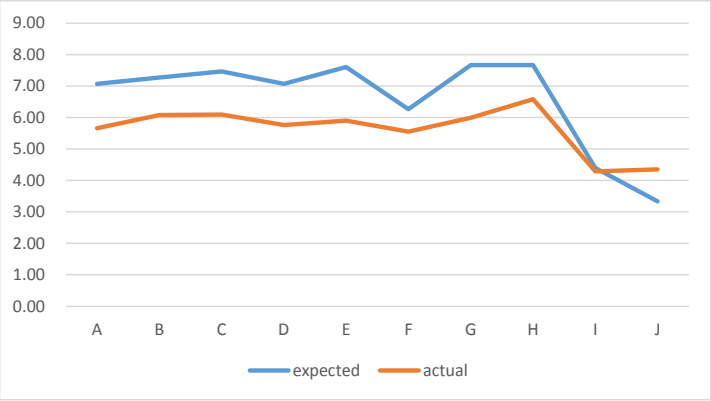

Figure 3: The deviation between the anticipated result and the actual outcome

Table 2: The statistic of the imagery intention of the “Fortune Chicken”

Groups	A	B	C	D	E	F	G	H	I	J
Adjectives	mean	mean	mean	mean	mean	mean	mean	mean	mean	mean
Joyful	5.37	5.57	6.83	6.27	5.47	5.90	6.70	6.60	4.13	3.87
Lucky	5.93	6.00	6.17	6.07	6.13	5.23	6.17	7.37	3.67	3.70
Beamish	5.97	6.37	6.7	5.87	5.47	5.13	6.30	7.43	3.43	3.37
Blissful	6.13	6.13	6.47	6.43	5.10	6.40	6.40	6.50	4.10	4.23
Nostalgic	5.67	6.27	6.00	6.8	6.7	5.87	5.63	6.53	7.00	6.63
Warm	6.13	6.23	5.83	6.53	5.63	7.07	5.77	5.60	5.43	5.20
Amatory	5.57	5.57	5.27	5.47	4.37	5.47	5.70	5.20	3.90	3.77
Blessed	5.67	6.57	5.87	5.67	6.03	5.00	5.73	7.13	3.43	3.67
Gracious	5.00	5.33	5.63	4.60	6.87	4.17	5.60	7.50	3.13	3.73
Distinctive	5.93	6.60	6.47	5.93	7.70	6.00	6.90	7.60	5.00	5.80
Lively	5.67	6.63	6.80	5.23	5.37	5.50	6.63	6.00	4.23	4.03
Aesthetic	6.03	5.87	6.20	5.43	6.53	5.93	5.47	6.33	4.07	4.47
Tactful	4.90	5.40	5.77	4.80	5.47	4.80	5.50	5.90	4.33	4.60
Amiable	5.50	6.30	5.87	6.23	4.97	6.67	5.17	5.07	5.27	4.90
Gorgeous	5.37	6.30	5.53	5.00	6.63	4.17	6.17	7.90	3.27	3.30
Total average	5.66	6.08	6.09	5.76	5.90	5.55	5.99	6.58	4.29	4.35
Expected result	7.07	7.27	7.47	7.07	7.60	6.27	7.67	7.67	4.40	3.33

4.2. Analysis of the statistics above is as followed:

A. The overall degree of perception for Group A, the notable receptions are: Blissful (6.13), Warm (6.13), Aesthetic (6.03), Beamish (5.97), Lucky (5.93), Distinctive (5.93), Lively (5.67), Blessed (5.67) and Nostalgic (5.67) etc… In terms of gender, there is a significant difference between Joyful and Nostalgia. In terms of age, there is a notable difference among Warm, Amatory, Blessed, Distinctive, Aesthetic, Tactful and Amiable.



The use of Peony with pink and indigo underlay and medium-saturation, the expected result is (7.07) which is higher than the actual result (5.66). The designer believed that Peony is the most popular flower among the locals, but the subjects didn’t have the same reaction toward the design.

B. The overall degree of perception for Group B, the notable receptions are: Distinctive (6.60), Lively (6.63), Blessing (5.57), Beamish (6.37), Amiable (6.30),

Gorgeous (6.30), Nostalgic (6.27), Warm (6.23) and Blissful (6.13) etc… In terms of gender, there is a significant difference among Joyful, Lucky, Beamish, Blissful, Amatory and Aesthetic. In terms of age, there is a notable difference among Distinctive, Aesthetic and Tactful.



The use of Peony with red and green underlay and high-saturation, the expected result is (7.27) which is higher than the actual result (6.08). The designer believed that Peony is the most popular flower among the locals, but the subjects didn't have the same reaction toward the design, it could be the use of green underlay. On the contrary, the mean of Lively (6.63) in this group is the second highest as group G.

C. The overall degree of perception for Group C, the notable receptions are: Joyful (6.83), Lively (6.8), Beamish (6.7), Blissful (6.47), Distinctive (6.47), Aesthetic (6.2) and Lucky (6.17) etc… In terms of gender, there is no significant difference. In terms of age, there is a notable difference among Amatory, Aesthetic and Gorgeous.



The use of Peony with red and blue underlay and high-saturation, the expected result is (7.47) which is higher than the actual result (6.09). The designer believed that Peony is the most popular flower among the locals, especially the combination of red and blue is often seen in the local wedding, but the subjects didn't have the same reaction toward the design. But, the mean of Joyful (6.83) in this group is the highest among all, in another words, the subjects can sense a strong feeling of joy through this design.

D. The overall degree of perception for Group D, the notable receptions are: Nostalgic (6.8), Warm (6.53), Blissful (6.4), Joyful (6.27), Amiable (6.23), Lucky (6.07), Distinctive (5.93) and Beamish (5.87) etc… In terms of gender, there is a significant difference in Distinctive. In terms of age, there is a notable difference among Warm, Amatory and Aesthetic.



The use of Peony with pink and yellow underlay and medium-saturation, the expected result is (7.07) which is higher than the actual result (5.76). The designer believed that Peony is the most popular flower among the locals, and the combination of pink and yellow tends to be tender, but the subjects didn't have the same reaction toward the design. There is a huge deviation for this combination, perhaps this combination isn't commonly used in the local wedding.

E. The overall degree of perception for Group E, the notable receptions are: Distinctive (7.7), Gracious (6.87), Nostalgic (6.7), Gorgeous (6.63), Aesthetic (6.53), Lucky (6.13) and Blessed (6.03) etc… In terms of gender, there is a significant

difference in Blessed perception. In terms of age, there is no notable difference.



The use of Peony with diverse colors underlay and medium-saturation, the expected result is (7.60) which is higher than the actual result (5.9). The designer believed that Peony is the most popular flower among the locals and without the use of any traditional color of Peony, but the subjects didn't have the same reaction toward the design. There is a huge deviation for this design, perhaps this combination isn't commonly used in the local wedding. Both the designer and the subjects felt strongly on Distinctive.

F. The overall degree of perception for Group F, the notable receptions are: Warm (7.07), Amiable (6.67), Blissful (6.40), Distinctive (6.00), Aesthetic (5.93) and Joyful (5.90) etc… In terms of gender, there is no significant difference. In terms of age, there is no notable difference.



The use of Cherry blossoms with white, pink and light green underlay and medium-saturation, the expected result is (6.27) which is higher than the actual result (5.55). The designer believed that Cherry blossoms is the most popular flower among the locals and without the use of any traditional color of Peony and tends to be mild and fashionable. But the subjects didn't have the same reaction toward the design. There is a minor deviation for this design, perhaps this combination of colors isn't commonly used in the local wedding. The designer believed that the white color is a taboo in Taiwanese wedding, but the subjects had a strong feeling towards Warm.

G. The overall degree of perception for Group G, the notable receptions are: Distinctive (6.90), Joyful (6.70), Lively (6.63), Blissful (6.40), Beamish (6.30), Lucky (6.17) and Gorgeous (6.17) etc… In terms of gender, there is a significant difference in Warm and Beamish. In terms of age, there is no notable difference.



The use of white Cherry blossoms with red and blue underlay and high-saturation, the expected result is (7.67) which is higher than the actual result (5.99). The designer believed that Cherry blossom is the most popular flower among the locals and it's mild and fashionable, but the subjects didn't have the same reaction toward the design. Although the size of flower tends to be small, it has the highest mean in Joyful.

H. The overall degree of perception for Group H, the notable receptions are: Gorgeous (7.90), Distinctive (7.60), Gracious (7.50), Beamish (7.43), Lucky (7.37) and Blessed (7.13) and Joyful (6.60) etc… In terms of gender, there is no significant difference. In terms of age, there is a notable difference in Lucky, Gracious and Gorgeous.



The use of different colors of Cherry blossoms and Plum flowers collocated with golden stripes and with red and blue underlay and high-saturation, the expected result is (7.67) which is higher than the actual result (6.58). The designer believed that Cherry blossom, plum flower and gold color are the most popular flowers and color among the locals. Red with black underlay is a common combination in traditional wedding. In contrast, the subjects didn't feel the same way as the designer. But there are many adjectives which scored higher than 7, such as Lucky, Beamish, Blessed, Gracious, Distinctive and Gorgeous, especially Gorgeous got the highest mean and it's the highest among 10 groups. Taiwanese are fond of gold and red color, although the size of flower tends to be small, it has a strong reception.

I. The overall degree of perception for Group I, the notable receptions are: Nostalgic (7.00), Warm (5.43), Beamish (5.27), Distinctive (5.00) and Tactful (4.33) etc… In terms of gender, there is a significant difference in Amatory.



The use of smaller size Plum flowers with khaki and khaki-green underlay and low-saturation, the expected result is (4.40) which is close to the actual result (4.29). The designer believed that the design posses a strong reception of Nostalgia which is similar with the subjects. This combination, the designer believed, is rarely used in the Taiwanese wedding, but the subjects feel a sense of distinctiveness. Perhaps, it's the difference in receptions between the old and young generations.

J. The overall degree of perception for Group J, the notable receptions are: Nostalgic (6.63), Distinctive (5.80), Amiable (4.90), Tactful (4.60) and Aesthetic (4.47) etc… In terms of gender, there is a significant difference in Lucky, Beamish, Blissful, Warm, Amatory, Blessed and Distinctive. In terms of age, there is no notable difference.



The use of Plum flowers with blue underlay and low-saturation, the expected result is (3.33) which is lower than the actual result (4.35). The designer believed that the design posses a strong reception of Nostalgia which is similar with the subjects. This combination of blue low-saturation, the designer believed, is rarely used in the Taiwanese wedding, and would not be accepted, but surprisingly, the degree of reception is higher than expected. Especially, the subjects at age around 20 to 30 with design background could well accept this combination and tend not to be affected by the traditional color usage.

4.3.The overall analysis of Imagery Intention

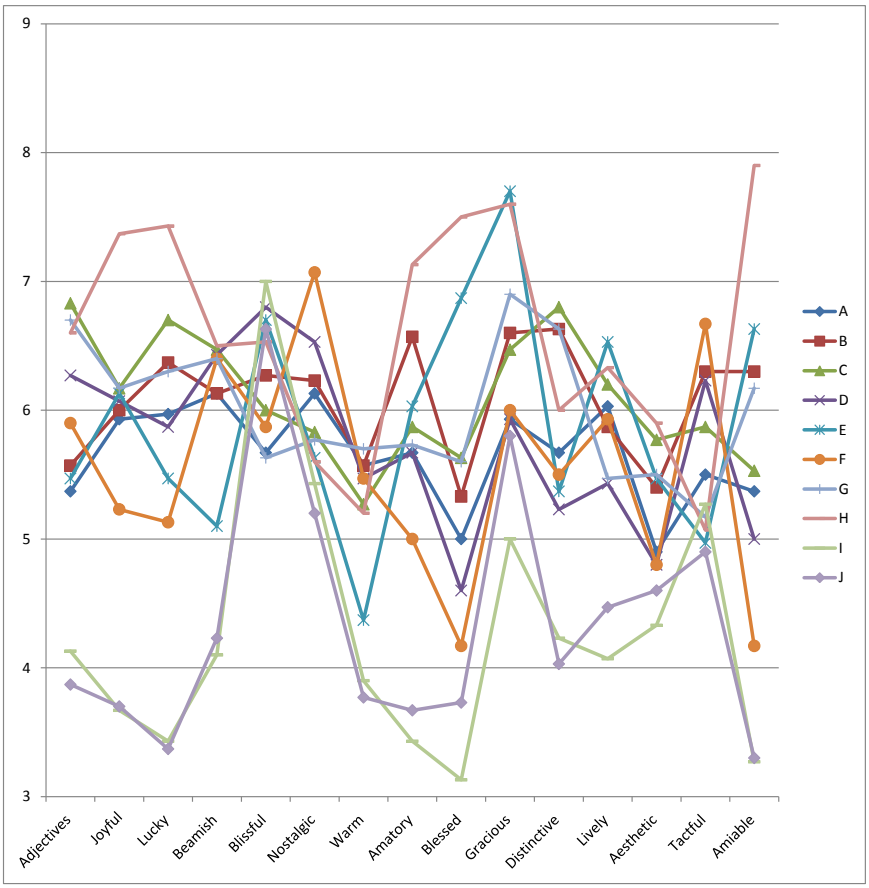

Figure 4: The chart of the deviation in mean for the overall “Fortune Chicken” test

The analysis of the test result for each “Fortune Chicken” group based on Table 3 shown above:

a. In the category of Joyful intention, group C (6.83) is the strongest, and large Peony with the red and blue underlay is the common color combination used in Taiwanese wedding. Group G comes in second with the mean of (6.70), it uses the same red and blue underlay with Peony florets. Group H ranks thirdly with the mean of (6.60) with the use of red and black underlay and various Cherry blossoms and Plum flowers collocated with golden patterns. The combination of red, blue and black in high-saturation represents Joyful appropriately. The combination of red and green in Group B comes with an unsatisfactory result among the subjects. Red is a vital color in Taiwanese wedding, it delivers a strong sense of joy to the people, so when it comes to color selection, pay more attention to Joy. The weakest in this category goes to Group J with blue Plum flowers. In Taiwanese wedding, blue is seldom used, since it doesn’t resemble joy. It will have a better representation of Joy, if blue goes with red.

b. In the category of Lucky intention, group H (7.73) is the strongest with the red and black underlay and various colors of Cherry blossoms, Plum flowers and golden

pattern. Red represents Luck in Taiwan, in traditional wedding attires, bride usually wear red gown and groom goes with black. Group C and G both comes in second with the mean of (6.17) Group B ranks thirdly with the mean of (6.00), it can be inferred that the stronger use of red, the better sense of luck. The weakest in this category goes to Group I with the Cherry blossoms florets and the khaki and green underlay in low-saturation. Group J with the mean of (3.70) and the use of Plum florets in low-saturation isn't well accepted by the subjects. The use of these colors in low-saturation is not common in Taiwanese wedding and it has a weak sense of luck.

c. In the category of Beamish intention, group H (7.43) is the strongest with the red and black underlay and various colors of Cherry blossoms, Plum flowers and golden pattern. This combination can be easily correlated with Taiwanese wedding custom and possesses a strong sense of Beamish. Both Group C (6.7) and Group B (6.37) use red Peony without golden pattern, from this we can infer that gold color helps enhance Beamish. Group J with blue Plum flowers, low-saturation and I with Cherry blossoms florets and the khaki and green underlay in low-saturation come in last, since the combinations in low-saturation are rarely seen in Taiwanese wedding.

d. In the category of Blissful intention, group H (6.50) is the strongest with the red and black underlay and various colors of Cherry blossoms, Plum flowers and golden pattern. Group F (6.40) with red and green florets and the white underlay in medium-saturation and Group G (6.40) with pink and white Cherry blossoms and the red and blue underlay in high-saturation are not affected by the red color in terms of Blessing. The rest, such as group A, B, C, D, with Peony has the mean above (6.13), they all have strong sense of bliss. However, Group I is the lowest with the mean of (4.10) with Cherry blossoms florets and the khaki and green underlay in low-saturation, as well as Group J (4.23) with blue Plum florets in low-saturation. I and J represent weakly in bliss.

e. In the category of Nostalgia intention, group I (7.00) is the highest with Cherry blossoms florets and the khaki and green underlay in low-saturation. The combination brings a sense of practicality and old-fashioned. Group G (5.63) with pink and white Cherry and the red and blue underlay in high-saturation is the weakest in this category. Cherry blossoms florets in high-saturation and red fabric carry low sense of Nostalgia.

f. In the category of Warm intention, group F (7.07) is the highest with Red and green florets and the white underlay in medium-saturation. The combination is easily to be accepted by the people and its elegant and quiet flower color brings out the sense of warm. Group J (5.20) with blue Plum florets in low-saturation is the weakest

in this category. Blue belongs delivers a sense of coldness, therefore the degree of warm is relatively low.

g. In the category of Amatory intention, group G (5.70) is the highest with pink and white Cherry blossoms and the red and blue underlay in high-saturation. Blue resembles male while red resembles female, therefore the combination with pink and white florets leads to the feeling of love. Group J (3.77) is the lowest with blue Plum florets in low-saturation, since there is no harmonization of colors, the sense of amatory is low.

h. In the category of Blessed intention, group H (7.13) is the highest with diverse colors of Cherry blossoms and Plum flowers collocated with golden pattern with the red and black underlay in high-saturation. The color on Chinese New Year's couplets matches with this combination, especially the word "Bless" in Chinese character. Groups I gets the lowest score of (3.43) with Cherry blossoms florets and the khaki and green underlay in low-saturation. Since the word "flower" in Chinese phonic pronounces as same as "prosper" in Chinese phonic, the florets and the soft underlay are not favorable in terms of Blessing.

i. In the category of Gracious intention, group H (7.50) is the highest with diverse colors of Cherry blossoms and Plum flowers collocated with golden pattern with the red and black underlay in high-saturation. This is the only group which owns golden color, golden color gives a valuable sense to the public. Group I (3.13) is the lowest with Cherry blossoms florets and the khaki and green underlay in low-saturation. Florets is weak in presenting grace, on the contrary, huge flower is stronger.

j. In the category of Distinctive intention, group E (7.7) is the highest with Peony and diverse colors fabric in medium-saturation. Its design is distinct from the traditional Peony design method in group A, B, C, D. Therefore, it possesses a strong sense of distinctiveness. Group I (5.00) is the weakest with Cherry blossoms florets and the khaki and green underlay in low-saturation. Florets can well present the sense of distinctiveness.

k. In the category of Lively intention, group G (6.63) and B (6.63) top the rest. Group G uses pink and white Cherry blossoms with the red and blue underlay in high-saturation. More florets provide more senses of rhythm to the public. Group B uses Peony with red and green underlay in high-saturation. Red and green underlay present a strong contrast, the two colors belongs to Lively category in color science. Group J with the mean of (4.03) is the lowest, it uses blue Plum florets in low-saturation. Blue color represents cold and delivers a weak vigorousness.

l. In the category of Aesthetic intention, group E (6.53) is the highest with the use of

Peony and the diverse colors underlay in medium-saturation. Its design is distinct from the traditional Peony design method in group A, B, C, D. That's why it stands out. Perhaps its color and pattern pass a strong sense of aesthetic onto the subjects. Group I (4.07) is the weakest with the use of Cherry blossoms florets and the khaki and green underlay in low-saturation. Florets cannot bring out the sense of aesthetic.

m. In the category of Gracious intention, group H (7.50) is the highest with diverse colors of Cherry blossoms and Plum flowers collocated with golden pattern with the red and black underlay in high-saturation. Group I (4.33) is the weakest with Cherry blossoms florets and the khaki and green underlay in low-saturation. Florets represent a sense of weak tactfulness. Among these 10 groups, the tactfulness doesn't have a huge deviation and only in this category groups in high-saturation have a weak tactfulness comparing with those in low-saturation. It might be the low-saturation shows a feeling of serenity and it enhances tactfulness.

n. In the category of Amiable intention, group F (6.67) is the highest with red and green florets and the white underlay in medium-saturation. The white underlay makes it easy to be accepted by the people and its elegant and quiet flower color brings out the sense of warm. Group J (4.90) is the weakest with the use of blue Plum florets in low-saturation. Blue color represents cold and delivers a weak amiability.

o. In the category of Gorgeous intention, group H (6.67) is the highest with diverse colors of Cherry blossoms and Plum flowers collocated with golden pattern with the red and black underlay in high-saturation. This is the only group which owns golden color, golden color gives a gorgeous sense to the public. Group I (3.27) is the lowest with Cherry blossoms florets and the khaki and green underlay in low-saturation. Khaki and green resemble a simple life in countryside and an image of nature, therefore, the sense of gorgeousness is relatively weak.

4.5 Brief Summary

1. According to the assortment of 15 adjectives, Group H obtains the highest in Beamish, Blessed, Gracious, Tactful and Gorgeous and Group I scores the lowest. Group H brings out the most "Beamish, Blessed, Gracious, Tactful, Gorgeous" to the public, but not Group I. In term of Warm and Amiable, Group F is the strongest and Group J is the weakest, therefore, the color used in Group F delivers a sense of warm and amiability, instead of Group J. Group E tops the rest in Aesthetic and Distinctive, but Group I hits bottom in this category, the color created in Group E presents the most aesthetic and distinctiveness.
   As shown on Table 4 below:

Table 4:The table of significant intention representation of design

Weak Perception	Adjectives	Strong Perception
	Beamish, Blessed, Gracious, Tactful and Gorgeous	
	Warm and Amiable	
	Aesthetic and Distinctive	

5. Summary

Based on the study of the relationship between the design of the “Fortune Chicken” and the Imagery Intention, the research has assorted several analyses.

1. Group H contains the strongest Imagery Intention and Group I is the weakest of all.

2. Group J is the most distinguished in the relationship between gender and the “Fortune Chicken” through independent sample T test analysis.

3. Group A is the most significant in the relationship between age and the “Fortune Chicken” through independent sample T test analysis.

A special attention must be paid when it comes to designing the “Fortune Chicken” in bringing out the Western aesthetic of “Representing” and “Presenting” as well as to merge the ideas with Asian arts. Only through the study of sensibility and a continuous research on the art of craftsmanship will the creation of the “Fortune Chicken” meet the need of consumer.

Group H sample is the combination of red hen and black rooster with the use of florets fabric and golden pattern in high-saturation. The selection of material and the use of cooler tend to be more diversified in this experiment. The subjects between age of 20 and 30 with design background were selected. In this experiment, Group A, B, C, D used the same Taiwanese big Peony fabric with different underlay and colors. Group A with the use of pink and indigo is the most significant in the relationship between age and the “Fortune Chicken” through independent sample T test analysis. Group J with the design of blue Plum flowers

in low-saturation is the most distinguished in the relationship between gender and the “Fortune Chicken” through independent sample T test analysis and the expectation rate of the designer is lower than the actual rate. Designers in Taiwan consider that the use of the fabric in low-saturation is uncommon and rarely seen in a traditional Taiwanese wedding ceremony. Since the low-saturation fabric is not a conventional color existing in Taiwan, it leads to a low acceptance rate. In the individual adjective analysis, Group H obtains the highest in Beamish, Blessed, Gracious, Tactful and Gorgeous and Group I scores the lowest. In term of Warm and Amiable, Group F is the strongest and Group J is the weakest. Group E tops the rest in Aesthetic and Distinctive, but Group I hits bottom in this category, perhaps the same fabric will deliver different receptions to people.

The “Fortune Chicken” is a gift, with full of blessing, given to children by parents and through this study, it is anticipated that a brand new design of the “Fortune Chicken” which meets the need of customer will launch in the market. With the change of time and the blending of different cultures, the younger the consumer, the higher the acceptance in the use of unconventional fabric, such as the fabrics other than the one with big Peony is more likely to be welcomed. In order to satisfy the need of consumer, more exotic fabrics should be utilized to create a personalized “Fortune Chicken”.

ACKNOWLEDGMENTS

The Authors would like to thank the kind sponsors partly support this study from the National Science Council of Taiwan, NSC102-2221-E-224-054

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Ming-Chyuan Ho has worked in design for more than 30 years. He has been the director of various departments and centers and the dean of the College of Design at both NYUST and NCKU. He has also been collaborating closely with the industry and completed more than forty design and research projects. Dr. Ho is the author of numerous publications for academic journals of design in user interface design, craft design, design aesthetics and design strategy. He received MFA and PhD degrees in design from the University of Kansas.

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5B - Textile 3

The Evaluation of Mechanical and Thermal Property of Women's Hosiery and Aesthetic Impression

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Abstract: To wear comfortable stockings and make legs look beautiful are the attractive subjects for women of all ages. With the exception of summer season, almost all women wear hosiery: panty hoses, tights, knee-length socks and socks. In general, knitted fabric of hosiery has the advantage of being highly efficient at both stretching highly and fitting. In this study, a variety of women's hosiery ate examined for their performance both under no deformation and deformed condition during wearing. One of purposes of this study is to compare the performance of various hosieries objectively. The other of purposes is to estimate the change of the performance by wearing deformation for each sort of hosiery. Deformation is observed in wearing test and given an account of stretch ratio values for wale and course directions. Compression property is measured first. Standard thickness, compression work and resilience values are recorded from the pressure-thickness relation curves. And air resistance and thermal conductance are measured by KES- AP1 and KES- THERMO- LABO II fabric testing instruments, respectively. In addition, sensory tests are carried out to examine affective disposition of women who choose stockings to acquire better aesthetic and comfort. Tests are held with several items, for example, tactile impressions of softness, thickness and smoothness, and visual impressions of transparency and degree of compression. In the tests questionnaires are used and judges are young women.

Keywords: hosiery, compression property, air resistance, thermal conductance.

1. INTRODUCTION

Clothing style to wear skirts is reported to begin in the tumulus period in Japan. Skirts have become the important item and at the same they has specialized men and women's wears. Skirts design has changed in times, and women have paid the attention to foot fashion. As Japan's textile industry developed in modern times, length of skirts has changed in the times. For foot wears, epoch making shall be the development of the hosiery which was actualized by the invention of a circular knitting machine. In previous studies many scholars studied the quality of durability (Aly

and Stanley, 1973) (Gibson, 1973) (Sasaki, Toyoma, Kato and Tanaka, 1977). Since mass production, bulk buying and mass consumption, days has come the quality evaluation research becomes active. Although hosieries tend to be recognized as expendable objects, the high quality which let legs to show beautiful and slim is keen required among women. Papers on the relation of feeling to wear and deformation during wearing and tensile properties of typical hosieries have been reported (Fujimoto, Sukigara and Niwa, 1989) (Sukigara, Fujimoto and Niwa, 1990).

In this study, various mechanical properties are measured using KES-FB (Kawabata Evaluation System for Fabrics) system. Air Resistance is measured for all the samples. From the results, categorized typical hosiery groups such as tights, knee length socks and panty hoses are evaluated and compared for their properties. The sensory test is also carried out on the other hand. Subjects judge seven samples of panty hosieries on foot torsos.

2. SURVEY OF ACTUAL STATE TO WEAR HOSIERY

In order to get the knowledge and requirements of consumers, questionnaire investigation was carried out as follows:

Term: the end of November to the beginning of December, 2013

Subjects: 94 universities students, 20-22 years old

Investigation method: Using a questionnaire, Respondents fill out evaluation forms which Include seven items on purposes to wear hosiery, wearing frequency, time and seasons, favorite combination of bottoms and hosiery, value of buying hosiery, other requirements. After collected questionnaire sheets, answers on items were amounted and discussed.

3. EXPERIMENTAL

3.1. Hosiery Samples

Table 1: Samples basic properties

No	Hosiery	Group	Fiber contents	Courses / cm	Wales / cm	Thickness ,m	Weight, mg / cm^2	B.D, gf / cm^3
1	Knee/ high length-socks	H	cotton / acrylic	11.25	10.25	0.0026	38.53	0.148
2			wool	10	8.25	0.0033	40.05	0.122
3	Tights	T	nylon / polyurethane	16.75	17	0.0013	15.60	0.124
4			nylon / polyurethane	15.5	17.75	0.0013	15.67	0.118
5			nylon	23.75	17.75	0.0008	10.54	0.136
6			nylon	25.5	21	0.0008	9.82	0.116
7			wool	16	10.75	0.0020	29.22	0.148
8			nylon	15.75	12.25	0.0017	26.88	0.158
9	Panty hoses	P	nylon / polyurethane	14	19.75	0.0003	3.23	0.108
10			nylon / polyurethane	18.75	19.5	0.0003	3.51	0.111
11			nylon / polyurethane	11	17	0.0003	3.16	0.095
12			nylon	18.75	19.5	0.0003	2.14	0.063
13			nylon / polyurethane	85.25	56.75	0.0005	11.94	0.244
14			nylon / polyurethane	12.75	17.5	0.0003	3.41	0.110
15			nylon / polyurethane	21.75	16	0.0003	1.96	0.058
16			nylon / polyurethane	38	42.25	0.0004	6.73	0.168
17			nylon / polyurethane	16	20.75	0.0003	3.02	0.092
18			nylon	30.5	25.25	0.0005	2.59	0.057
19			nylon / silk / polyurethan	15	20.75	0.0003	3.47	0.118
20			nylon / silk / polyurethan	21	17.25	0.0003	4.87	0.156

After researching the hosieries sold on the market, 20 typical hosieries were prepared. Basic properties of samples for this study are shown in Table 1. Samples are classified into three groups that are knee/over-knee length socks, tights and panty hoses.

3.2. Wearing test to measure extension during wearing

In order to know the stretch ratio when the subject wear a hosiery, the distances of marks, which are marked in both of wale and course directions, are measured before and after putting on samples. Those samples before and after stretched by wearer were provided to the measurement of air resistance and thermal property.

3.3. Measurement of structural properties and mechanical properties

Compression property was measured by KES-FB3 fabric testing apparatuses respectively. Thickness at the compression stress of 0,5gf/cm^2 was derived from the compression stress-thickness curve measured under the condition at the maximum compression stress of 50gf/cm^2.

3.4. Measurement of air resistance and Thermal conductance

Air resistance was measured by KES-AP1 apparatus under one cycle process of the charge-discharge of constant air flow amount through sample sides.

For the measurement of thermal property, rectangle of specimen were taken from samples of each group and conditioned in the laboratory. Thermal conductance and insulation ability are measured by d KES-Thermo-labo II fabric testing instrument which applies the method of two plates of different temperatures under steady state condition. Heat flux from heat source to heat sink was measured.

Those experimental measurement were carried out in the laboratory controlled at the standard condition of 20 ± 2 ℃ and 65 ± 5 % R.H. .

4. SENSORY TESTS BY TOUCH AND VISION TABLE

Semantic differential method is applied in the sensory tests, using selected words list which includes the ten most important words for the vision tests and the six most important words for the touch tests. The sensory tests were carried out for seven kinds of characteristic hoses which were displayed as shown in Figure 1. The “feel “of the hosiery’s wear – both positive and negative adjectives were elicited. The pairs of bipolar words were prepared and arranged into a grid where each trait was put on the between the extreme values of its poles and could be estimated on a five point scale. The ten pairs in the vision tests were “wishing to wear everyday/not” “ wishing to wear sometimes/not” “ transparent/not transparent” “look beautiful/not” “look slim/not slim” “comfortable/not comfortable” “durable/not durable” “thick/thin” ” warm/cold” “preferable/not preferable”. The six pairs of words for touch tests are “wishing to wear everyday/not” “smooth/rough” “comfortable/not comfortable” “thick/thin” ” warm/cold” “preferable/not preferable”.

Samples were rated with consumer respondents by touch and vision. The results were examined in relation to the samples properties measured in the experiment.



Figure 1: A part of displayed samples in the sensory test

5. RESULTS AND DISCUSSION

5.1. Purposes to wear hosiery

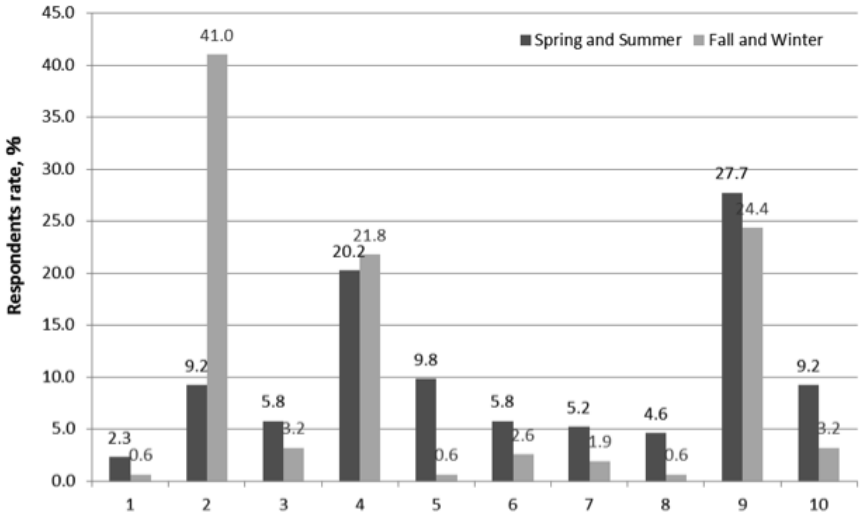

Figure 2: Purposes to wear panty hoses and comparison of them between ‘‘spring and summer ’’ and ‘‘fall and winter ’’

1: To be cool 2: To be warm 3: Keep foot clean 4: Neat appearance 5: UV cut 6: Prevent blister 7: Prevent welling 8: Prevent fatigued 9: To show legs beautiful 10: The others

Figure 2 shows the result of a survey on “purposes to wear hosiery”. In order of higher respondent’s rate to wear panty hoses, “to show legs beautiful” and “for neat appearance” are ranked. To wear “to be warm” is required markedly in fall and winter seasons.

5.2. Results of measurement of structural properties and mechanical properties

Thickness and bulk density are plotted in Figure 3. Samples in H group are thick at around 3 mm. Tights samples of T group have a range of thickness at 0.8 - 0.13 mm. For samples of panty hoses, P group, thickness shows thinner than 0.3 mm, but bulk density has a wide range from 0.06 - 0.25.

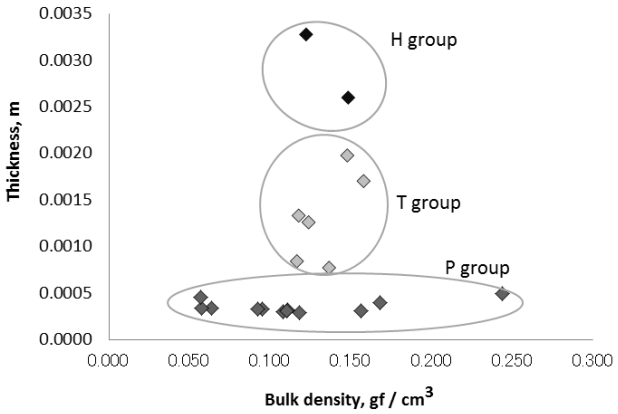

Figure 3: Relationship between Thickness and the bulk density

5.3. Air Resistance and thermal property

The relationship between the specific air resistance and the bulk density is shown in Figure 4.The specific air resistance increases with the increase of the density. The H group samples exhibits larger air resistance than other samples of T and P groups. The air resistance of yarn assemblies increases as the diameter of consistent yarn increases.

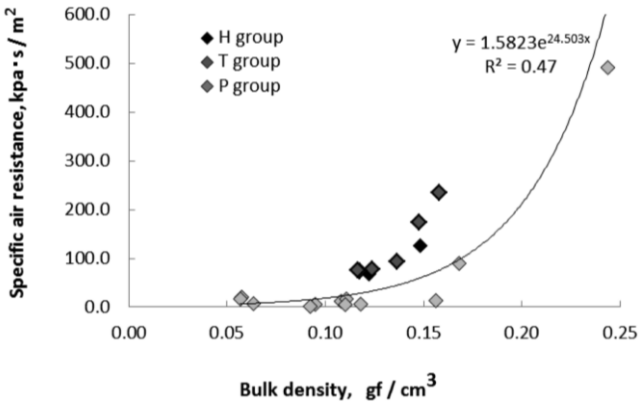

Figure 4: Relationship between the specific air resistance and bulk density

For thermal property, the effective thermal conductance of samples was measured. To calculate the thermal conductance, values were divided by the standard thickness of each sample. The effective thermal conductance of samples of H group is 20 - 30 W· $m^{-2}K^{-1}$; T group is 40 - 70 W· $m^{-2}K^{-1}$; P group is 80 - 120 W· $m^{-2}K^{-1.}$. The effective thermal conductance panty hoses has a wide range depending to the consistent yarn thickness, however, which is thinner than other two groups samples. Then thermal insulation ability is one fourth or one fifth.

When hosiery is strained by wearing, the knitted fabrics are extended and change the properties.

We measured extension rates during wearing. Stretch ratio of area for calves of high length hosiery was around 1.5 and that of other type hosieries and tights showed 2.0 - 2.5 ratios. By the deformation of area of sample during wearing, thickness decreased by 30 %. The decrease of thickness bought the reduction of air resistance and insulation.

5.4. Sensorial estimation of panty hoses

We selected samples of P group, the sensory estimation on aesthetic and favor impression. The feeling to the touch are summarized by calculation of ranking score by respondents for "wishing to wear everyday/not" "smooth/rough" "comfortable/not comfortable" " "thick/thin" " warm/cold" "preferable/not preferable" in Figure 5.

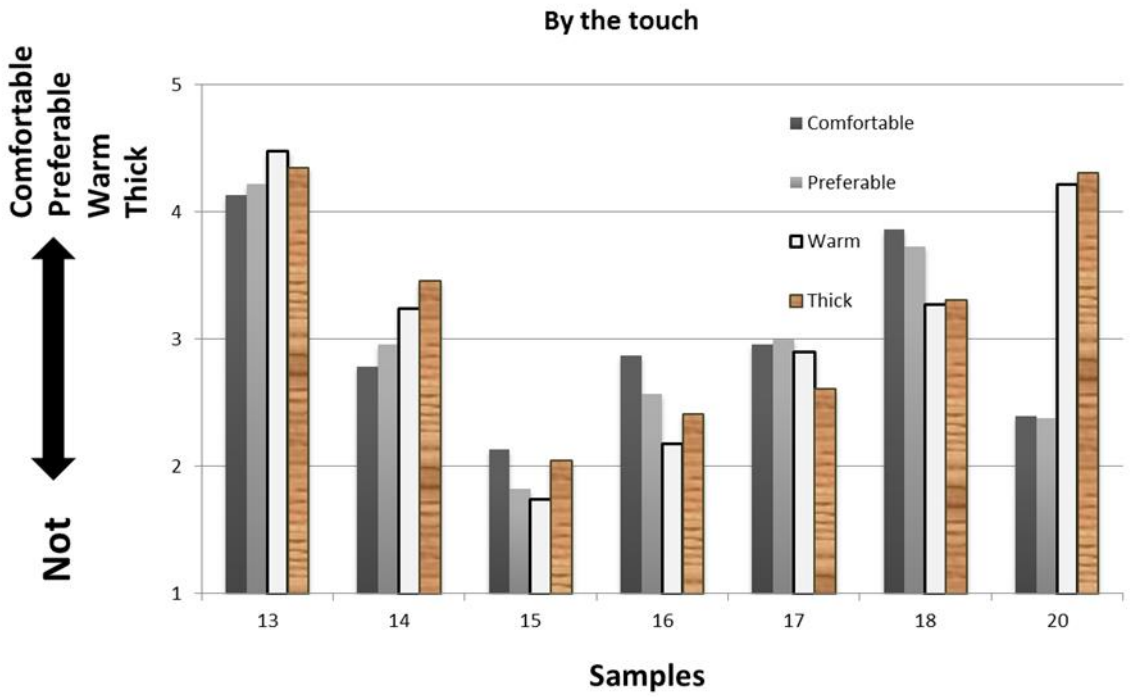

Figure 5: Results of sensory touch test for panty hoses

The vertical axis shows the five steps differential scales and chart graphs are the mean values of each feel rating. It is obvious that thick feeling links warm feeling as shown for samples with no. 13, no. 18 and no. 20. Comparing them, the sample no.13 which is most dense stitches, was recognized as to be preferable and comfortable. The sample no. 18 follows. The sample no. 20 with sparser stitch than no. 13 was judged as to be not preferable and not comfortable.

It was found that visual feeling becomes better as the area stitch density is sparser and for the dense sample could be said oppositely felt comfortable, preferable to the touch.

6. CONCLUSIONS

Although hosieries tend to be recognized as expendable objects, the high quality which let foot to show beautiful and slim is keen required among women. Sensory tests are carried out to examine affective disposition of women who choose stockings to acquire better aesthetic and comfort. This time, Sensory test's Samples were rated with consumer respondents by vision and touch. The results were examined in relation to the samples properties measured in the experiment

Consumers tend to make decisions about purchasing hosieries on the basis of appearance on showcases. In this study, however, there were great differences in some items between results of the vision tests and that of the touch tests. This suggests that comprehensive selection including considerations of tactile sensation is needed to heighten utility.

As a result of the touch test and measurements of panty hoses samples, bulk density of materials strongly affected overall preference. Specifically, higher bulk density made consumers more comfortable.

Sensory tests of this study carried out in cold districts in winter. Therefore, it is assumed that samples looking thick and warm tend to be preferred. In addition to tests in this paper, detailed tests with consideration of seasons and areas are required.

ACKNOWLEDGEMENTS

We would like to express our gratitude to Professor M. Murakami and her students of Gifu City Women's Junior College for supporting the questionnaire investigation.

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BIOGRAPHY

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A New Evaluation Method for Fabric Wrinkles using the Morphological Technique

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Abstract: A new evaluation method of fabric wrinkles based on mathematical morphology is proposed. The method employs morphological size distribution to the shape of wrinkle caused by folding a fabric. The size distribution of a shape is measured by size density function, which shows proportion of areas of a part corresponding to each size in an image object. It is shown experimentally that the shape of wrinkle is characterized by the skewness of the size density function.

Keywords: wrinkle evaluation, mathematical morphology, size distribution

1. INTRODUCTION

Easiness of forming wrinkles on fabrics by bending process is often evaluated by the rheological viscoelasticity of the bending properties of the fabrics. However, it is not entirely in agreement with the evaluation of visual impressions on the appearance of the fabric wrinkles, because the edge angles formed by the wrinkles are often influenced by the thickness or area size of the fabric used in the final process.

In this paper, we propose a method that can quantitatively evaluate the strength of the edge and angle of the wrinkle appearance when a fabric has made wrinkles by bending. The shapes of the wrinkles are evaluated by using size distribution analysis based on mathematical morphology, which is a mathematical formulation of image processing and digital geometry (Soille, 2003). The method fits disks of various sizes to an object in an image, extracts the part of the object corresponding to each size from the object, and measures the area of the part corresponding to each size. The size distribution analysis offers the size density function, which expresses the

relationship between a size and the relative area of the part corresponding to the size in an object.

We apply the size distribution analysis to the images of fabric wrinkles. The sharpness of a wrinkle is evaluated by the distribution of the area extracted from the part corresponding to each disk size. That is, the sharper the wrinkle edge is, the larger the ratios of the smaller sizes are in the size density function. This method was applied to the several fabrics made from different kinds of fibers. The result shows that the proposed method for evaluating fabric wrinkles has a strong relationship to the assessment of visual impressions.

We describe in Section 2 the standard method of wrinkle evaluation. In Section 3, we briefly explain the basics of mathematical morphology and size distribution analysis. We show experimental results of wrinkle evaluation using the proposed method in Secion 4, and we conclude our work in Section 5.

2. WRINKLE EVALUATION

In the 1960's, evaluation of the degree of sharpness of the wrinkle, crease and pleat has attracted by the garment product and consumers. It is a crucial time to establish the standards for the measurement of wrinkle/crease property (Industrial standards shown in the reference list) worldwide and since then various apparatuses were designed and developed. For those instruments, measuring principle is same and simple. It is called the wrinkle/crease angle test as follows:

> Fabric a rectangle shape of 10cmx20cm specimen (fabric) prepared, A fold fabric in half was placed(weighted) between two plates like tiles of 10cmx10cm so as to make coincide the folding line. After releasing, an angle of two wings of specimen, centralizing the pleat line.

The above method is observing a fold / crease of one fabric under a fixed weight load for a fixed time. The method has been widely used since it is directly related to mechanical properties of fabrics. On the other hand, methods of evaluating winkle roughness on the surface of the whole fabric using image processing and/or two-dimensional signal processing techniques were proposed, since wrinkles on the whole fabric have an influence to visual impressions on cloths (Su et al., 1999; Matsudaira et al., 2002).

It is well known that the impression on the wrinkle roughness on the whole cloth is related to its rheological property and has a temporal variation, since the fabric is composed of fiber materials (Cooke et al., 1954; Xu et al., 1995). The temporal variation of the wrinkle roughness is closely related to the temporal variation of the edge sharpness of each fold. Thus a further investigation of the evaluation method of a fold to develop a simple and effective method of evaluation is important in practical fabrication processes.

This paper aims to develop a method of analyzing the sharpness at central line area which is folded and to solve the instability of the observation using an image processing technique based on mathematical morphology.

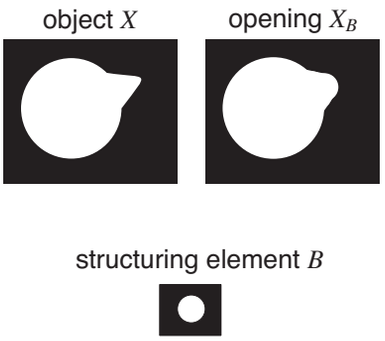

Figure 1: Opening.

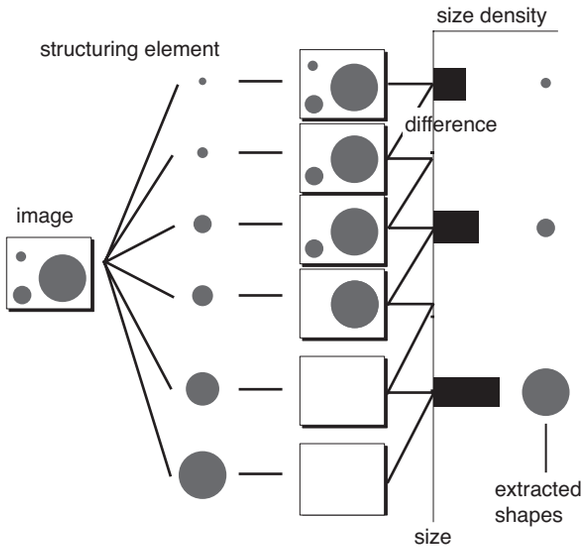

Figure 2: Size distribution analysis.

3. MATHEMATICAL MORPHOLOGY AND SIZE DISTRIBUTION

3.1. Basics of mathematical morphology and morphological opening

Mathematical morphology is a fundamental framework of image manipulation, and the morphological operations manipulate quantitatively the effect of shape and proportion of pattern or figure in an image with a small object called structuring element by set operations (Asano et al., 2006).

The fundamental operation of mathematical morphology is opening, which discriminates and extracts object shapes with respect to the size of objects. Opening of an image object X with respect to a structuring element B indicates the locus of B itself sweeping all the interior of X, and removes smaller white regions than the structuring element, as illustrated in Fig. 1. Since opening eliminates smaller structures than the structuring element, it has a quantitative smoothing ability.

3.2. Size distribution analysis

Size distribution analysis evaluates the size of each part in an image object utilizing the property of opening, that is, opening removes smaller parts than structuring element from the object and preserves larger parts.

We assume openings of a target image with respect to a structuring element and its homothetic magnifications, and a size is assigned to each magnifications of the structuring element, as shown in Fig. 2. The objects in the difference between the results of opening with the structuring element of size n and size $n + 1$ are those which are not removed by the structuring element of size n but removed by that of size $n + 1$. The objects are regarded to belong to size n, and the function of n to the area of objects belonging to size n is defined as the size density function.

Since the size density function has the same property as the probability density function of a random variable, the average and moments of size are derived from the size density function,

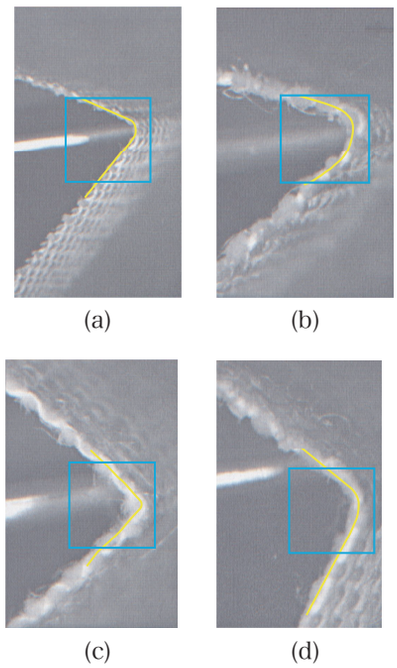

Figure 3: Examples of wrinkles.

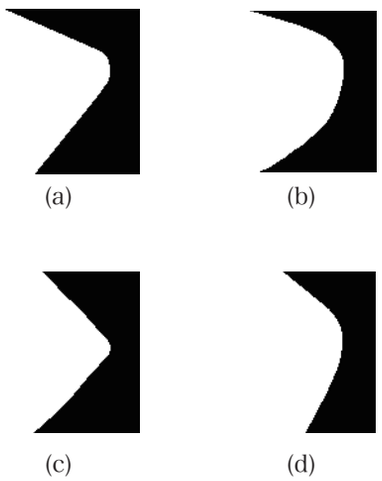

Figure 4: Transformed binary images.

similarly to the average and moments of the random variable. The average size indicates the size of the target object in one value. The skewness is the third order moment indicating the distortion of the shape of a density function from the symmetrical shape. If the skewness is positive (or negative), the shape of the size density function is biased to the smaller (or larger) sizes, and the absolute value of the skewness indicates the degree of bias.

4. EXPERIMENTAL RESULTS

Figure 3 shows examples of wrinkles yielded by the standard method of wrinkle evaluation explained in Sec. 2. A square region including the wrinkle, indicated in blue, is extracted from each of the images, and the shape of wrinkle is manually traced by yellow line in each square. Although the sizes of the images are slightly different, the scaling and the resolution, and the size of extracted square, are the same for all the images. The regions extracted from Fig. 3 (a)-(d) were transformed to binary images as shown in Fig. 4 (a)-(d), respectively. The size of the binary images is 128x128 pixels. The traced line is regarded as a boundary, and the left side is white and the right side is black in each of the binary images. Figures 5 (a)-(d) illustrate the side density functions of Fig. 4 (a)-(d), respectively, where the size is indicated on the horizontal axis and the size density is on the vertical axis. The structuring element is disk-shaped, and the size is defined as the radius of the disk. The maximum size is set to 60 pixels, since the height of the binary images is 128 pixels and the structuring element should not be larger than the image itself.

Table 1 shows the average size and the skewness for the size distributions where the maximum size is limited to 60 pixels. The average sizes are not so different for all the images, however,

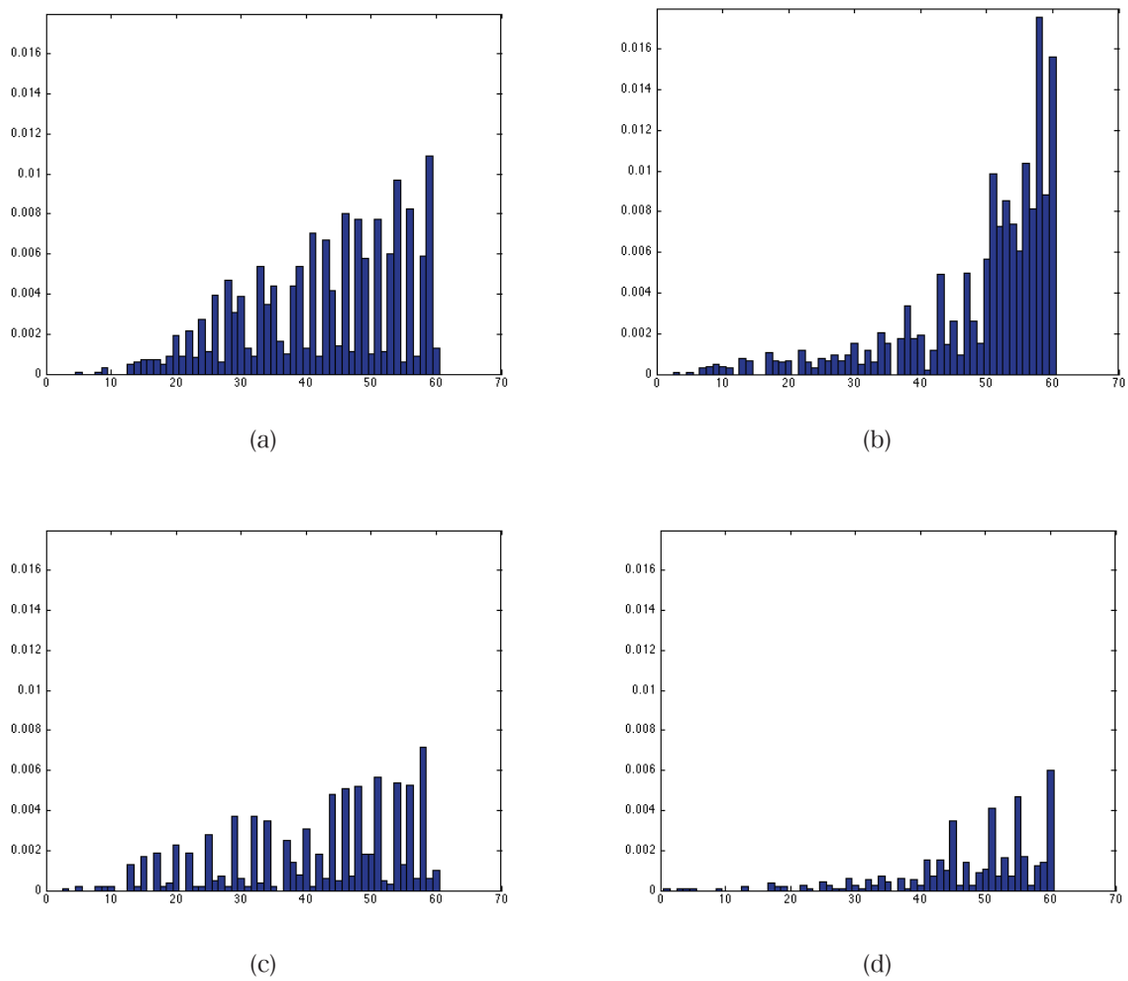

Figure 5: Size density functions of Fig. 4 (a)-(d).

the skewnesses are significantly different. It is obviously indicated that the absolute values of the skewnesses are small for sharp wrinkles, and large for rounded wrinkles. Figure 5 indicates that the local maxima of the size densities are nearly linearly increasing for the small absolute values of the skewnesses, and those are increasing in some curve for the large absolute values of the skewnesses.

Figure 6 is a binary image of a corner, which was artificially generated, for reference. Its size density function is illustrated in Fig. 7. The average size is 40.26 pixels and the skewness is -1.92. The function is almost exactly linearly increasing, and the skewness in this case is similar to the real images of the sharp wrinkles. It supports our conclusions in the relationship between the shape of the wrinkle and the skewness.

Table 1: Average sizes and skewnesses of the size density functions in Fig. 5 (a)-(d).

	(a)	(b)	(c)	(d)
Average size	42.74	49.41	41.54	48.06
Skewness	– 1.23	– 4.15	– 2.10	– 6.87



Figure 6: An artificial corner image.

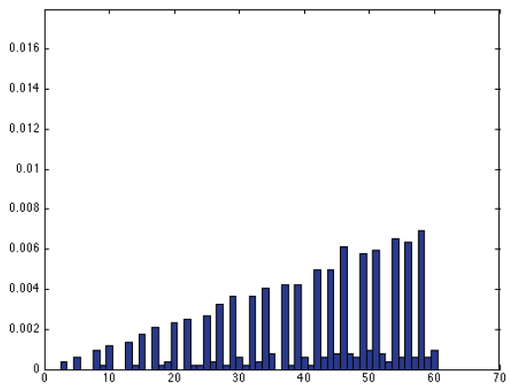

Figure 7: Size density function of the artificial corner image.

5. CONCLUSIONS

This paper has proposed a method of evaluating the sharpness of fabric wrinkles. Our method measures the morphological size density function of the image of a wrinkle. We have found that the sharpness of the wrinkle is evaluated by the skewness of the size density function.

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BIOGRAPHY

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Effects of the modification of fiber surface on the mechanical properties of cotton fabric

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Abstract: Recently, the modification of the fiber surface is becoming an essential factor for comfortable clothing life. Therefore, understanding the relationship between the fiber surface characteristics and comfort of the garment is very important. However, studies on the effect of modification of the fiber surface on wear comfort of the garment has been done little. In this study, the effect of balance between hydrophilic and hydrophobic property of the fiber surface on the mechanical and frictional properties of the cotton fabric is investigated. In order to change the hydrophilic/hydrophobic balance of the fiber surface, we adopted a method of fixing the hydrocarbon chains directly to the surface of the cotton fiber. The resulted fabrics demonstrated a good water repellency and the degree of water repellency can be controlled by the hydrocarbon agent (stearylamine) concentration in the non-aqueous media. Mechanical and friction properties of cotton fibers that are immobilized by stearylamine are assessed by KES-FB1~4, and 16 properties are measured [1]. In addition, based on these values, the primary hand value is computed. Consequently, it is found that hysteresis of shear force, 2HG, and hysteresis of bending moment, 2HB, of stearylamine-treated cotton fabrics tend to be lower, and tensile resilience, RT, tends to be higher. On the other hand, it is found that KOSHI (stiffness), HARI (anti-drape spread) tend to be lower, and SHINAYAKASA (flexibility with soft feeling) tends to be higher. These results suggest that the cotton fabric used in this study becomes softer by immobilizing the hydrocarbon chains.

Keywords: modification of cotton fiber, KES, water-repellent

1. INTRODUCTION

Functionalization of fabrics has been studied for a long time for comfortable clothing life. Many of them are carried out by modification of the fiber surface. In many cases, some resin, which are play a role of fixation of the functional agent, are used for the fiber surface treatment. Unfortunately, this process harden the texture (hand feeling) of the fabric. In other words, mechanical and frictional properties of fabric surface are changed. These properties are involved in comfort of the garment. Therefore, understanding the relationship between the fabric surface properties and comfort of the garment is very important. It is necessary to clarify the change in the fabric mechanical and frictional properties caused by the modification of the surface of fabrics

So far, the effect of the treatment by natural indigo dyeing [2] and softener [3] on the mechanical and surface properties of fabrics have been reported. However, some changes in these properties caused by hydrophobizing of the fiber surface has not been studied. In this study, we tried the application of the water repellent on hydrophobizing of the fiber surface. A general method of water-repellent has been using the resin for fixation of water-repellent agents. Mechanical and frictional properties of the treated fabric by these methods are affected by the properties as caused by resin. Consequently, it is not possible to evaluate the change in some mechanical and frictional properties caused by hydrophobizing of the fiber surface. Therefore, to clarify the change in their properties caused by hydrophobizing of the fiber surface, we have adopted the method of immobilizing a hydrocarbon chains directly to the surface of the cotton fibers which gave reactive by treatment with cyanuric chloride [4].

2. EXPERIMENT

2.1 Materials

Sample fabrics were cotton fabric (broad) as shown in Table 1. Reagents were used cyanuric chloride, stearylamine and benzene of special grade.

Table 1: The specimens used in this study

Sample	Weave	Weight (mg/cm^2)	Thickness (mm)	Bulk Density (g/cm^3)	Volume Fraction(%)
Broad	Plain	11.4	0.20	0.568	36.88

2.2 Methods of cyanuric chloride treatment

First, the cotton fabric was swollen by distilled water (100℃) for 3 min, and then returned to normal temperature. The preswollen fabric was treated with 5%v/v aqueous sodium hydroxide solution at 20°C for 30min. After that, an excess alkaline solution remaining in cotton fabrics was removed. Then, Cotton fibers that has been converted to cellulose anion cellulose-anion fabric was treated with 5%v/v cyanuric chloride solution in benzene at 20°C for 5min, and washed with running water and dried.

2.3 Methods of stearylamine treatment

The cotton fabric modified by cyanuric chloride was immersion treatment with 5×10^{-2}mol/L stearylamine solution in benzene at 30°C for 30min. After that, washed with running water and dried.

2.4 Evaluation of the hydrophobizing the fiber surface

The hydrophobizing the fiber surface was evaluated by the shape of water droplet that was dropped on the cotton fabrics. Water droplets photographs were taken with digital microscope.

2.4 Measurement of mechanical and frictional properties

Mechanical and frictional properties were measured by KES (Kawabata Evaluation System). Measurements were carried out under standard conditions [1]. Measured values are the average of the three points. In addition, the primary hand value of each sample is computed with KN-201-LDY that based on measured value by KES.

3. RESULTS AND DISSCUTION

3.1 Reaction with water repellent

Fig.1 shows the water droplet on the cotton fabric which was treated by some commercial ready-made water-repellent. The photograph of the water droplet on the cotton fabric treated with 5×10^{-2}mol/L stearylamine benzene solution was exhibited in Fig.2. Both water droplets has a shape close to spherical, indicating that the fiber surface is covered with the water-repellent agents.

Fig.3 shows the water droplet on the cotton fabric that was immersed in 5×10^{-4}mol/L stearylamine benzene solution. The shape of a water droplet became a semi-spherical shape. This suggests that stearylamine are immobilized on the fiber surface, but the reaction of stearylamine is insufficient. Consequently, it was found that the degree of hydrophobizing the fiber surface could be controlled by the hydrocarbon agent (alkylamine) concentration in the non-aqueous media.

1

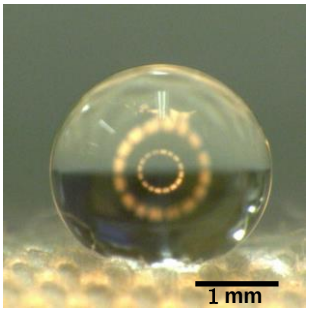

Fig.1 Photograph of the water droplet on the cotton fabric treated with a commercial ready-made water-repellent.

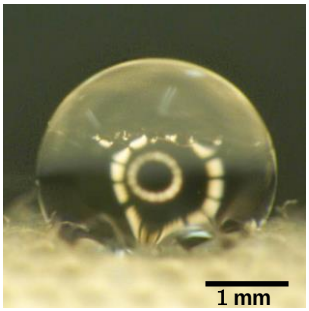

Fig.2 Photograph of the water droplet on the cotton fabric treated with with 5×10^{-2}mol/L stearylamine benzene solution

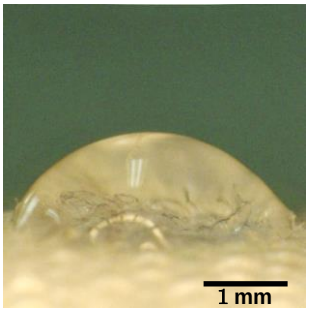

Fig.3 Photograph of the water droplet on the cotton fabric that was immersed in 5×10^{-4}mol/L stearylamine benzene solution.

3.2 Mechanical and frictional properties

Table 2 shows the measured values of untreated, alkali-treated and stearylamine-treated sample that was evaluated using KES system. Stearylamine treatment cotton fabrics have been subjected to alkali treatment in the initial process. This alkali treatment is expected to be affecting the physical properties of the fabric. Therefore, the changes in the mechanical and frictional properties caused by hydrophobizing the fiber surface can become obvious by comparing the stearylamine-treated samples and the alkali-treated samples. Alkali-treated sample was prepared by treated with the blank solution in benzene after treatment with the alkaline solution.

When comparing the untreated and the alkali-treated sample, the changes were indicated at following properties. Strain of maximum load, *EM*, and tensile energy, *WT*, increased. Shear rigidity, *G*, and hysteresis of shear force, *2HG*, decreased. Bending rigidity, *B*, and hysteresis of bending moment, *2HB*, decreased. Compression resilience, *RC*, decreased clearly. Mean of friction coefficient, *MIU*, did not change. Mean deviation of *MIU*, *MMD*, increased slightly.

Table 2 The measured value of the different samples that was evaluated using KES system.

	Symbols	Units	Untreated	Alkali-treated	Stearylamin-treated
Tensile	LT	–	0.938	0.873	0.775
	WT	gf · cm/cm^2	8.00	11.6	10.8
	RT	%	48.5	49.1	56.5
	EM	%	3.26	5.32	5.58
Shear	G	gf/cm · deg	0.770	0.650	0.750
	2HG	gf/cm	1.05	0.850	0.990
	2HG5	gf/cm	3.64	3.19	2.33
Bending	B	gf·cm^2/cm	0.117	0.0855	0.0518
	2HB	gf·cm/cm	0.0719	0.0502	0.0337
Compression	LC	–	0.318	0.354	0.405
	WC	gf · cm/cm^2	0.210	0.180	0.260
	RC	%	41.8	36.3	36.5
Surface	MIU	–	0.143	0.143	0.152
	MMD	–	0.015	0.0204	0.0173
	SMD	μm	1.50	2.03	1.73
Thickness	T	mm	0.200	0.220	0.222
Weight	W	mg/cm^2	11.4	11.6	12.2

*Average of values

When comparing the properties of alkali-treatment sample with that of stearylamine-treated samples, changes were observed in the following items. Tensile linearity, *LT*, and *WT* decreased. Tensile resilience, *RT*, increased clearly. Therefore, stearylamine-treated sample becomes soft elongation and increase resilience is suggested. *G* increased. *2HG*, *B* and *2HB* further decreased. As well as changes in the alkali treatment, the decreased *2HG* and *2HB* suggest a reduction in the friction between the fibers coated with stearylamine. Compression linearity, *LC*, and compression energy, *WC*, increased, but *RC* did not change.

In the friction properties which was expected to change greatly, *MIU* increased slightly and *MMD* decreased slightly. This change means that hand feeling of the fiber surface coated with stearylamine is not substantially changed. However, feeling touched by the finger actually are considerably different, and it can be expressed as waxy feeling. This suggests that measurement of friction by KES is not possible to represent the feeling of reality.

3.3 Primary hand value

Figure 4 shows the values of the primary hand value of each sample that was computed with KN-201-LDY. When comparing the primary hand value of alkali-treatment sample with that of stearylamine-treated samples, it was found that *KOSHI* (stiffness), *HARI* (anti-drape spread) and *SHARI* (crispness) decreased, and *SHINAYAKASA* (flexibility with soft feeling) increased. *FUKURAMI* (fullness and softness) and *KISHIMI* (scooping feeling) hardly changed. *KOSHI*, *HARI* and *SHINAYAKASA* are affected by bending and shear properties.

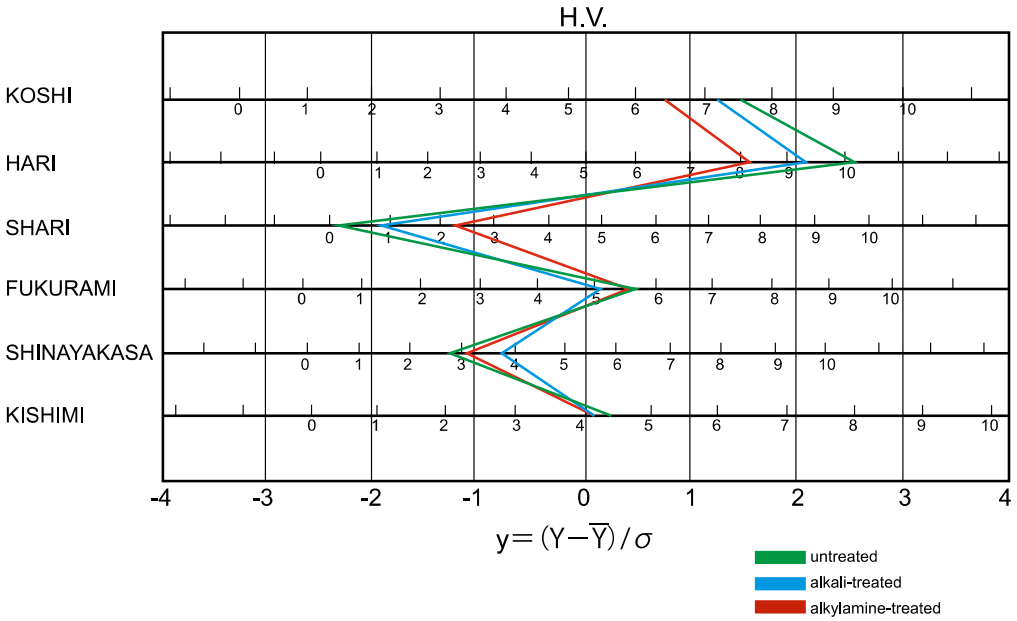

Figure 4: Primary hand value of samples

4. CONCLUSIONS

To hydrophobize the surface of cotton fibers, we adopted the method of immobilizing a hydrocarbon chains (stearylamine) directly to the surface of the cotton fiber. As a result, surface of cotton fabric showed a good water repellent. Mechanical and friction properties of cotton fabric that was treated with this method are *2HG*, *2HB* and *B* were decreased, and *RT* was increased clearly. These results suggest that friction between the fibers coated with stearylamine was decreased and elastic effect was increased. Hand feeling touched by the finger actually are considerably different, Indicating that friction properties change clearly by stearylamine treatment. Unfortunately, the value of friction properties measured by KES could not obtain the expected result of hand feeling. On the other hand, in primary hand value, *KOSHI* and *HARI* were decreased, and *SHINAYAKASA* was increased. Consequently, it was suggested that the cotton fabric used in this study became softer by immobilizing a hydrocarbon chains directly to the surface of the cotton fiber.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Influence of Plasma Treatment on Total Hand Value and Adhesion Properties of Bi-Fabrics of Fused Interlining and Wool Fabrics

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Abstract: Plasma treatment to wool fabrics is effective to the shrink-resistant performance without using chlorination and dyeing performance. The adhesive property between fabrics is growing by the treatment when we make two-layer fabric from face fabric and fusible interlining. During the process of apparel making, interlining fabric is fused on the rear side of the face fabric to make and keep a beautiful silhouette of garments. In this study plasma effects on adhesive strength between face and interlining fabrics are measured objectively. Fabric mechanical properties are investigated, and adhesion properties of bi-fabrics structure of fused interlining and wool fabrics are also discussed. Three types of face fabric are treated by argon-plasma and fusible interlining is adhered on them respectively. Interlining used in this study is polyester plain weave with polyamide adhesive resin. Interlining and face fabrics are bonded together using Flatbed type press machine. Face fabric samples used in this experiment are basket weave, twill and hound's-tooth wool fabrics. Bending, shearing and compression properties and air permeability are measured by KES measurement instruments [1]. Peeling strengths of the bonded fabrics were measured using KES FB1 tensile tester. The results show that adhesion property enhances by the plasma treatment. In the next stage, we study how adhesion bond impregnate with fibers and yarns and what is the difference in penetration between treated and untreated fabrics. Finally we study the influence of plasma treatment on total hand value of bi-fabrics.

Keywords: Bi-fabric, plasma treatment, fusible interlining, adhesion property, mechanical property

1. INTRODUCTION

Wool has many excellent characters as to elastic, stain ability, moisture absorbency, warm, moisture retain, water repellency and fire retardancy because of the fiber mechanisms. And at the end of fabric it goes back to the earth. Wool fabrics make beautiful and comfortable appearance of garments. But some reasons, as to feeding damage by insect and felting property, make it difficult to

be convenient apparel materials like polyester. Felting is one of superior character and it makes beautiful texture of wool fabrics. But, as for the easy care performance for daily garment like underwear and T-shirt, it becomes a weak point of wool. Wet chlorination has been used as anti-felting methods traditionally, but it needs much toxic chemical matters and much energy, in addition sewage should be treated. Some research works against anti-felting treatment of wool without chlorination has been developed [2]. Plasma treatment is understood to be effective as a non- chlorination system for the anti-felting of wool. Mori mentioned the mechanical property and anti-felting property of wool fabric treated with low temperature plasma [3] and its' dyeing properties [4]. Mechanism of anti-felting by plasma treatment is discussed by Mori, Tahara [5], Dai [6] and Molina [7]. Plasma treatment gives wool not only anti-felting character but also good dyeing performance and mechanical properties changes. In addition it is estimated that bonding performance between treated wool fabric and fusible interlining becomes strong. Fusible interlining makes an important role to the beautiful silhouette and its retaining of jacket. But high fusing temperature and pressing force cause fabric shrinkage. Lower temperature, pressing force and shorter pressing time are preferred. In this study influence of plasma treatment on adhesion and mechanical properties, hand values (HV) and total hand value (THV) of bi-fabrics of fused interlining and wool fabrics.

2. EXPERIMENTAL

2.1. Fabric Samples

Three types of face fabric were treated by the low temperature plasma and fusible interlining is adhered on the rear side of face fabrics respectively. Untreated face fabrics are also prepared for comparison. Interlining used in this study was polyester plain weave with polyamide adhesive resin, which is used widely in the front part of jacket. Face fabric and interlining were placed on the flat bed type press machine and bonded under the conditions of 140°C and 125g/cm^{2} for 10 seconds. Face fabric samples used in this experiment are basket weave, twill and hound's-tooth wool fabrics. Constructional details of fabric samples are provided in Table 1.

Plasma reactor used in this study is a type DSSO-422 (Daia Sinku Co., Ltd.). The discharge frequency was fixed at 13.56 MHz. Plasma treatment was carried out by the following procedures. The fabric sample was placed in the reactor, and the reactor was evacuated to 0.001 Torr (0.13 Pa). Then argon (Ar) was fed into it at a volumetric flow rate of 10 mL/min. The electric power for plasma discharge was fixed at 100 W. The internal pressure of the reactor was maintained at 0.1 Torr (13.3Pa) during a plasma-treatment time of 300 s. The treated fabric samples were finally rinsed with water and dried by air, and then subjected to property measurements.

Table 1 Fabric Samples Used in This Study and Their Symbol

Fabric Symbol	Fiber	Fabric	Density(/cm) Ends	Density(/cm) Picks	Thickness (mm)	Weight (mg/cm^{2})
Face Fabric BR	Wool	Basket Weave	33.8	29.0	0.85	26.45
Face Fabric WH	Wool	2/2 Twill	28.3	26.0	0.52	20.41
Face Fabric HT	Wool	Hound Tooth	30.5	25.7	0.73	23.55
Interlining	Polyester	Plain Weave			0.36	3.72

2.2. Measurement of Mechanical Properties

Fabric mechanical properties, bending, shearing, compression and tensile properties, surface properties and air permeability were measured by KES measurement instruments under the atmospheric conditions of 20±2°C and 65%RH. Parameters and conditions of mechanical properties are summarized in Table 2.

Peeling strengths of the bonded fabrics were measured using KES FB1 tensile tester. Figure 1 shows a photograph of peeling test. One end of peeled face fabric is clutched on the fixed grip and another peeled interlining fabric end is clutched, loaded and peeled. Sample width for peeling test is 2.5cm. Peeling speed is 0.2mm/sec and 2.0cm of samples were peeled.

Table 2 Details of Fabric Mechanical Properties

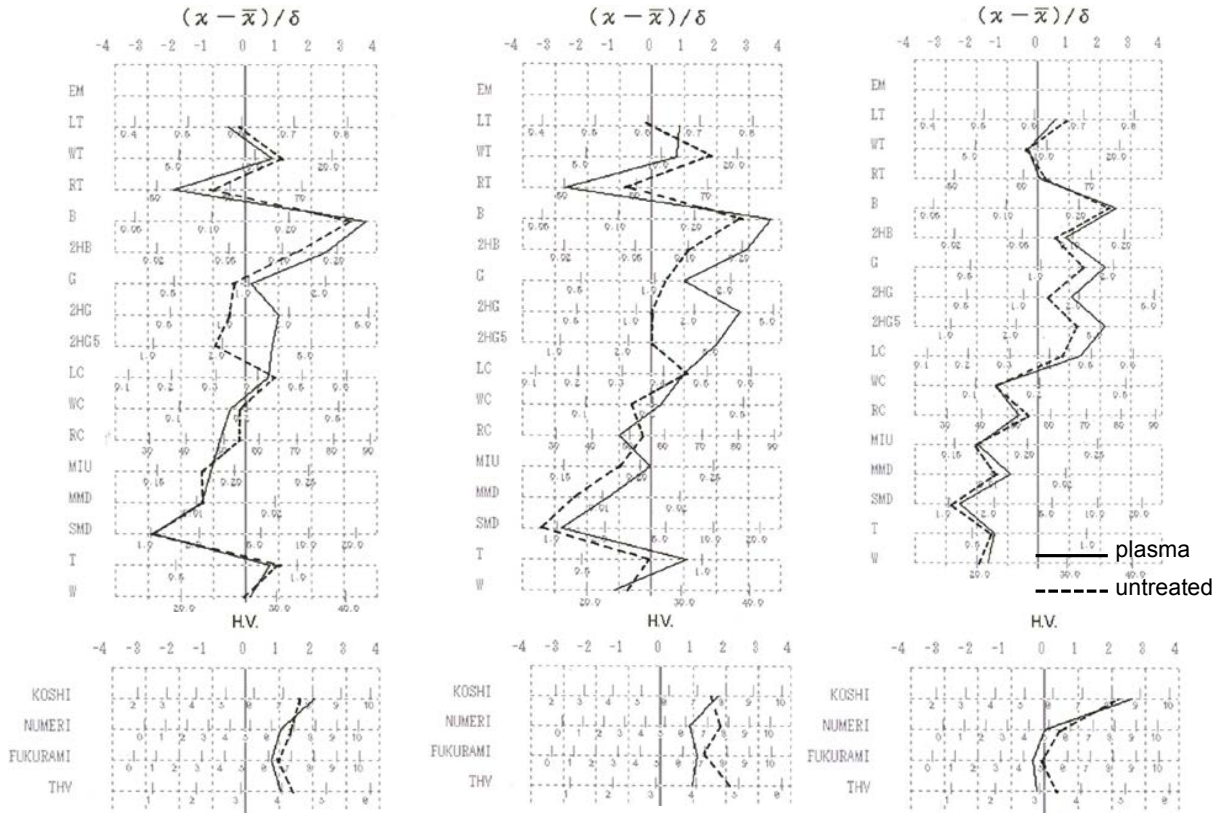
Property Block	Symbol	Details of Property	Unit
Tensile	LT	Linearity in tensile stress and strain	non
	WT	Energy in tensile	gf·cm/cm^2
	RT	Resilience in tensile	%
Bending	B	Bending rigidity	gf·cm^2/cm
	2HB	Bending hysteresis	gf·cm/cm
Shearing	G	Shear rigidity	gf/cm·deg.
	2HG	Shear hysteresis at 0.5 deg. of shear angle	gf/ cm
	2HG5	Shear hysteresis at 5 deg. of shear angle	gf/ cm
Compression	LC	Linearity in compression	non
	WC	Energy in compression	gf·cm/cm^2
	RC	Resilience in compression	%
Surface	MIU	Mean frictional coefficient μ	non
	MMD	Mean deviation of MIU	non
	SMD	Surface roughness	non
Thickness	T	Fabric thickness under the load of 0.5 gf/cm^2	mm
Weight	W	Fabric weight per unit area	mg/ cm^2

3. RESULTS AND DISCUSSION

3.1. Fabric Mechanical Properties,Hand Values and Total Hand Value

Fig. 1, Fig. 2 and Fig. 3 shows plotted mechanical properties on the data chart of men' winter suit [1] of bi-fabrics with interlining and face fabric HT, BR and WH respectively. Solid and dotted lines show plasma treated and untreated face fabrics respectively.

Most remarkable differences between plasma treated and untreated bi-fabrics were bending and shearing properties. Bending rigidity, B, and hysteresis, 2HB, shear rigidity, G, shear hysteresis, 2HG and 2HG5 were larger in plasma treated bi-fabrics compared with untreated ones. These



(a) Face fabric BR (b) Face fabric HT (c) Face fabric WT

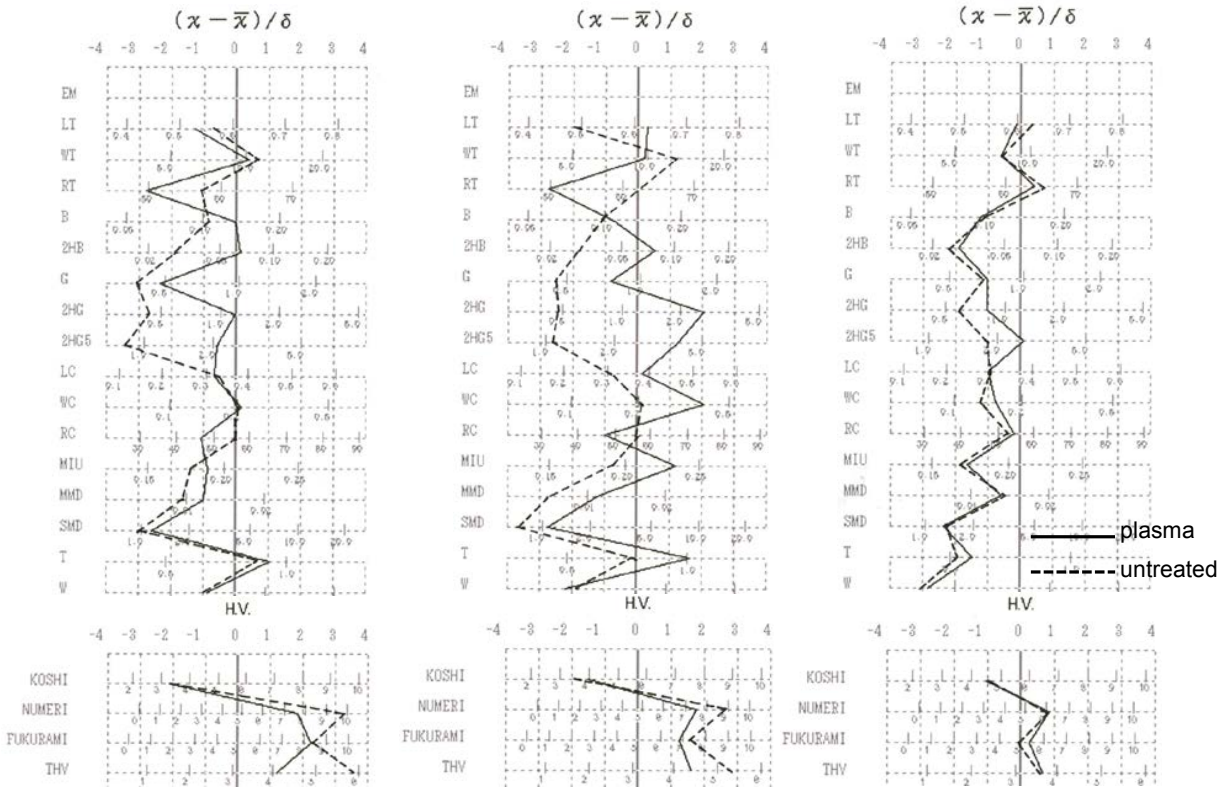
Fig.1 Mechanical Properties, HVs and THV [1] of Bi-Fabrics with Face fabrics

changes were shown the face fabrics shown in Fig.2. In tensile property, RT values were smaller in plasma treated bi-fabrics compared with untreated ones. The degree of the change in maximum elongations at 500gf/cm became smaller in plasma treated bi-fabrics were differ in three face fabrics, while RT values became in all samples. And WT values were smaller in HT and BR bi-fabrics and almost same value in WH. In plasma treated bi-fabrics resin penetrate deeply to the face fabric and hold yarns strongly, which might be a reason of the change of RT values. As for the compression property, linearity, LC, and compression energy, WC were differ from samples. But as for the compression resilience, RC values were smaller in all plasma treated bi-fabrics.

In the cases of two fabrics BR and WT, there were almost no changes in the fabric thickness between untreated and treated conditions, while treated fabric became thicker than untreated in fabric HT. Table 3 shows the weave density and thickness of face fabrics under the conditions of untreated and plasma treated. For the fabric HT, shrinkage along weft direction might occur during

Table 3 Changes of Fabric Structural Factors before and after Plasma Treatment

Fabric	Density Ends/Picks (/cm)		Thickness (mm)	
	Untreated	Treated	Untreated	Treated
BR	33.8 / 29.0	34.1 / 29.1	0.520	0.567
WH	28.3 / 26.0	28.7 / 27.1	0.848	0.908
HT	30.5 / 25.7	28.1 / 25.4	0.723	1.015



(a) Face fabric BR (b) Face fabric HT (c) Face fabric WT

Fig.2 Mechanical Properties, HVs and THV[1] of Face fabrics

plasma radiation.

Hand values of KOSHI, NUMERI and FUKURAMI and Total Hand Value (THV) [1] are shown in the figures in Fig.1. Fig.2 shows mechanical properties, HVs and THV of three face fabrics. In these figures properties of plasma treated fabrics (solid line) are compared with untreated (dotted lines) ones. HVs and THV are calculated using equation KN-101-winter for men's winter suiting fabrics [1]. For face fabrics BR and HT, when fabrics are plasma-irradiated, hand value of NUMERI and THV are reduced compared with original ones. As for the bi-fabric, increase of KOSHI value and decrease of NUMERI and FUKURAMI values are observed and consequently derive the little decrease of THV values. For face fabric, the degree of THV change by the plasma radiation is different from its type. As for the change of HVs and THV by plasma irradiation, there were small. But shearing and bending properties were changed, which are acting to be stiffer. The influence for tailor-ability and comfort to wear of this change must be considered.

3.2. Peeling Strength

Fig.3 shows an example of measurement of peeling strength using KES-FB1 tensile tester in sample BR. After chucking the both sides of peeled face and interlining fabrics, load was applied to fabrics until peeled length arrived 2.0cm, and then loaded side returned to the original position, while peeling of two fabrics peeling force was detected. Under the same conditions of bonded process peeling strength, that is, bonding strength is different between plasma treated and untreated face fabrics, that of plasma treated is larger than untreated one. In this experiment, mean peeling strength during peeling is measured visually. Fig. 4 shows the results of three face fabrics. Red and blue data show the peeling strengths in plasma treated and untreated respectively, and



Fig. 3-1 Peeling Strength Test Using KES FB1 Tensile Tester

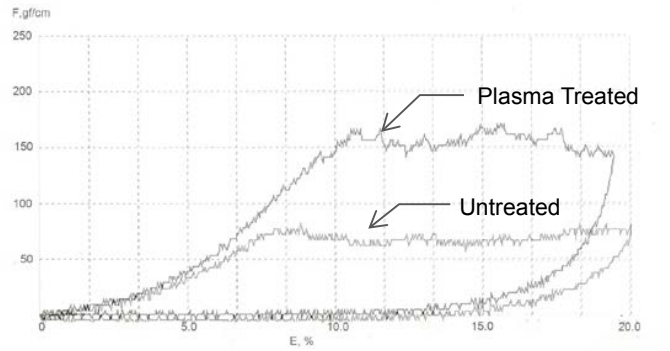


Fig. 3-2 Example of Measurement of Peeling Strength Using KES-FB1 Tensile Tester

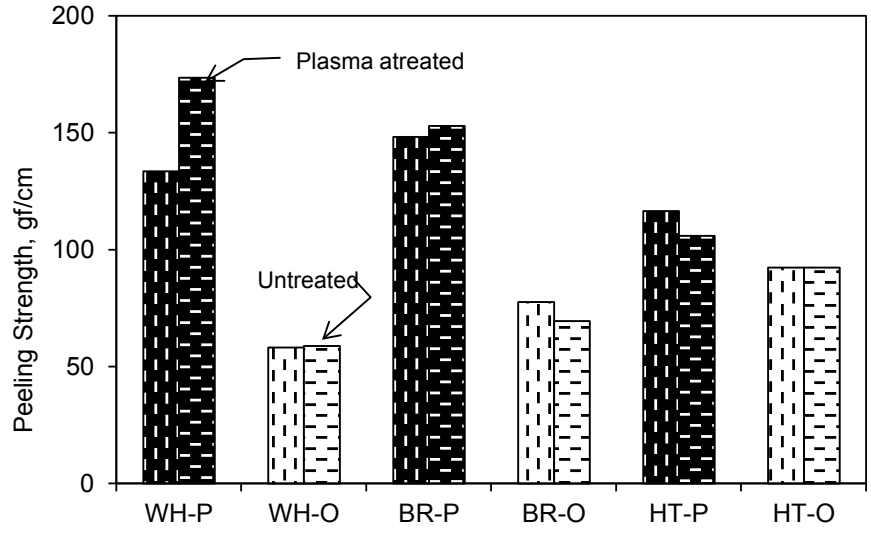


Fig. 4 Peeling Strength for Three Fabric Samples (Warp and Weft Directions)

solid and dotted data show along warp and weft directions respectively. In cases of face fabric sample WH, 2/2 twill weave, and BR, basket weave, different of peeling strengths between plasma treated and untreated, over two times larger in treated than untreated. In case of face fabric HT, peeling strength of plasma treated bonding fabric is larger than untreated, but the difference between them is rather small.

Mori et al. concluded that chemical and structural changes of the wool surfaces by the plasma treatment were investigated using XPS and SEM and thin layer of 36 nm thickness was removed from the surface of wool fiber, which suggested that most of the epi-cuticle layer at the outermost surface of the fiber was etched away [2]. In this experiment the reason why bonding force is increase in plasma treated face fabrics is related with the etching of fiber surface wool. Mori also mentioned the implantation effect of plasma treatment on wool fiber [2]. Wool fiber can react easily with oxygen in the air because of a generation of oxidative sulfurs as to S, SO_2 and SO_3 which were formed as a result of keratin resolution by plasma treatment. As results of etching and implantation effect penetration of binding resin is increasing in plasma treatment and as a result of penetration bonding strength is enhanced. Fig.5 show photos of cross section of bi-fabric with face fabric HT (hound-tooth fabric). In case of bi-fabric with plasma treated face fabric bonding resin penetrates

into face fabric, while in case of untreated face fabric resin lays on the face fabric. This result means that smaller volume of bonding resin, lower dot density of resin, can make proper bonding strength

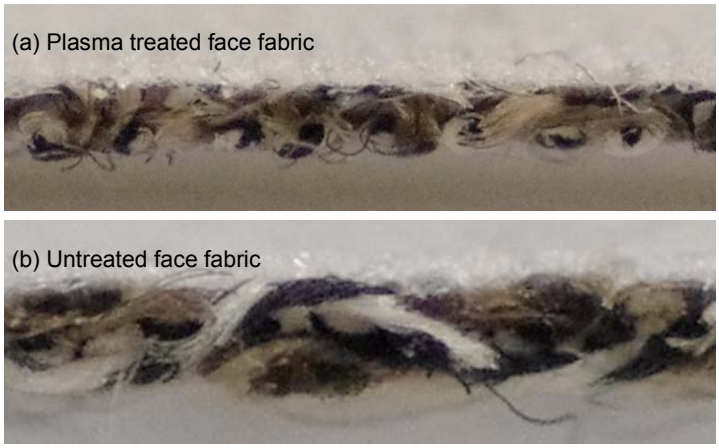


Fig.5 Cross-Section of Bi-Fabrics (a) Plasma Treated Face Fabric, (b) Untreated

for the plasma treated face fabric and interlining, which can prepare softer handle of bonded bi-fabric.

4. CONCLUSION

In this study the bonding performance of plasma treated wool fabrics with fusible interlining was discusses. Plasma treatment on wool fibers and fabrics are effective to the anti-felting performance as an environmentally-friendly method. And at the same time binding strength between treated face fabric and fusible interlining was predicted to be stronger compared with untreated one. In this study, this prediction was resulted experimentally. That is, bi-fabrics of plasma treated face fabric and interlining showed strong peeling strength compared with untreated bi-fabrics under the same bonding conditions. Bi-fabrics play an important role to the formation of beautiful shape. From this study we can use lower dots density of adhesive resin on the interlinings than useal for the plasma treated face fabrics. Lower dots of adhesive resin affect softer handle of face fabrics. This rsult that when we make up the garment like jacket, we can get not only easy care performance but also softer handle bi-fabrics for the plassma treated fabrics. On the other hand, mechanical properties as to B, 2HB, G, 2HG were change to the stiffer region.

In the next stage we will examine the effects of dots density of adhesive resin on plasma treated face fabrics and fusible interlining from the points of bonding strength and the change of mechanical properties to find the optimum conditions of strong and soft bi-fabrics for garments.

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BIOGRAPHY

Machiko Murakami

Machiko Murakami graduated the master course of Nara Women's University in 1978 and belonged 1) Kobe Gakuin Women's College (1978-1979), 2) Mimasaka Women's University (1978-1983) and has belonged 3) Gifu City Women's College (1988-at present) and has been professor since 2007. Her major research areas in scientific achievement are 1) mechanical properties and handle estimation of clothing fabrics, 2) objective evaluation of clothing materials and 3) mechanical properties of bi-fabrics related to clothing silhouette.

Masukuni Mori

Dr. Mori, professional engineer had been working and studying about textile technology, dying, fabric handling and mechanical properties of wool fabrics since 1950, having got a job at Tsuyakin Kogyo Co. Ltd. up to 1996, retiring the company. he joined the " Hand Evaluation and Standardization Committee, Textile Machinery Society of Japan", established by former Professor Dr. Kawabata, Kyoto University and former Professor Dr. Masako Niwa, Nara Women's University in 1973. His knowledge and experience about textile, especially in dyeing and finishing of wool fabrics, have been absolutely imperative still now. After 1996, he has been working as a consultant of textile engineering not only in Japan but also in China, Korea and Italy.

Takako Fujimoto

Dr. Takako Fujimoto belonged to 1)Niigata University (1977-1981) and then has belonged to 2) Hokkaido University of Education (1992- at present), and has been professor since 1992. She has been Head, Japan Section of The Textile Institute of UK (2005-) and was a visiting professor, University of New South Wales, Australia (1996.9-1997.3). Her major research areas are theory of heat transfer of fibrous materials, mechanical properties and handle estimation of clothing fabrics, objective evaluation of clothing materials and durability of clothing materials. The number of her published original books is 5 and papers and articles is around 130. She received three prizes and awards related to the above scientific achievements.

Choji Murata

Choji Murata has been an engineer of Kato Tech. Co. Ltd. Since 19 and supports this research works technically.

5C - Measurement 3

The Sensation of Pleasantness during Tactile Exploration

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Abstract: Humans constantly explore surfaces with their fingertips, providing information regarding the surfaces' physical attributes and their (un)pleasantness level. It is therefore of interest to investigate whether the perception of pleasantness is related to surfaces' physical attributes. Pleasant touch perception is generally measured indirectly and generates ordinal scores, lacking fundamental psychometric properties which are essential for objective and quantitative measurement. Consequently, probabilistic measurement models have been established to allow transformations of ordinal scores into linear measures.
Accordingly, we first elaborated a solid basis for future investigations in the domain of pleasantness sensation resulting from active surface explorations with index fingertips. The Rasch model was used to develop a unidimensional, linear and invariant *Pleasant Touch Scale*, which classifies 37 different everyday life materials according to their pleasantness levels. The latter seemed to be influenced by the respective surfaces' topographies and by the frictional forces resulting from the tactile surface exploration. These evidences were confirmed in our second study. Indeed, the net values of friction forces, recorded during active fingertip explorations of various material samples of the *Pleasant Touch Scale* could reliably be correlated with their respective pleasantness measures. A further correlation was found between the fluctuations of friction forces and the surfaces' pleasantness measures. Our third study was conducted to determine whether (i) these findings hold true for passive fingertip stimulations and (ii) temperature variations of stimuli

impact their pleasantness levels. Frictional forces and surfaces' topographies of stimuli played a crucial role in passive touch pleasantness perception.

Keywords: pleasant touch, surface topography, friction, Rasch model

1. INTRODUCTION

In everyday life, we incessantly explore surfaces with our fingertips.This stimulates the somesthetic senses, described as having 4 different modalities, *i.e.* proprioception, nociception, thermal perception, discriminative touch (Kandel, 2000). However, studies point to the existence of a supplementary *pleasant touch* modality (Johansson et al., 1988; McGlone et al., 2007; McGlone & Reilly 2010; Nordin, 1990). Each of these modalities can be perceived through stimulation of specialized afferent nerve fibers and their specific receptors. The afferent systems are embedded in the skin and vary according to the skin type. For example, C-Tactile nerve fibers, playing a fundamental role in the detection and transmission of pleasant stimuli applied to *hairy* skin, seem to be missing from *glabrous* ones (Johansson et al., 1988; Nordin, 1990). However, as surfaces touched with glabrous skin sites (*e.g.* the fingertips) can be perceived as (un)pleasant, it can be hypothesized that the perception of pleasantness at fingertip level is initiated through stimulation of other sensory modalities, especially discriminative touch. If this would be that case, specific surface physical attributes would probably be related to pleasantness sensation. Finally, it is of interest to investigate whether pleasantness perception is influenced by the exploration strategy (*i.e.* active *vs*. passive).

Information regarding the discriminative modality of touch is captured by thousands of mechanoreceptors, innervated by 4 types of mechanosensitive afferents. Each of these afferent fiber systems responds selectively to specific stimulus features (*e.g.* the spatial image of stimulation, skin vibrations) applied actively or passively to the fingertip. Whether identical stimulus features induce similar percepts during active and passive touch is still debated in the literature (Gibson, 1962; Landrigan et al., 1974; Lederman, 1981; Heller, 1984; Smith et al., 2009; Richardson et al., 1981; Vega-Bermudez et al., 1991).

An essential starting point to investigate in pleasant touch is to be able to measure pleasantness. As pleasant touch is a latent variable it can only be measured indirectly, *e.g.* through a test which (i) is composed of items/questions reflecting increasing levels of pleasantness and (ii) locates people respective to their pleasantness satisfaction level. Typically, the items are rated using either categorical rating (CR) or magnitude estimation (ME) methods. In CR, subjects use a predefined set of categories to rate their perception of pleasantness. This rating can be done using a dichotomous response format, *e.g.* “unpleasant” (scored 0) and “pleasant” (scored 1), or a polytomous one, *e.g.* “unpleasant” (scored 0), “pleasant” (scored 1) and “very pleasant” (scored 2). Usually, the response scores are summed together into a total score, which evaluates the latent variable on an ordinal basis. However, such data are unsuitable for quantitative analyses. In contrast, ME is an unlimited rating procedure, which was originally constructed to overcome the shortcomings of measurement methods generating ordinal data (Stevens, 1975). Nevertheless, it remains unclear whether this aim was really achieved (Wills & Moore, 1994). Consequently, independently of the scaling method used to rate latent variables, modern psychometric methods should be used to assess fundamental scaling properties of the measures prior to any further data interpretation. The Rasch model is a probabilistic measurement model, which can be used to establish linear, unidimensional and invariant scales from ordinal scores (Rasch, 1960). The model enables thus the objective measurement of latent variables and provides an estimate of what our data would be if we were to create a ruler to measure it (Bond & Fox, 2001).

Here, 3 different studies, investigating in pleasant touch perception, are described. Two deal with

active touch (Study 1 and 2) and 1 with *passive* touch (Study 3). These studies were all approved by the Biomedical Ethical Commission of the Faculty of Medicine of the Université catholique de Louvain (2010/07JUI/174, Belgian registration number: 40320108947).

2. STUDY 1 – RASCH-BUILT MEASURE OF PLEASANT TOUCH TROUGH ACTIVE FINGERTIP EXPLORATION (*adapted* from Klöcker et al., 2012)

2.1. Materials and Methods

2.1.1. Subjects

One hundred and ninety-eight healthy subjects were enrolled for this study.

2.1.2. Stimuli

To elaborate the *Pleasant Touch Scale*, 48 everyday life materials (*e.g.* wax, fabrics, woods, papers) were selected and glued onto an aluminum plate (77 mm x 32 mm).

2.1.3. Procedure

Before each experiment, the index fingertip moisture level of each participant was measured using a Corneometer® CM 825 (CK electronic GmbH, Köln, Germany). Participants were blindfolded and each material was randomly presented to them. Participants explored the material surfaces with their index fingertips through lateral sliding movements, while using a preferred exploration normal force and speed. Each participant then rated the pleasantness level on a 4-level scale: (0) very pleasant, (1) pleasant, (2) unpleasant or (3) very unpleasant. The total score of each material could thus range from 0 (*i.e.* all participants rated it as very pleasant) to 594 (*i.e.* all participants rated it as very unpleasant).

2.1.4. Data Analysis – The Rasch model

Data were analyzed using the Rasch Unidimensional Measurement Models software (RUMM2020).

The Rasch model was originally elaborated to test the "data to model fit" for dichotomous data (Wright & Stone, 1979). Applied to pleasant touch perception, a Rasch analysis of dichotomous data tests for the probability that subject "n" will choose category "x" for surface "i". This probability should be influenced only by the subject's general satisfaction level elicited by surface exploration (β_n) and the surface's pleasantness level (δ_i). In this sense the model is unidimensional as it involves only the pleasant touch dimension of the subjects. The probability that subject "n" perceives surface "i" as pleasant is thus based on the comparison of β_n and δ_i, allowing in turn the calculation of the expected pattern of responses to a set of items (Tennant, 2004). The data to model fit is tested by comparing the expected responses from the model to the observations. The invariance of the scale is thereafter checked to verify that measurements are not influenced by variables other than the measured one (*e.g.* a meter is only sensitive to the length of an object but not its weight). If the data to model fit and the invariance are verified, then the Rasch model has reliably transformed the originally collected ordinal data into linear, unidimensional and invariant measures (Tennant, 2004; Wright & Linacre, 1989). These measures are expressed in logits, the unit of measurement after transformation of the ordinal raw scores into log odds ratios (*i.e.* ratio between the probability of perceiving a surface as pleasant and the probability of perceiving the surface as unpleasant) on a common interval scale (Bond & Fox, 2001). One logit represents the increase in surface pleasantness which is needed to increase the odds ratio by a factor of 2.71. Similarly, one logit represents the increase in person's satisfaction level needed to increase the odds ratio by a factor of 2.71. For illustration, consider Figure 1 where surface A is located at 1

logit and surface B at 2 logits. If person D explores both surfaces, this person will have a e^1=2.71 higher probability of perceiving surface B as pleasant than surface A. If person C is located at 1 logit and person D at 2 logits, person D will have a e^1=2.71 higher probability to rate surface A as pleasant than person C.

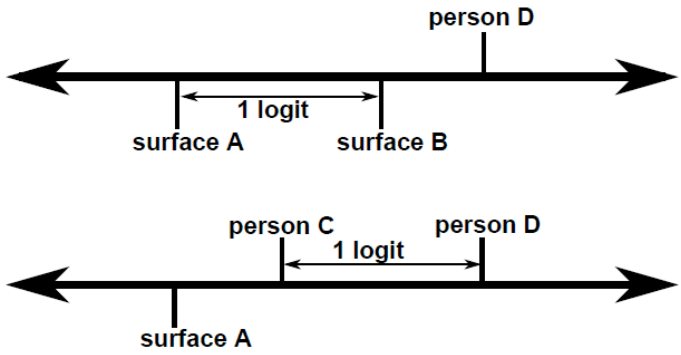

Figure 1: Illustration of the logit

The Rasch model can also be applied to the analysis of polytomous data (Andrich, 1978; Wright & Masters, 1982). In this case, the probability that subject "n" chooses category "x" for item "i", should be influenced only by β_n, δ_i and the threshold[1] (τ_{ij}) location between two successive response categories (Wright & Masters, 1982).

2.1.5. Material selection

Successive analyses were performed to select materials (i) presenting ordered response categories and (ii) fitting a unidimensional scale.

2.1.5.1. Ordered response scale

The subjects were asked to report their pleasantness perception on a 4-level scale: (0) very pleasant, (1) pleasant, (2) unpleasant or (3) very unpleasant. The order of the response categories was verified for each material by checking whether the categories represent decreasing pleasantness levels. If the response categories were ordered, the thresholds were located in the anticipated order, that is, less satisfied subjects should have selected a higher response for any given material, whereas subjects selecting a higher response to a given material should be less satisfied.

2.1.5.2. Unidimensional scale

The item χ^2 fit statistics were used to test the fit of the data to the model requirements. In this method, the squared standardized residuals (*i.e.* the difference between the response expected by the model and the observed response by the subject) of all subjects are summed, leading to a χ^2 value for each material. A significance test is used to evaluate whether the χ^2 is too high to be attributed to random variation (p-value < 0.05 indicates misfitting items) (Tennant & Conaghan 2007).

[1] Thresholds or boundaries between successive response categories, are the level at which the likelihood of choosing a given response category below the threshold is equal to the likelihood of choosing the response category above the threshold (Bond, 2001). The surfaces difficulty level corresponds to the mean threshold location of the surface.

2.1.6. Differential item functioning

The invariance of the pleasantness hierarchy of the materials within the sample was tested through a "differential item functioning" (DIF) analysis. DIF occurs if subjects of distinct subgroups (*e.g.* males vs. females) with the same satisfaction level perceive any given material differently (Tennant et al. 2004). In this study, DIF was investigated according to (i) gender, (ii) age (<37 vs. ≥37 years, the median age of the subjects) and (iii) fingertip moisture level (<70 vs. ≥70 arbitrary units, or "a.u.", the median moisture level). To investigate DIF, each subgroup was divided into 5 class intervals (CI) of decreasing pleasantness satisfaction, and two-way analysis of variance (ANOVA) was computed on the standardized residuals of the different CIs (Andrich, Sheridan and Luo 2004). Factors analyzed in two-way ANOVA included (i) subject subgroups (*e.g.* males vs. females), and (ii) CIs of decreasing pleasantness satisfaction levels.

2.2. Results

Successive Rasch analyses were performed to construct the final *Pleasant Touch Scale*. The categories "unpleasant" and "very unpleasant" were merged into one category ("unpleasant") as subjects were not able to discriminate between them for eleven material samples. The entire data set was thus reanalyzed using a three-level scale: (0) very pleasant, (1) pleasant and (2) unpleasant. Two items were deleted from further consideration as they still presented disordered thresholds. Furthermore, 9 items did not fit a unidimensional scale. They were also eliminated, resulting in a 37-item scale. The invariance analysis highlighted that 21 material samples presented a DIF according to the participants' fingertip moisture levels. These samples elicited different levels of pleasantness when touched by participants with dry and wet skin and were therefore split into two different items with locations specific to fingertip moisture level (*i.e.* one each for participants with dry and wet skin). Consequently, the final *Pleasant Touch Scale* includes 58 items, of which (i) 16 items share a common location in low and high moisture level subgroups and (ii) 42 items have locations specific to the fingertip moisture level.

2.2.1. Metric properties of the *Pleasant Touch Scale*

The calibration of the 58 items of the *Pleasant Touch Scale* is presented in Table 1, in which the items were ordered from the most unpleasant, at the top, to the most pleasant, at the bottom. Items followed by "_LM" and "_HM" are split items with pleasantness locations specific to subjects with low and high fingertip moisture levels, respectively. The pleasantness levels of the 58 items covered a range of 6.91 logits indicating that the odds of pleasing any particular subject was in a ratio higher than 1000:1 (*i.e.* $e^{6.91}$:1) between the most and least pleasant items. This pleasantness range was arbitrarily centered at 0 logits. Furthermore, the table presents the standard errors (SE) associated with the estimations of the pleasant levels of the different items (mean: 0.18 logits; range: 0.36 logits).

Table 1: Items of the *Pleasant Touch Scale*

Material description	Pleasantness [logits]	SE [logits]
sandpaper_LM	-4.47	0.48
rough sponge_LM	-4.19	0.40
sandpaper_HM	-2.45	0.30
silicon_LM	-2.44	0.27
silicon_HM	-2.23	0.24
latex	-1.88	0.17
wax	-1.73	0.17
clingfilm	-1.49	0.15
rough sponge_HM	-1.43	0.23
carbon paper_HM	-1.19	0.20
linen	-1.12	0.14
leather chamois_LM	-0.84	0.19
tesa tape_HM	-0.75	0.19
carbon paper_LM	-0.71	0.19
wood_LM	-0.64	0.18
leather chamois_HM	-0.60	0.19
plastic_HM	-0.59	0.19
argil_LM	-0.57	0.18
plexiglass_HM	-0.51	0.17
glass_HM	-0.26	0.16
aluminium_HM	-0.19	0.18
tile_HM	-0.18	0.16
argil_HM	-0.15	0.17
wood_HM	-0.13	0.19
chipboard_LM	-0.10	0.19

cork	0.06	0.13
table cloth_HM	0.20	0.17
plexiglass_LM	0.26	0.15
marble_HM	0.28	0.15
plastic_LM	0.39	0.15
tesa tape_LM	0.40	0.15
glass_LM	0.43	0.15
cast_LM	0.46	0.18
silk	0.52	0.13
transparent paper_HM	0.57	0.15
viscose tissue	0.60	0.12
paper_250g/m²_HM	0.62	0.16
chipboard_HM	0.63	0.17
foam	0.63	0.12
cotton tissue_LM	0.66	0.18
table cloth_LM	0.68	0.16
aluminium_LM	0.70	0.17
tile_LM	0.81	0.17
cast_HM	0.87	0.19
tights	1.07	0.13
paper_250g/m²_LM	1.08	0.17
marble_LM	1.12	0.16
cotton tissue_HM	1.17	0.19
paper_70g/m²	1.22	0.14
paper_120g/m²_LM	1.23	0.19
transparent paper_LM	1.40	0.18
baking paper	1.49	0.13

synthetic tissue	1.50	0.13
velvet	1.74	0.12
cellular rubber	1.83	0.13
paper_120g /m²_HM	1.86	0.20
paper_80g/m²	1.89	0.14
paper_160/g/m²	2.44	0.14

Several material samples of the *Pleasant Touch Scale* were used in the next study to investigate whether any correlation can be detected between the physical properties of the samples and their respective pleasantness levels.

3. STUDY 2 – PHYSICAL FACTORS INFLUENCING PLEASANT TOUCH DURING TACTILE EXPLORATION (*adapted* from Klöcker et al., 2013)

3.1. Materials and Methods

3.1.1. Participants

Eight healthy participants were enrolled for this study.

3.1.2. Apparatus

The measurement apparatus (Figure 2) included a sample holder which was rigidly connected to a high-resolution piezoelectric force sensor (9217a, Kistler Instrumente AG, Winterthur, Switzerland) connected to a charge amplifier (5015A, Kistler Instrumente AG, Winterthur, Switzerland). The piezoelectric force sensor measures fluctuations of friction forces. The force sensor has a 500 Hz exploitable frequency bandwidth and a theoretical noise floor of 10 µN. Two parallel leaf springs provided a high rigidity support for the sample holder in the normal and radial directions, and optimal transmission of the interaction force in the lateral direction. The entire structure was connected to a 6-axis, strain-gauge force-torque sensor (Mini 40, ATI Industrial Automation, Inc., Apex, NC, USA) that allowed us to gain access to the complete interaction force vector in the low frequencies and with a resolution of 20 mN. The finger position was measured by an optical motion tracking system (Optotrak, Northern Digital Inc., Waterloo, Ontario, Canada) that located a light-emitting fiducial marker attached to the scanning finger nail at a rate of 400 Hz. Acquisition of sensor signals have been made using a 12 bits analog to digital converter at a sampling rate of 20 kHz.

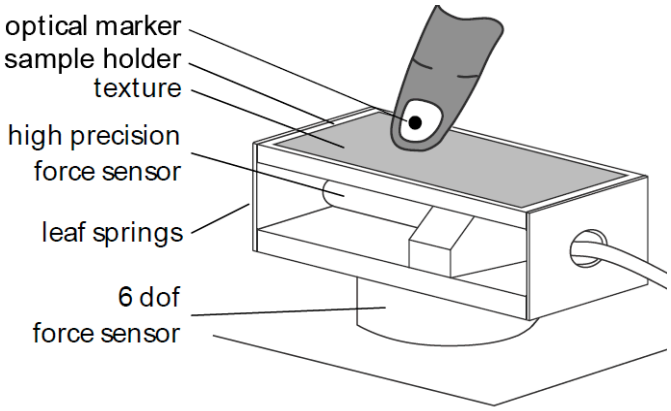

Figure 2: Measurement apparatus of “Study 2”

The participants’ fingertip moisture levels were evaluated using the Corneometer® CM 825 (CK electronic GmbH, Köln, Germany).

3.1.3. Stimuli

Twelve surfaces, of the *Pleasant Touch Scale* (Klöcker et al., 2012) were selected for this study. These surfaces ranged from the most unpleasant to the most pleasant surface of the scale.

3.1.4. Protocol

Participants were blindfolded and the moisture level of their right index fingertip was measured using the Corneometer® CM 825. The materials were mounted in a randomized order on the

measurement device and the participants were instructed to position their right index fingertip just above the selected material before spontaneously exploring the sample through ten successive lateral sliding movements. During surface exploration the high-frequency tangential force fluctuations were recorded, along with the net interaction force, and the fingertip position. The fingertip moisture level was recorded immediately after the last exploration trial of each surface.

3.1.5. Data processing

All analyses focused on 20 mm (*i.e.* between 40 and 60 mm of each material) of the active steady-state fingertip slip phase. The software package Matlab® (version 7.10) was used to process force and fingertip position data. Force data were numerically low-pass filtered (butterworth 4th order filter) at 800 Hz and the fingertip position signal was used to estimate the exploration velocity.

Firstly, mean values of exploration velocity (*v),* tangential *(f_T)* and normal *(f_N)* forces were computed per sample exploration and per participant. The dynamic coefficients of friction (μ) were determined by dividing f_T by f_N. Secondly, mean values for all parameters were computed over the 10 explorations.

To investigate the effect of surface topography, analyses focused on the rapid fluctuations of the friction force (f_T). Indeed, following the analysis detailed in Wiertlewski et al. (2011), the raw friction force data of each participant and each exploration was resampled with respect to space, using the corresponding fingertip positions. This signal was fast Fourier transformed, generating a spatial spectrum. Consequently, the rapid force fluctuations of each surface could be analyzed in terms of spatial frequencies. To quantify the decay of the friction force with respect to spatial frequency, a regression line was fitted to the spatial spectrum of each sample situated between 0.1 mm^{-1} and 10 mm^{-1},

$$f_T = \beta\eta^{\alpha}$$

where η represents the spatial frequency, $\alpha < 0$ the slope of the regression line and β its offset. Consequently, α and β could be estimated for each sample and each participant (except for one of them who scanned the samples too quickly to be reliably processed).

3.1.6. Statistical analyses

All statistical analyses were conducted using IBM® SPSS® Statistics (version 20).

To investigate whether the participants' fingertip moisture levels remained constant during exploration of each surface, a Repeated Measure Analyses of Variance (RM-ANOVA) was conducted, where "surfaces" and "time" were defined as "within-participant factors" and the two fingertip moisture levels measured per surface exploration as "within participant variables". Further RM-ANOVAs were conducted to determine whether the exploration kinematics, friction and surface topography changed significantly according to the surface being explored. For each of these RM-ANOVAs, "surfaces" were defined as a "within-participant factor" and "within-participant variables" were respectively v, f_N, f_T, μ, α and β.

The correlations between the surfaces' pleasantness levels (independent variable) and respectively v, f_N, f_T, μ, α and β (dependent variables) were estimated using a Spearman correlation analyses.

For all analyses, effects were considered significant for $p<0.05$.

3.2. Results

The participants' fingertip moisture levels did not vary significantly between first and last exploration of each material ($F_{(1,7)} = 1.70$; $p = 0.23$).

The range and the mean values of the participants' spontaneous exploration kinematics and f_T are indicated in Table 2.

Table 2: Summary of exploration kinematics

Variable	Mean (mean±std)	Range (min-max)
v	104.0 ± 56.4 mm/s	42.0 – 321.0 mm/s
f_N	0.7 ± 0.3 N	0.2 – 1.6 N
f_T	0.5 ± 0.3 N	0.1 – 1.5 N

RM-ANOVAs and correlation analyses suggested both that participants adopted a preferred exploration strategy. Indeed, v and f_N were neither significantly adapted according to the surfaces being explored, nor significantly correlated with pleasantness (Table 3). In contrast, f_T, μ, α and β varied significantly according to the scanned surface (Figures 3-4; Table 3).

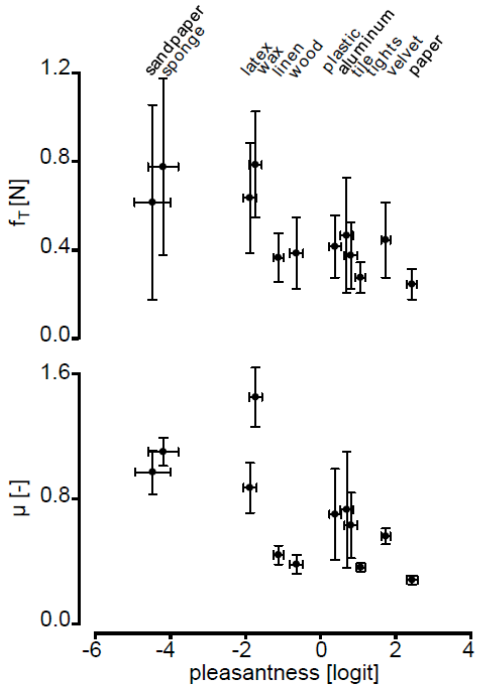

Figure 3: Correlation f_T - *pleasantness* (top) and μ - *pleasantness* (bottom)

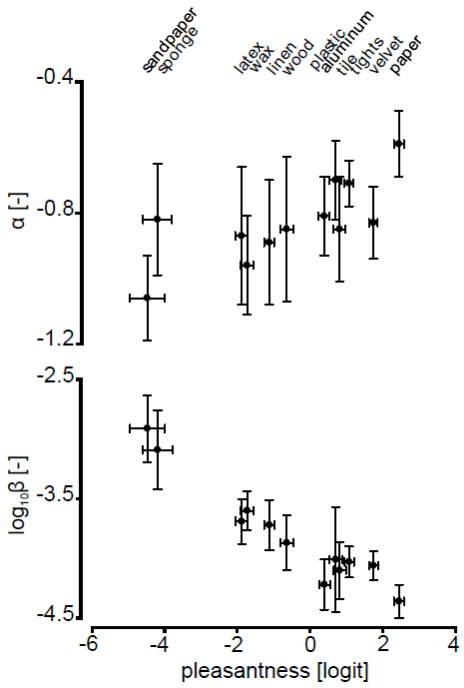

Figure 4: Correlation *α* - *pleasantness* (top) and *β* - *pleasantness* (bottom)

f_T and μ were both negatively correlated with pleasantness (Table 3), suggesting that higher friction, occurring during surface exploration, induces lower pleasantness perception. Finally, the statistical analyses of the character of the motion-induced vibrations during surface exploration showed that (i) surfaces were perceived to be more pleasant if the spectrum of the friction force fluctuations was evenly distributed in the low and high spatial frequencies (*i.e.* significant positive correlation between *α* and pleasantness; Table 3) and (ii) the resulting vibration strength was low (significant negative correlation between *β* and pleasantness; Table 3).

Table 3: Results of RM-ANOVA and Correlation analysis

Variable	n	RM-ANOVA		Correlation	
v	8	$F_{(11,77)}$=1.66	p=0.99	ρ=0.16	p=0.130
f_N	8	$F_{(11,77)}$=1.82	p=0.65	ρ=0.14	p=0.187
f_T	8	$F_{(11,77)}$=5.99	p<0.001	ρ=-0.45	p<0.001
μ	8	$F_{(11,77)}$=38.80	p<0.001	ρ=-0.65	p<0.001
α	7	$F_{(11,66)}$=9.13	p<0.001	ρ=0.46	p<0.001
$log_{10}\beta$	7	$F_{(11,66)}$=33.09	p<0.001	ρ=-0.80	p<0.001

This observation is illustrated in Figure 5, where the friction induced vibrations of ‘paper’ are evenly distributed in the low and high frequencies. This is not observed for those of the ‘sandpaper’.

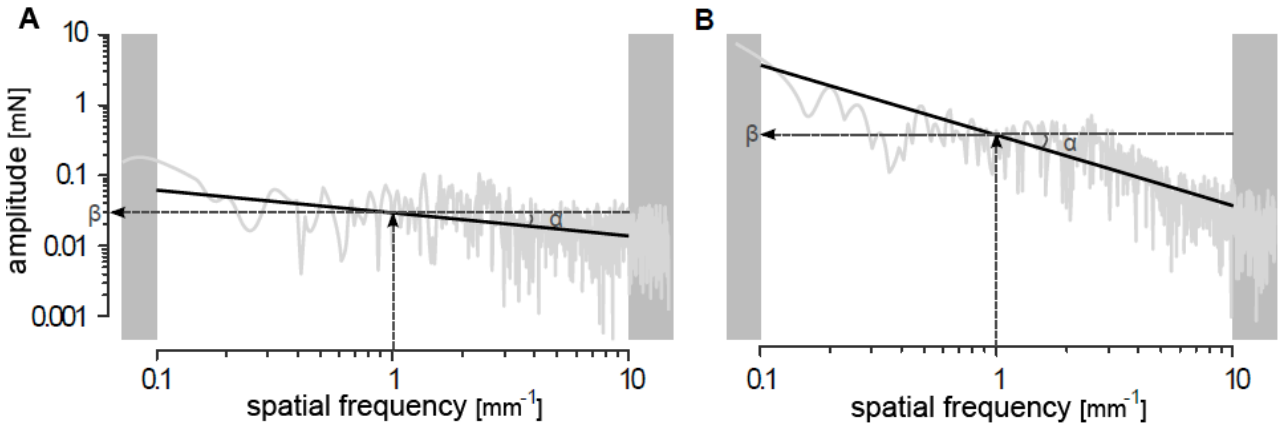

Figure 5: Illustration of the friction induced vibrations by A “paper” and B “sandpaper”.

The next study was conducted to investigate whether pleasantness perception induced through *passive* fingertip stimulation was influenced by the surfaces’ topographies and the friction forces occurring during stimulation. Furthermore, the effect of normal force with which the stimuli are applied and the stimulus temperature on pleasantness perception have been investigated.

4. STUDY 3 – PHYSICAL FACTORS INFLUENCING PLEASANT TOUCH DURING PASSIVE FINGERTIP STIMULATION (*adapted* from Klöcker et al., 2014)

4.1. Materials and Methods

4.1.1. Participants

Twenty-two healthy subjects were enrolled for this third study.

4.1.2. Experimental apparatus

The experimental apparatus consisted of 3 thermal stimulation modules (TSM), on the top of which aluminum plates could be fixed (Figure 6). Every TSM (Figure 6) allowed to regulate the surface temperature of the aluminum plates in a range between 10°C and 50°C by using two high performance Peltier cells (HP-127-1.0-1.3-71P, TE Technology, Inc., MI, USA), a heat sink (MBF35003-24W/2.6, Malico, Inc., Taiwan) and exhaust fans (GM1203PFV1-8 F-GN, Sunonwealth Electric Machine Industry Co., Ltd, Taiwan) that contributed to remove the amount of exceeding heat from Peltier cells. Two NTC thermistors (TCS-610, Wavelength Electronics, Inc., MT, USA), embedded in the aluminum plates, allowed thermal feedback together with 2 linear Proportional-Integral temperature controllers (HTC3000, Wavelength Electronics, Inc., MT, USA) and also allowed the stimulation temperature (TS) to be measured. The 3 TSM were rigidly fixed on an aluminum frame. This structure was installed on the top of two 6-axis, strain-gauge force-torque sensors (Mini 40 and Nano 43, ATI Industrial Automation, Inc., Apex, NC, USA) which were positioned on a 4-axis robot (4-axis SCARA HS series 4535G, DENSO Products and Services Americas, Inc., CA, USA). The robot could be controlled in the normal, tangential and rotational directions with predefined velocities. Acquisitions of the force sensor signals, the position of the robot as well as the temperature of the stimuli have been made at a sampling rate of 1 kHz. Furthermore, to control the participants' fingertip moisture levels (M), the room temperature (T_R) and the relative humidity (H) during the experiment, a Corneometer® CM 825 (CK electronic GmbH, Köln, Germany) was fixed on the measurement experimental apparatus. The fingertip temperature (T_F) could be measured through an infrared thermometer Raytek MI3 (Raytek Corporation, Santa Cruz, CA, USA) which was also fixed on the apparatus. The measurement experimental apparatus was equipped with a hand-arm support which allowed the participant to rest its arm and hand in a way that only the right index fingertip could be stimulated (Figure 6).

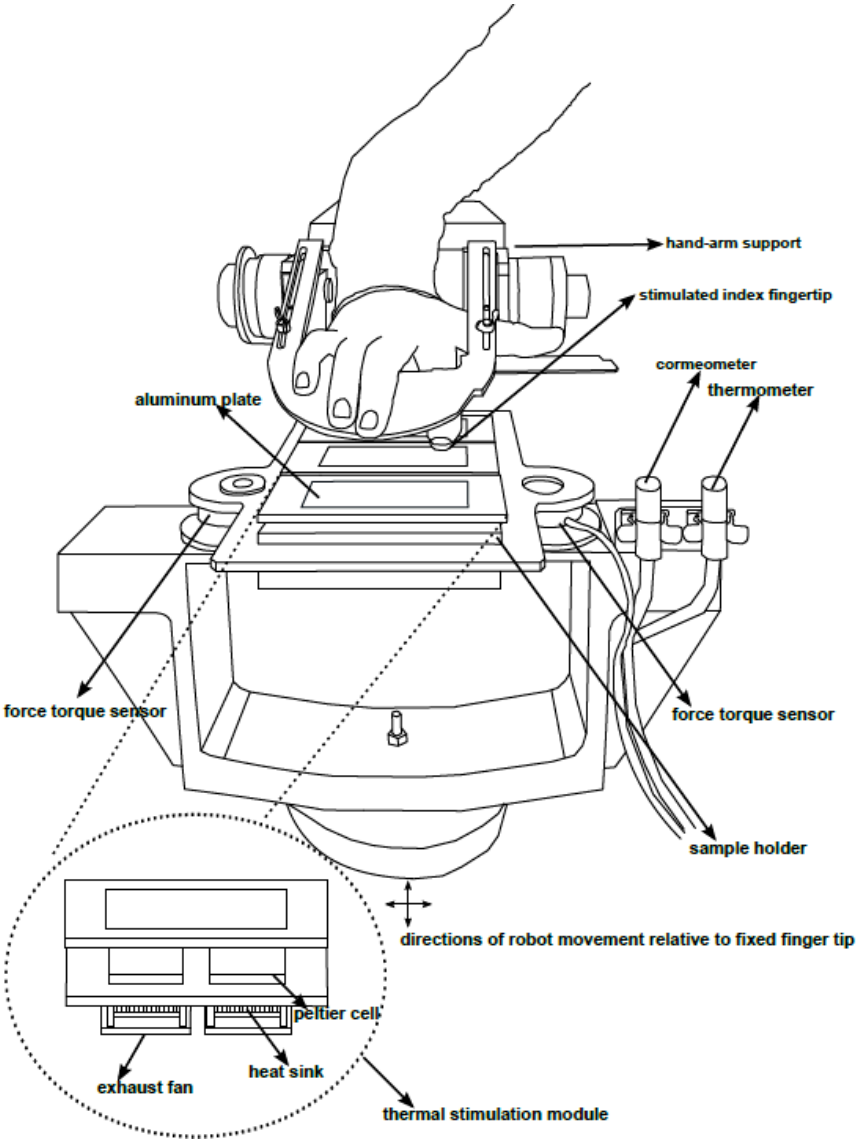

Figure 6: Measurement apparatus of “Study 3”

Three aluminum plates with different average roughness levels (*Ra*) were obtained through controlled electric discharge machining of their surfaces. Their *Ra* was characterized by surface contact profilometry (DektakTM 150 profiler, Veeco Instruments Inc., Arizona, USA). Three profilometry measures were taken per aluminum plate following the long axis of the plate. Mean *Ra* of (i) the smooth plate was 1.4±0.1 µm, (ii) the medium plate was 13.1±1.1 µm and (iii) the rough plate was 40±3 µm.

Each aluminum plate was applied to the index fingertip with 3 different normal forces (f_N) of 0.5N, 1N and 2N and 3 different temperatures (T_S) of 15°C, 30°C and 40°C. As a consequence, we used 27 different stimuli during the experiment (*i.e.* combination of three roughness levels, normal forces and temperatures).

4.1.3. Experimental procedure

Each participant was installed next to the measurement apparatus and the right upper limb was comfortably positioned for stimulation (Figure 6).

After blindfolding the participant, T_R and H were measured. Before fingertip stimulation, M and T_F were controlled. The initial stimulation was then applied in three phases: (i) the robot moved

vertically to bring the index fingertip in contact with the stimulus, (ii) the robot was maintained stationary in contact with the fingertip during five seconds to achieve a stable $f_{N,}$ (iii) the robot applied the stimulus to the participant's index fingertip, by a horizontal movement (from left to right) at 35 mm/s. Participants had to rate the pleasantness of the third phase of each stimulation as very pleasant (scored 0), pleasant (scored 1) or unpleasant (scored 2). The same procedure was repeated for the remaining 26 stimuli. During fingertip stimulation, f_T and f_N were recorded, along with T_S and the robot's position. Figure 7 illustrates a typical trial of the signals recorded during the stimulation phase.

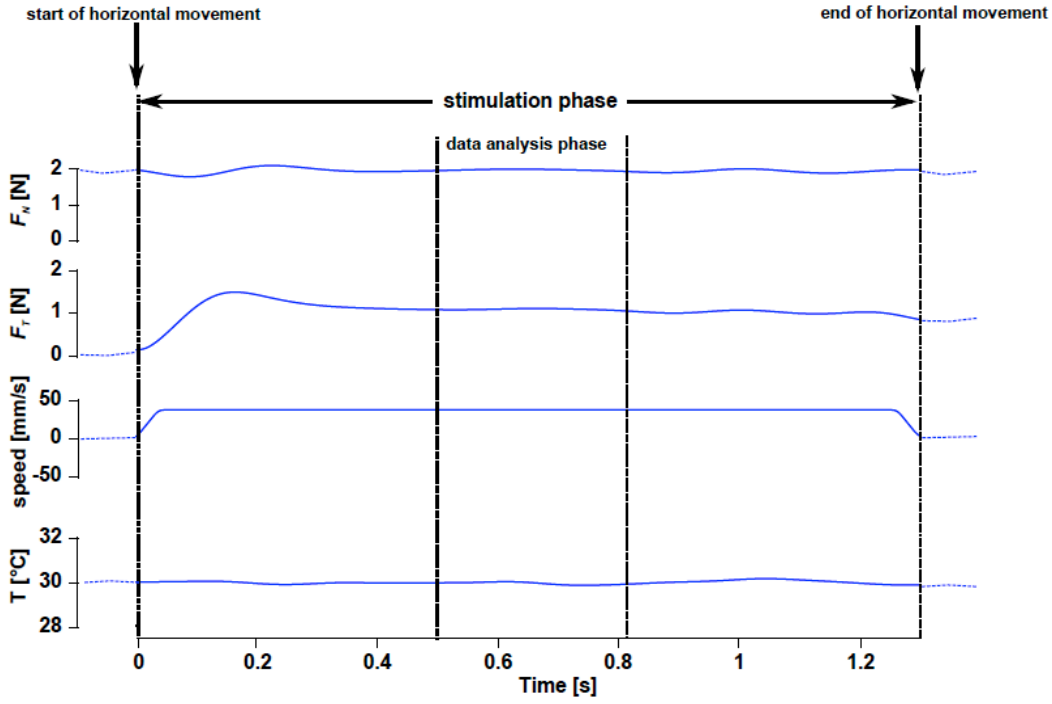

Figure 7: Typical trial of one stimulation

If the aluminum plates were applied at 15°C, mean fingertip moisture level, M, and mean fingertip temperature, T_F, were respectively 39±2.7 arbitrary units (a.u.) and 33±0.2°C. If the aluminum plates were applied at 30°C, M was 40±3.2 a.u. and T_F was 32±1°C. If the aluminum plates were applied at 40°C, M was 39±3.4 a.u. and T_F was 33±0.2°C. Room temperatures ranged from 23.1°C to 30.9°C and room humidity from 44.5 % to 58.1 %.

4.1.4. Data processing

One ordinal pleasantness total score could be calculated per stimulus. These scores could range from 0 (all participants rated it very pleasant) to 44 (all participants rated it unpleasant). The Rasch model was used to logarithmically transform these scores into linear and unidimensional pleasantness measures. DIF was investigated for M, T_F, age, gender, T_R and H.

All data analyses of the stimulation variables (*i.e.* f_N, f_T, T_S) focused on 600 ms of the steady-state fingertip stimulation phase (third phase) (Figure 7). The software package Matlab® (version 7.10) was used to (i) numerically low-pass filtered (Butterworth 4th order filter; 5 Hz) all data and (ii) compute mean f_T, f_N, μ as well as T_S per stimulation and per participant. Table 4 summarizes the mean f_T and μ values per aluminum plate and normal force level.

Table 4: Mean tangential force values and mean dynamic coefficient of friction

Normal force [N]	Smooth plate (MEAN±SD)	Medium plate (MEAN±SD)	Rough plate (MEAN±SD)
0.5	F_T = 0.27±0.12 [N] μ = 0.54±0.24 [-]	F_T = 0.22±0.03 [N] μ = 0.44±0.06 [-]	F_T = 0.25±0.01 [N] μ = 0.5±0.02 [-]
1.0	FT = 0.52±0.22 [N] μ = 0.52±0.22 [-]	FT = 0.46±0.03 [N] μ = 0.46±0.03 [-]	FT = 0.56±0.02 [N] μ = 0.56±0.02 [-]
2.0	FT = 1.01±0.42 [N] μ = 0.63±0.22 [-]	FT = 0.92±0.16 [N] μ = 0.45±0.08 [-]	FT = 1.14±0.01 [N] μ = 0.57±0.007 [-]

4.1.5. Statistical analyses

Stepwise forward multiple linear regression has been used to investigate whether pleasantness perception of the stimulations could be predicted by (i) the surfaces' topographies, (ii) the friction forces occurring during stimulation, (iii) the normal force with which the stimuli were applied and (iv) the stimulus temperature. The linear and unidimensional pleasantness measures were defined as dependent variables, whereas Ra, f_T, f_N, T_S, T_F, M were defined as independent variables. This analysis was performed with JMP® 10.0 (SAS Institute Inc., Cary, NC 27513, USA) where effects were considered significant for $p < 0.05$.

4.2. Results

One stimulus was rated as unpleasant by every participant (rough plate, 2 N, 15°C) and had thus an extreme score. This indicates that the stimulus was too unpleasant for the subject sample. As it is not possible to determine a definite pleasantness level for such stimuli, it was no longer taken into account for further investigations[2]. The final *Passive Pleasant Touch Scale* was thus formed of the 26 remaining stimuli. In Table 5, all stimuli are presented according to their pleasantness measures (expressed in logits) along with their associated standard errors. The rough plate, 2 N, 40°C, was the most unpleasant stimulus of the scale, whereas the smooth plate, 0.5 N, 30°C, the most pleasant one. The invariance analysis did not highlight any DIF.

[2] To illustrate this phenomenon, imagine students would take mathematical test where only 20% were able to say that 5^2 equal 25. This allows locating the difficulty level of this exercise respective to the ability level of the sample. Indeed, the result indicates that the difficulty to solve this problem should be lower than the mean ability of the 20% of students who were able to solve it but higher than the mean ability of the 80% of students who were not able to solve it. However, if no student would have been able to answer the problem correctly, it would be impossible to fix a difficulty level based on the students' abilities. The only information would be that this exercise was too difficult for the sample.

Table 5: Items of the *Passive Pleasant Touch Scale*

Stimulus	Pleasantness [logit]	SE [logit]
R F2 T40	-4.359	1.332
R F2 T30	-3.004	0.731
R F1 T40	-1.449	0.431
R F1 T15	-1.396	0.425
R F1 T30	-1.395	0.425
M F2 T15	-1.145	0.401
R F0.5 T15	-0.523	0.359
S F2 T15	-0.414	0.355
R F0.5 T30	-0.382	0.353
R F0.5 T40	-0.325	0.351
M F2 T40	-0.002	0.342
M F2 T30	0.123	0.339
S F1 T15	0.218	0.338
S F2 T40	0.231	0.338
S F0.5 T15	0.232	0.338
M F0.5 T15	0.35	0.337
M F1 T15	0.393	0.337
M F1 T40	0.572	0.337
M F1 T30	0.915	0.341
M F0.5 T40	1.012	0.343
S F1 T40	1.023	0.343
M F0.5 T30	1.4	0.356
S F2 T30	1.594	0.366
S F0.5 T40	1.962	0.390
S F1 T30	2.035	0.396

S F0.5 T30	2.336	0.424

The multiple linear regression analysis showed that only *Ra* and f_T significantly predicted the pleasantness measures as defined through the *Passive Pleasant Touch Scale*. Together, *Ra* and f_T explained 88% of the variance of the pleasantness measures. *Ra* seemed to predict a higher part (54%) of these measures than f_T (34%). Figure 8 shows actual pleasantness measures vs. those predicted by the model as well as the model's equation. The latter highlights that stimuli are perceived as less pleasant if (i) their *Ra* increases and (ii) the f_T, brought about by the movement of the plate under the fingertip increases.

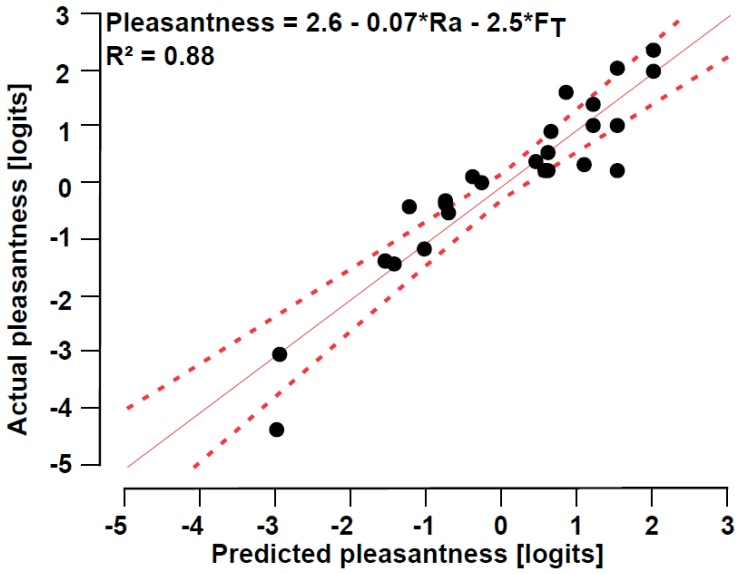

Figure 8: Typical trial of one stimulation

5. GENERAL DISCUSSION

Touching and exploring surfaces with the fingertips induces skin deformations which will be transformed into nerve impulses, leading to a perception or a conscious experience (Kandel, 2000). At fingertip level four different afferent units respond to such mechanical skin deformations. However, no afferent fiber type at fingertip level responds specifically to the pleasantness level of stimuli applied to the skin. We hypothesized therefore that pleasantness sensation at fingertip level arises through the (combined) activity of specific mechanoreceptive afferent systems and is thus dependent on specific physical characteristics of surfaces.

For more than 1 century, scientists are interested in the study of pleasant touch. Major (1985) asked subjects to explore fifty-one different textures and found that “stiffness”, “roughness” and “coarseness” perceptions were found unpleasant. The contrary was shown for “softness” or “smoothness” perceptions. Further studies strengthened these indications (Ripin & Lazarsfeld, 1937; Ekman et al., 1965; Guest et al., 2009; Essick et al., 2010). The studies suggested thus that the subjective perception of surface texture played a role in subjective pleasantness perception occurring through stimulations at fingertip level. However, none of them investigated whether the subjective ratings of pleasantness and of texture qualities met fundamental scaling properties, questioning the psychometric validity of these ratings. Some studies went even a step further and applied parametric statistics to these data.

Reliable measures of latent variables should result from objective measurement scales. Fundamental scaling properties of such measurement scales should also be tested, by using for example the Rasch Model. Consequently, we used this model to elaborate a unidimensional and linear *Pleasant Touch Scale* (Klöcker et al., 2012). This scale pointed to material physical properties being perceived as more or less pleasant to touch, namely (i) the materials’ surfaces topographies and (ii) the friction occurring at interface finger-surface during exploration. The second study strengthened our initial findings (Klöcker et al., 2013). Indeed, the pleasantness level of twelve materials of the *Pleasant Touch Scale* could significantly be correlated with the average friction force arising at finger-surface interface through tactile surface sensing. Furthermore, their pleasantness levels could significantly be correlated to variables reflecting the frequency content of the exploration induced vibrations. The third study (Klöcker et al., 2014) dealt with passive touch. The latter indicated that, similar to the active touch condition, friction occurring at interface finger-surface during fingertip stimulation as well as the average surface roughness level of a stimulus (or its surface topography) predict both pleasantness levels of stimuli during passive touch. Furthermore, results of this study indicated that neither the stimulus temperature nor the normal force with which stimuli were applied to the fingertip had the potential to influence the pleasantness perception.

The results of the studies presented in this manuscript are of relevance for the “tactile branding” field. The aim of “tactile branding” is to generate a connection between the consumer’s emotional feeling and the brand through the stimulation of the tactile sense. Indeed, what a product feels like can influence people’s decision on buying this product or not (Spence and Gallace 2011). For example, the textile industry typically aims to create comfortable and pleasant products. Indeed, consumers are more likely to pick up and touch products with pleasant material properties (McCabe et al. 2003) which may induce them to buy these products. The electronic industry tries also to use more and more “tactile branding” to promote their products. For example, the Apple

iPod can easily be recognized by only touching it (Spence and Gallace 2011). Another industry dealing with tactile sensation is the cosmetic industry (Horiuchi et al. 2009). Indeed, users like to achieve a smooth tactile sensation after the application of a hand lotion. Finally, it is interesting to note that marketing campaigns use nowadays even other sensory modalities, such as the visual or auditory modalities, to evoke specific tactile perceptions. This is of importance for the online shopping marked.

In order to avoid any intermodal interference between vision and touch, participants of the studies presented in this thesis manuscript were systematically blindfolded. A future study could explore whether the visual presentation of textures does influence the tactile perception of pleasantness.

The assessment of pleasantness perception induced through tactile surface sensing used in this work was based on a measurement scale which had been elaborated using the Rasch model. The material classification is therefore unidimensional and linear. On the basis of this material classification, physical surface properties could reliably be related to the materials pleasantness levels induced through active and passive surface exploration.

ACKNOWLEDGMENTS

We are grateful for the kind participation of all participants, the technical support provided by Julien Lambert, Domenico Camboni and Dr. Calogero Oddo. This work was supported by a grant from the Commission of the European Union under Contract No. EU-FP7-NMP4-SL-2009-228844, NanoBioTouch. This work was supported by the European Research Council, Advanced Grant PATCH, agreement No.247300.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

An Interactive Genetic Algorithm for the Study of Product Semantics

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Abstract: This study uses an Interactive Genetic Algorithm (IGA) for eliciting users' perceptions of products. It aims to understand perceptions, and to determine the product's attributes that contribute to reinforce - or inhibit - a given semantic dimension. The product proposed to illustrate the study, defined in collaboration with the Renault Company, is a digital instrument panel, integrated in a car dashboard, and the semantic dimension considered is its "sportiness". After a parameterization of the instrument cluster, an interactive assessment test, based on IGA, is conducted on different products' pictures with a panel of 30 participants. The IGA test proposes a set of 8 parameterized designs, which are iteratively presented to each participant with their pictures via an interactive interface. From these designs, the user has to select the most representative ones according to the considered semantic dimension (sportiness). From iterative choices of the user, the results show that the design of the product converges toward representative designs of the semantic dimension. We present in the paper the analysis of the results of the IGA test, using Hierarchical Ascendant Classification (HAC), univariate and multivariate analysis. The effect of the design variables and their different modalities on the sportiness of the product is discussed. The agreement between the different participants is also studied, to uncover different typologies of products and identify design trends. The results show that IGA can be an interesting alternative to classical rating tests on experimental designs, used in conjoint analysis or in Kansei Engineering.

Keywords: interactive genetic algorithms, product semantics, user centered design, multivariate analysis.

1. INTRODUCTION

Emotions elicited from product appearance may enhance the pleasure of using things and design for emotions is now an important topic in engineering design (Barnes & Lillford, 2009) The development of successful products requires the control of product semantics, the “symbolic qualities of man-made forms in the context of their use and application of this knowledge to industrial design” (Krippendorf & Butter, 1984). To manage the risks of design projects, companies must control that a product matches the design brief, defined by specific semantic dimensions. For example, the digital instrument cluster of a sporty car must inspire “sportiness" to customers, and the company must control since the early stages of the project that the design decisions are in agreement with this connotation along the design process. The challenge for designers is to understand what “sportiness” means to customers, in order to translate it into relevant design attributes. Even if designers are trained and skilled to understand customers, capture trends, and make innovative proposals, discrepancies may occur between designers’ and user’ product perception (Hsu et al., 2000). Furthermore, design decisions concerning the materials or the manufacturing processes may be in conflict with the initial designer intend. Therefore, to assist designers and engineers in their design decisions and to confirm their proposals, an active research field in product design concerns the analysis of end-users’ evaluations, in order to extract useful information for product innovation (Hsiao, 2002) (Orsborn et al., 2009).

In this context, a first category of contributions concerns the modeling of customers’ perceptions and preferences (Hoyle et al., 2009). Conjoint analysis, the typical decomposition method of preference, initiated in marketing, has now several applications in design (MacDonald et al., 2009) (Wassenaar et al., 2005). Conjoint analysis shares similarities with the Japanese Kansei engineering, a design method to account for user’s feelings and perceptions (Nagamachi, 1995). From subjective measurements of the user’s “Kansei”, obtained generally with the semantic differential method and adjective pairs, different statistical models are proposed to translate the user’s perceptions into design elements and take design decisions. The design of a car control panel using multivariate analysis and partial correlation coefficients is for example proposed in (Jindo & Hirasago, 1997). In the same spirit, the influence of slight changes in product attributes on user’s emotions using an ANOVA model is presented in (Artacho et al., 2010). All these approaches have in common subjective assessments of users, and assume a mathematical model (defined a priori) between the perceptions/preferences and the design attributes.

A second category of methods for the analysis of users’ evaluations is not model-based and uses human-computer interactions. In this case, an algorithm gradually refines the propositions made to the users, for example with interactive evolutionary computation (IEC), a category of methods where the user plays the role of the evaluator in an evolutionary process (Takagi, 2001). In IEC, the user assesses the fitness of the population (adaptation of the population to the problem), by choices or ratings for example. Particular cases of IEC are IGA (Interactive Genetic Algorithms), where genetic operators such as recombination, crossover, and mutation are used to modify design samples (Kelly, 2008). This method has been used to capture aesthetic intention of participants for the design of cartoons (Gu et al., 2006), car’s silhouettes (Yannou et al., 2008), for preference modeling (Kelly et al., 2011). IGA have also been tested in previous studies for the design of table glasses (Poirson et al., 2011) or cars’ dashboards (Poirson et al., 2013). These studies confirmed their utility to extract designs trends and to obtain a final product representative of a determined semantic dimension.

We present in this paper a study using IGA to investigate product semantics. An experiment is

conducted with a panel of participants who is charged to assess the degree of “sportiness” of the digital instrument panel of a car dashboard. The objective is to show how IGA can be used to understand a specific semantic dimension and to extract representative design attributes. We propose in this paper to show how the results of an IGA test can be analysed to understand the relations between design attributes and a semantic dimension of the product, assessed by the participant. An additional objective of the paper is to show how to account for inter-individual differences in the perception of the semantic dimension.

The paper is organized as follows. A short background on Interactive Genetic Algorithms is presented in section 2. After a description of the parameterisation of the digital instrument cluster, Section 3 presents the organisation of the IGA test. Section 4 presents the results. Conclusions are drawn in section 5 on the main contribution of this paper and recommendations in product design.

2. BACKGROUND ON INTERACTIVE GENETIC ALGORITHMS

2.1. Principles

Genetic algorithms are evolutionary optimization methods (Goldberg, 1989). Based on the principle of Darwin’s natural evolution theory, the algorithm proceeds to a selection of parents, which will spread in the next generation their genetic dominant heritage, suitable for a desired objective. Classically, the fitness evaluation of the individuals is calculated numerically with a mathematical function known beforehand. A particular category of GA, Interactive Genetic Algorithms (IGA), introduces the user in the optimization loop to assess the fitness. For each iteration, the user selects solutions (products) that he/she considers as the most interesting for the desired objective. After a number of iterations (convergence loop), the method may converge toward solutions that fulfill the users objective. These algorithms are used for example to explore design spaces and to encourage creativity (Kim & Cho, 2006) (Qian & Ben-Arieh, 2009). Since the user decides the individual fitness, there is no need for a prior and unique formulation of the fitness function. For some applications, such as exploring the semantic dimensions of a product, this advantage is crucial.

2.2. Implementation of the IGA

After a definition of the variables of the product and their corresponding levels, a coding of the designs, represented by a chromosome, is proposed. Our implementation of the IGA uses a binary coding and discrete-valued variables. The IGA creates an initial population of designs by generating randomly the chromosomes, and presents them to the user as digital drawings. According to the instructions given to the user for the experiment, the user then has to select a subset of these individuals (1 or 2), representative of the semantic dimension studied. A new population of individuals is then created using one of the three following operators, applied to each individual of the population and selected according to tuning parameters:

- **Crossover**. The individual is crossed with a second parent in the population to form a child. Thanks to a “roulette wheel” method, the individuals selected by the user are favored to be parents in the next population. The roulette wheel is managed by the parameter *Rw* (the chance that a selected individual will be parent in the crossover operation is multiplied by the weight *Rw* >1). The probability of selection of this operator “crossover” is managed by the parameter *Rc*. This operator contributes to the convergence toward products with the desired perception.
- **Mutation**: random mutation of one variable of the individual. The probability of selection of this operator “mutation” is managed by the parameter *Rm.* This operator controls the diversity of the designs among the population.

- **Duplication**: simple duplication of the individual. The probability of selection of this operator is 1-(*Rc + Rm).* This operator allows the conservation of products with interesting features.

This iterative process runs until the program has reached the maximum number of generations allowed by the experimenter. The number of individuals in a population (8 in our study) is chosen by the experimenter according to the number of variables and levels, and the size of the screen to represent the designs. To tune the different parameters of our IGA, an automatic process has been implemented (Poirson et al., 2010). This process uses simulated "virtual" users and a "target" product in the design space. To simulate the choices of a virtual user, a distance function between the individuals of the population and the target is computed. By launching several simulations in the same conditions (Monte Carlo method), an average estimate of the convergence rates of the IGA is computed, given the value of the parameters. This process allows the experimenter to determine the "optimal" tuning of the parameters, given a maximum number of generations. To not fatigue the user, we considered that a participant could process a maximum of 30 generations. A more complete description of the implementation of our IGA can be found in (Poirson et al., 2013).

3. EXPERIMENT

3.1. Parameterization of the product

The product under study is the digital instruments panel of a car's dashboard. In modern cars, a display, made of a Thin Film Transistor (TFT matrix) can be used to show information to the drivers. This screen (see an example on figure **3**) is integrated in the dashboard and contains different elements showing driving information. The advantage of this display is that its design is customizable and that different trends can be programmed in vehicles.

According to the practice of car markers and after a qualitative analysis of different existing designs, 8 variables (V_1 to V_8) were defined to parameterize the design of the digital display. The definition of the 8 variables, and their associated modalities, is as follows (Table **1** shows the picture of each modality):

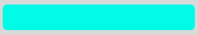
- V_1: Background colour: 3 modalities (light, dark and gradient)
- V_2: Strip colour: 3 modalities (light, dark and gradient)
- V_3: Theme colour: 3 modalities (neutral, orange and turquoise)
- V_4: Font weight: 2 modalities (thick and thin)
- V_5: Fuel gauge: 3 modalities (bar, simple analogic and full analogic)
- V_6: Speedometer: 3 modalities (numeric, simple analogic and detailed analogic)
- V_7: Revolution-counter (RPM counter): 4 modalities (circle bar, simple analogic, detailed analogic and absent)
- V_8: Motor temperature gauge: 3 modalities (continuous bar, divided bar and absent)

The designs proposed for the different modalities were defined on the basis of the current styles and designs available on today's vehicles. The modalities "absent" for the RPM-counter and the motor temperature gauge were included because these two elements are not compulsory in the instruments cluster design. So it is interesting to know if the presence of these two elements has an important influence on the perceived sportiness of the digital instruments cluster.

2D digital pictures were created to represent the digital instruments panel in a realistic way. The pictures of each modality were designed with an image editing software and saved in .png format, with a pixel density of 500 pixels per inch and a transparent background. All the possible

combinations of panels (full factorial design of 3*3*3*2*3*3*4*3 = 5832 products) were created by assembling the corresponding modalities into a panel picture. The pictures were named with their chromosome of 8 digits (one per variable), For example, the instrument cluster defined by the code 22122122 (figure **3**) corresponds to a digital instruments cluster with a dark background (2), a dark strip (2), a neutral theme (1), a thin font (2), a simple analogic gauge (2), a numeric speedometer (1), a simple analogic RPM-counter (2) and a divided bar motor temperature gauge (2).

Table 1: Picture of the different modalities of the 8 variables

Variable	Modality 1	Modality 2	Modality 3	Modality 4
V_1: Background colour	Light	 Dark	 Gradient	/
V_2: Strip colour	Light	Dark	Gradient	/
V_3: Theme colour	 Neutral	 Orange	 Turquoise	/
V_4: Font weight	**53 km/h** Thick	53 km/h Thin	/	/
V_5: Fuel gauge	 Bar	 Simple analogic	 Full analogic	/
V_6: Speed mt.	 Numeric	 Simple analogic	 Detailed analogic	/
V_7: RPM counter	 Circle bar	 Simple analogic	 Detailed analogic	Absent
V_8: temperature gauge	 Continuous bar	 Divided bar	Absent	/

3.2. Tuning of the IGA parameters

For the tuning of the IGA parameters, a goal-seeking task with an automatic procedure with Monte Carlo simulations (simulated subjects) was implemented in a previous study (Poirson et al., 2013). Given the size of the design space (number of variables and modalities), the different parameters of the IGA to get the best convergence given the maximum number of iterations with simulated IGA tests were determined. The following conditions were set:

- 30 generations were allowed for the iterative selection. The participants could not stop the test before the 30th generation. Even if they estimated that the task was fulfilled and the selected design satisfied their perception of sportiness.
- In each generation, the participants had to select at least 1 design and a maximum of 2 designs among a population of 8 designs.
- After the 30th generation, the last 8 selected designs were shown again to the participants. Then, they had to select just one of them and give it a score of sportiness from 0 (not at all sporty) to 10 (very sporty), corresponding to the "quality" of the obtained solution, according to their expectations.
- Values of the IGA parameters: crossover rate *Rc*=0.6, mutation rate *Rm*=0.2, and wheel rate *Rw*=12 to 22 (*Rw*=12 for the ten first generations, and *Rw* increases of one unit every 2 generations from generation 11 to generation 30, until reaching 22 at the 30th generation. This process is proposed to speed up the convergence, by giving more importance to the selected designs at the end of the process).

3.3. Description of the IGA test

The test was proposed to a panel of 30 participants (8 women and 22 men, students or professors at the Ecole Centrale de Nantes). The graphical interface of the test (Figure **1**) presents the 8 images of the current population. For each population, the participants were told to select the most "sporty" digital instruments panel among the population of 8 designs, by simply clicking on the image. This task is repeated until the maximum number of generations is reached (30 generations).

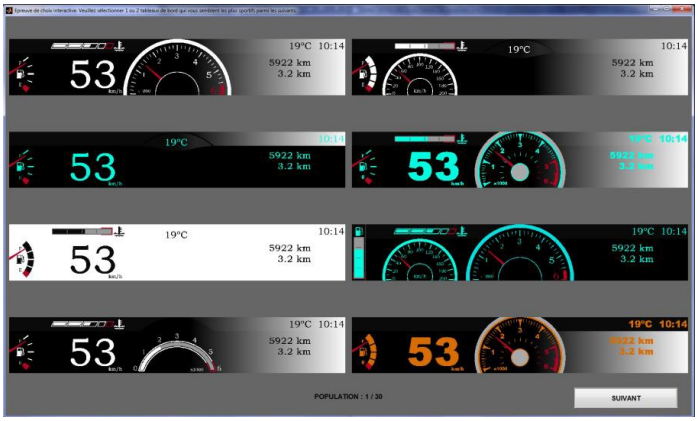


Figure 1: Graphical interface of the IGA test

At the end of the test, the participants answered a short questionnaire about their feelings concerning the test itself. Three questions were proposed: (1) the selection of 3 out of 12 positive and negative proposed terms to describe their feeling about the test (the terms proposed were "Amazing, Attractive, Boring, Clear, Complex, Complicated, Confusing, Intuitive, Repellent, Simple, Soothing, Stressful"), (2) a rating of their feeling during the test on a 5 levels Likert-sale (from 1-very unpleasant to 5-very pleasant), and (3) a free expression space to give comments about the test. The total duration of a session was approximately 20 minutes per subject.

4. RESULTS

The pictures of the 30 products representing the final choices of the 30 subjects at the end of the test are given in figure **2**. We notice that no one chose exactly the same digital instrument cluster.

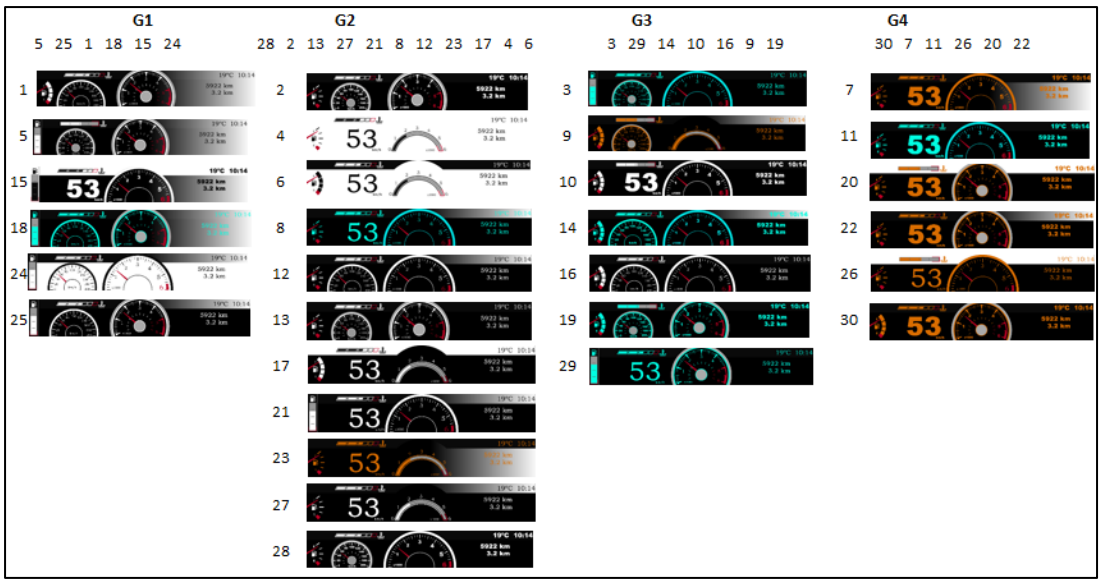


Figure 2: pictures of the 30 "sportiest" product of the 30 participants

The scores of sportiness given by the subjects of their final choices indicate an estimation of the quality of the obtained solution, according to their expectations in terms of sportiness. In our case, the average score was 7.6/10 with a standard deviation of 1.3. Only one subject gave a score lower than 3/10. The others score were higher or equal to 6/10. This relatively high score let us think that the subjects found satisfying product, and that the IGA test allows a convergence toward "sporty" instrument panels. To analyze more in detail the chosen products, we consider that the final choices of the subjects in the IGA test are represented by a matrix *X*, with subject *i* in row (*i*= 1 to 30) and the value of the variable *j* in column (*j*=1 to 8).

4.1. Global univariate analysis of the chosen designs

Table **2** shows the occurrences of each modality of the variables in the matrix *X*. For example, for the variable background (V_1), 3 participants chose the modality 1 (Light), 21 the modality 2 (Dark) and 6 the modality 3 (Gradient) for their final product.

Table 2: Occurrences of the different modalities of the variables in the final choices of the subjects for the IGA test

	V1: Background	**V2: Strip**	**V3: Theme**	**V4: Font**	**V5: Fuel gauge**	**V6: Speedometer**	**V7: RPM-counter**	**V8: temperature gauge**
Modality 1	*3*	*5*	**16**	*11*	*8*	**16**	6	6
Modality 2	**21**	**13**	7	**19**	**13**	*7*	**13**	**24**
Modality 3	6	12	*7*		9	7	11	*0*
Modality 4							*0*	
Multinomial test Signif.	***	N.S	N.S	N.S	N.S	N.S	***	***

***: p<0.01 N.S: not significant

With the occurrences of each modality in the final choice, we are able to define the product corresponding respectively to the most chosen modalities (in bold in table **2** – picture given figure **3**) and the product corresponding to the least chosen modalities (in *italic* in table **2** – picture given

figure **4**– in case of ex aequo, one modality is chosen arbitrarily).



Figure 3: Digital instruments cluster with the most chosen modalities in the matrix X: most “sporty” product in average

The most “sporty” product in average according to the IGA test has a dark background, a dark strip, a neutral theme, a thin font, a simple analogic gauge, a numeric speedometer, a simple analogic RPM-counter and a divided bar motor temperature gauge.

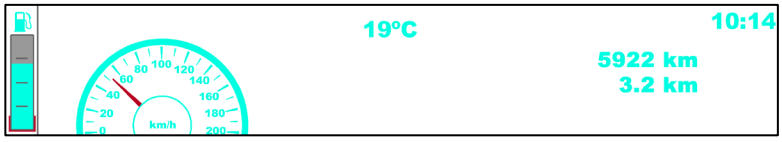


Figure 4: Digital instruments cluster with the least chosen modalities in the matrix X: least “sporty” product in average

The least “sporty” product in average according to the IGA test has a light background, a light strip, a turquoise or orange theme, a thick font, a bar gauge, an analogic speedometer, no RPM-counter and no motor temperature gauge. The data in Table **2** presents furthermore important differences in the scores of the modalities for certain variables. In particular, the modality “absent” for the RPM-counter (V7 - Modality 4) and the motor temperature gauge (V8 - Modality 3) were never selected in the final choice. These two modalities were however presented to the subjects during the test. Therefore, it can be concluded that these two optional elements of the digital instruments cluster are in fact mandatory in order to confer a sporty character to the instrument cluster. To define the variables subjected to the most consensual choice concerning their modalities, a multinomial goodness of fit test of the distribution of the occurrences was carried out. The results are presented in Table **2**. Three variables (V1 V7 and V8) obtain occurrences significantly different from a random distribution at the 1% level. These 3 variables are subjected to a consensus concerning the sportiness of the digital instruments cluster:

- For the background V1: the modality 2 (dark) is over represented comparatively to the two others,
- For the RPM counter V7: the modality 2 (analogic) is over represented comparatively to the modality 4 (absent),
- For the temperature gauge V8: the modality 2 (divided bar) is over represented comparatively to the modality 3 (absent).

In conclusion, for the whole group, a dark background, an analogic RPM-counter and a divided bar temperature gauge constitute consensual cues of a sporty control panel. For the other variables (V2, V3, V4, V5 and V6), there was no significant consensus: either because there were conflicting opinions of the subjects on these variables, or because these variables are not important in the perception of the sportiness.

4.2. Partitionning of the final choices - typology

The objective of this section is to study more in detail the inter-subject differences in the final choice of the product. The previous section showed that three characteristics (black background V1, analogic RPM counter V7 and divided temperature gauge V8) were representative of a sporty instrument cluster for the whole group of participants, but different characteristics may be also

representative for sub-groups of participants. In order to uncover a typology of products for sub-groups of subjects, a Hierarchical Ascendant Classification (HAC) has been performed on the Matrix *X*. The objective is to define a partition of the final choices according to their similarity. To estimate this similarity, the Euclidian distance cannot be used because the variables that define a product are nominal (modalities), not quantitative. A similarity measurements based on nominal variables must be defined. After a transformation of a chromosome into a binary coding using the full disjunctive form (contains a "1" when the modality is present and a "0" when it is absent), the Sokal and Michener similarity index was used with the complete linkage rule for the HAC (Hair et al., 1998). The corresponding dendrogram is shown in figure **5** with a partition in 2 groups A and B.

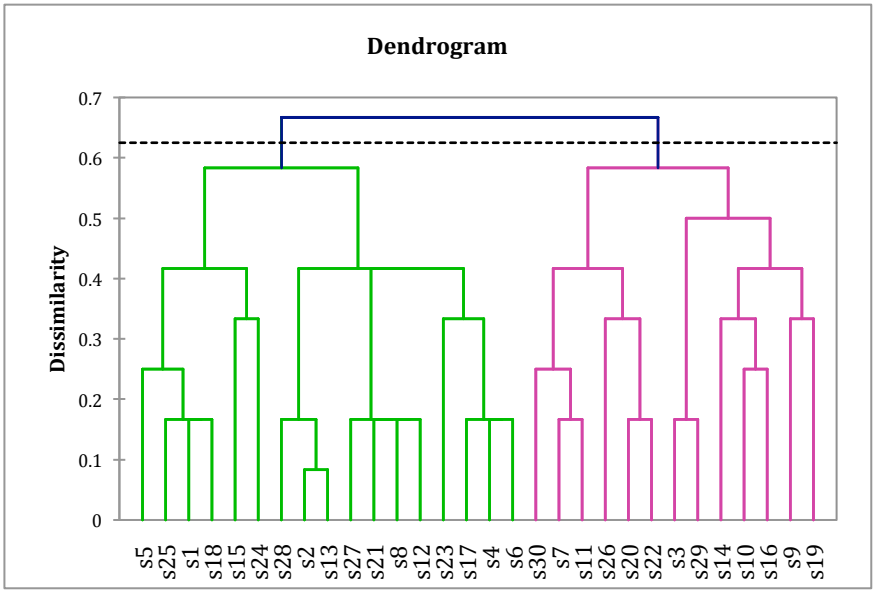


Figure 5: Dendrogram of the clustering of the 30 subjects according to their final choices

4.2.1. Characterisation of the two groups

Table **3** shows the occurrences of each modality of the variables, for each group A and B, and the results of the multinomial test of the distribution of the occurrences.

Table 3: For group A and B, occurrences of the different modalities of the variables in the final choices of the participants

		V1: Background	*V2: Strip*	*V3: Theme*	*V4: Font*	*V5: Fuel gauge*	*V6: Speedometer*	*V7: RPM-counter*	*V8: temperature gauge*
Group A (17 subjects)	Multinomial test Signif.	N.S	N.S	***	**	N.S	N.S	N.S	***
	Modality 1	3	3	**14**	3	6	**8**	5	1
	Modality 2	**9**	5	1	**14**	**8**	5	**6**	**16**
	Modality 3	5	**9**	2		3	4	**6**	0
	Modality 4							0	
Group B (13 subjects)	Multinomial test Signif.	***	N.S	N.S	N.S	N.S	N.S	**	**
	Modality 1	0	2	2	**8**	2	**8**	1	5
	Modality 2	**12**	**8**	**6**	5	5	2	**7**	**8**
	Modality 3	1	3	5		**6**	3	5	0
	Modality 4							0	

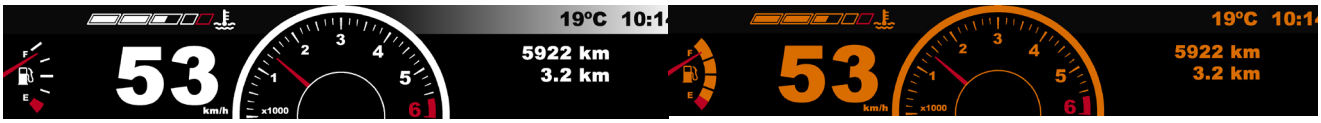
***: p<0.01 - **: p<0.05 N.S: not significant

For group B, the conclusions are similar to those of the whole panel: three variables (V1, V7 and V8) obtain occurrences significantly different from a random distribution. For these 3 variables, the modality 2 is over represented comparatively to the others. This group is relatively homogeneous and pulls the behaviour of the whole panel.

For group A, three variables are subjected to a consensus concerning the sportiness of the digital instruments cluster:

- Theme V3: the modality 1 (neutral) is over represented comparatively to the 2 others,
- Font V4: the modality 2 (thin) is over represented comparatively to the modality 1 (thick),
- As for group B and for the panel, for the temperature gauge V8, the modality 2 (divided bar) is over represented comparatively to the modality 3 (absent).

This analysis leads to a more detailed understanding of the concept of sportiness. For information, the images corresponding to the average product of the 2 groups (most sporty product in average) are given in figure **6**.



Group A Group B

Figure 6: picture of the most sporty product in average for group A (left) and B (right) – IGA test

We can see that the products are not so different visually. Except the colour, the differences concern details of the product, difficult to perceive at first sight. More subjects would be necessary to confirm these two trends concerning the sportiness.

4.2.2. Typology of the two groups

A supplementary analysis can be done on the two groups A and B in order to uncover the main characters that are representative of the differences between the groups (specificities). This analysis, different to those made in the previous section, aims to interpret now the differences between the groups. From the occurrence tables of each group, a computation of the rate of a modality in a group with respect to its rate in the whole population can be computed (Giordano et al., 2000). The rate γ_{ij}^{k} of a modality j for variable i in the group k is given by (equation 1):

$$\gamma_{ij}^{k} = \frac{n_{kij}/n_k}{n_{ij}/n} \qquad (1)$$

where n_{kij} is number of products with modality *j* in group *k* for variable *i*, n_k is the number of products in group *k*; n_{ij} is the number of products with modality *j* in the population for variable *i*, and n is the total number of products in the population. Over-represented modalities (abundant) are characterized by high values of γ_{ij}^{k}, whereas under-represented modalities (scarce) get low values. Given that there are only two groups, the rates are of courses opposite so the modality with the highest rate for A obtains the lowest rate for B. The analysis of the rate was performed to determine the specificities of each group in relation to the total population. Table **4** shows, for group A and B, the modalities V_{ij} that got the two highest rate γ_{ij}^{k}. A more tangible interpretation

concerning the style of the digital instruments cluster and the design trend is also provided.

Table 4: Interpretation of the differences between the groups of digital instruments clusters obtained by the abundance analysis

Group	**Modalities with the two highest rate** γ_{ij}^{k}	**Interpretation of the specificities of the group**
Group A	V11, V31	Light background - neutral theme
Group B	V32, V81	Orange theme - continuous bar temperature gauge.

These results show some specific features, representative of each group, which were not previously highlighted. For example, the light background for Group A and the orange theme for Group B. The light background is more represented in group A compared to group B. However, it doesn't mean that this modality is the most represented. In addition, the neutral theme is more representative of group A and the orange theme of group B. Theses analyses allow to differentiate the two groups and to determine which features are representative of the groups. These results are complementary to those obtained with the univariate analysis and allow a more in depth understanding of the semantic dimension "sportiness".

To conclude, the analyses allow us to extract the most influent variables on the perception of the sportiness. Especially, the variables Background (V1), RPM-counter (V7) and Temperature gauge (V8) have an important influence on the perceived sportiness and a consensus is observed. The variables Theme (V3) and Font (V4) have also an influence but there are different views. Finally, the Strip (V2), Fuel Gauge (V5) and Speedometer (V6) don't appear to influence the perception of the sportiness of digital instruments panels.

4.3. Participants feedbacks analysis

After the IGA test, the participants were allowed to give a feedback on their feelings and opinions on the progress of the test. The analyse of the answers to the questionnaires highlight the following results:

- **Selection of terms**: among the 12 terms proposed, more than half of the participants selected the following 3 positive terms: "Simple", "Intuitive" and "Clear" to describe their feeling about the test. The most selected negative term has been "Boring" with only 6 participants. We notice that among the 6 negatives terms, 2 of them were never chosen: complicated and repellent
- **Rating of feeling during the test**: half of the participants selected the level "4-pleasant" to characterize their pleasure during the progress of the test. Only three participants selected the level "2-Unpleasant" and nobody the level "1-very unpleasant".
- **Free expression about the test**: Among the principal free comments of the participants, we notice that they appreciated the convergence of the algorithm, but they sometimes complain against the fact that in the last generation, the proposed designs were very similar and the same design may be repeated several times.

The analysis of participants' feedbacks highlights the fact that in average, the test has been well accepted and perceived as pleasant and easy to understand.

5. CONCLUSIONS

This paper presented an experiment based on Interactive Genetic Algorithms in order to determine, with a panel of 30 participants, the product's characteristics that contribute to influence

the sportiness of an instrument panel of a car dashboard.

A global univariate analysis was proposed for the analysis of the final choices of the panel. It allowed an extraction of consensual design features, representative of the desired semantic dimension, and the associated levels. In our case, 3 variables associated to their modalities were identified as influential on the sportiness of the digital cluster for the whole group. An image of the most/least sporty product can be obtained. To refine the results, a partitioning of the final choices was realized to identify 2 groups of participants with different opinions on the studied dimension. Abundance analysis and the same univariate analysis that was used for the global population was done to extract consensual design features for each group of subjects. These analyses leaded to a more refined understanding of the concept of sportiness, for each group.

The analysis of the feedbacks of the participants (answers to the questionnaires) showed that the test, based on a choice task, is well accepted by the subjects, easy to understand and to carry out, even pleasant. We showed that even with a short test with few selections, the IGA converge toward representative designs of the semantic dimensions, in a tractable number of generations, acceptable by the subjects. This gives to IGA the potential to study the influence of a large number of variables and modalities with a restricted evaluations number. Furthermore, the method does not postulate any model between the response and the design variables. Complex interactions between the variables can then be studied without an increase of the number of evaluations in the experiment (interactions exclusive OR, logical interactions like A&B, A&-B, …). These interactions between variables may be very important, in particular for the design of forms (Sylcott et al., 2013). The IGA method seems to be especially relevant for creativity stages where the designer wants to identify which variables, among a large of number, have an influence on the perception of the studied semantic dimension. The IGA tests can be a first step before a more refined study with a more classical protocol in Kansei engineering, based on conjoint analysis and semantic differential. On the other hand, the IGA test gives global results, for the whole population of participants, or subgroups, but not at an individual level. Consequently, concerning the influent variables, the test limits to average conclusions, valid for a panel of participants.

For further studies, we will investigate the potential of IGA methods as a creative tool used by experts rather than participants. Different coding of the products can be proposed to promote the diversity of products and innovation (encoding with a tree structure fro example).

ACKNOWLEDGMENTS

Acknowledgments to the students of Ecole Centrale de Nantes for their help in their participation to the tests.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

A Model of User's Preference for Retrieving Preferred Clothes

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Abstract: This paper proposes a model of user's preference for retrieving preferred clothes. This paper has designed a decision process of user's preference. This paper has made the user's preference model based on indexes calculated in each step in the process. The process has three steps, i.e. Attention, Evaluation and Decision step. The attention step is that a user pays attention to principal features of clothes that is the features related to his/her interest. The attention step detects the principal features by the rough set and calculating Attention index. The attention index indicates the degree of user's positive (or negative) attention to the principal features. The evaluation step is that a user evaluates interest concerning the principal features. The evaluation step estimates the preferred degree of the principal features of a user by Evaluation index. The evaluation index is calculated by unifying the attention indexes of positive and of negative. The decision step is that a user decides his/her preference for clothes by using his/her evaluation. The decision step estimates the user's preference by Preference index that totalizes the evaluation index of the user. This paper has evaluated the estimation ability of user's preference by the preference index. The result shows that the preference index could estimate the preferred feature. This paper also shows the result that has evaluated the recommendation of clothes by using the preferred feature to 9 users. The average of the rate of which the clothes that include the preferred features of the user have appeared in top 5 is 98 %.

Keywords: User preference, User modeling, Personalization, Information retrieval, Rough set.

1. INTRODUCTION

Personalization services in the e-commerce are catching the attention of Internet users. They, such as Amazon.com or Ebay.com, analyze what item a user likes and recommend candidate items that he/she may like (Sung, 2005)(Fang,2004)(Ingrid, 2001)(Suk,2011). The users of them can find easily the item that best meets their preferences without spending endless hours on the e-commerce site. In order to support searching of the item that a user wants, the personalization services use personalization and recommendation techniques (Robin,2000). Collaborative recommender technique understands items related to users' preference on the basis of similarity of the ratings of the users. The technique recommends the candidate items to a user based on inter-user comparisons. With this technique, the user can know that many users who have similarity

in his/her rating of item selected the recommended item. However, the user may not be satisfied with the recommended item when the user's preference and other user's preference may not be equal. Content-based recommender technique understands a user's preference based on the features of items the user has rated. The technique can model a relationship between the features of items and the user's preference based on only the user own rating. A user may be satisfied with the recommended item than collaborative recommender technique. However, the technique uses the methods, i.e. neural nets, vector-based representations, etc., to simulate user's preference. Therefore the users cannot understand why the item has been recommended to me, through instinct. Therefore, the user sometimes cannot have confidence in items that the service has recommended.

On the other hand, in real world, a user often accepts the recommendation from a friend. One reason is that the friend explains the reason why he/she has selected the item for the user. Another reason is that a user has known friend's attitude of mind about clothes, and the user has known the friend's preference of clothes. This paper assume that a user has affinity to a service and gets comfortable with the service, if a user can understand what the service has thought and how the service has thought.

This paper proposes a model of user's preference for retrieving preferred clothes. This paper has designed a decision process of user's preference to make a model of user's preference. This paper has built the model based on indexes calculated in each step in the process. The process has three steps, i.e. Attention, Evaluation and Decision step. The attention step is that a user pays attention to principal features of clothes that is the features related to his/her interest. The attention step detects the principal features by the rough set and calculating Attention index. The attention index indicates the degree of user's positive (or negative) attention to the principal features. The evaluation step is that a user evaluates interest concerning the principal features. The evaluation step estimates the preferred degree of the principal features of a user by Evaluation index. The evaluation index is calculated by unifying the attention indexes of positive and of negative. The decision step is that a user decides his/her preference for clothes by using his/her evaluation. The decision step estimates the user's preference by Preference index that totalizes the evaluation index of the user.

This paper is organized as follows: Section 2 describes a decision process of user's preference for modeling user's preference. Section 2 explains Attention index, Evaluation index and Preference index as components of the model of user's preference, and also explains the model of user's preference using three indexes. Section 3 shows the evaluation of the proposed model by making a comparison between the preference of clothes that subjects have shown and the preference of clothes that the model has estimated. Finally, this paper describes the conclusion in the section 4.

2. MODEL OF USER'S PREFERENCE

This section describes the decision process of preference and the design of information processing in each step of the process.

2.1. Design of decision process of preference

A product is expressed by several features. The features are composed by attributes, such as color and texture. The features individualized by values, such as blue or red. A user takes notice of the specific features from several features. For example, even if two users see the same clothes, there are situation that one user pays attention to the color of the clothes and another user pays attention to the shape of it. A user has the criteria of features to which he/she pays attention.

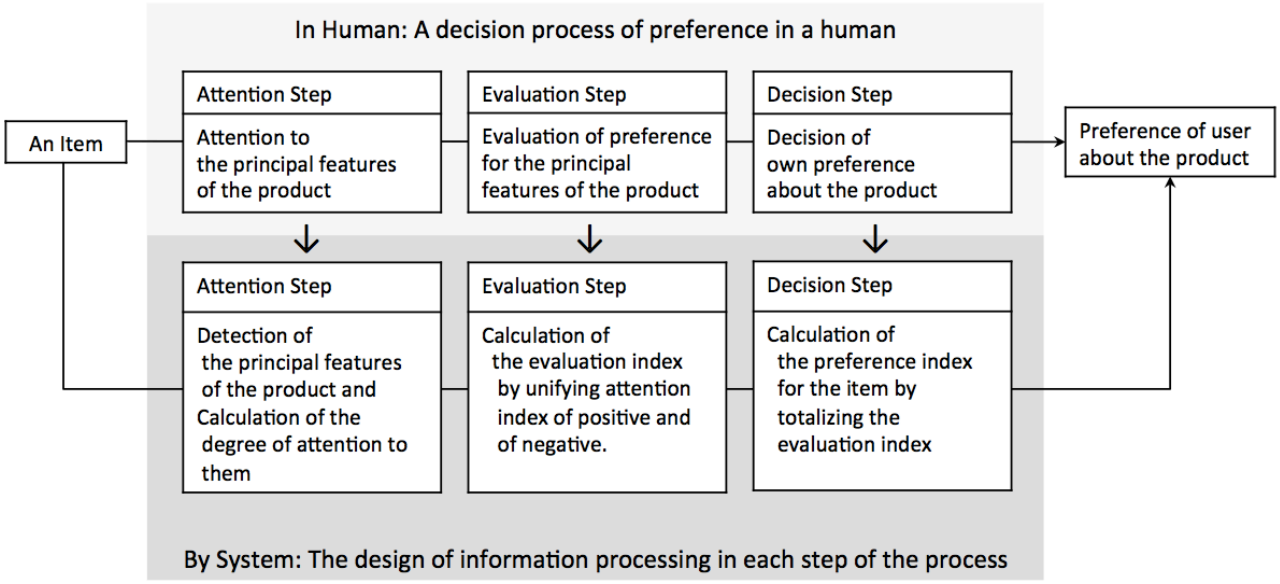

Figure 1: A decision process of preference and the design of information processing in each step

A user judges his/her positive or negative preference of the product based on the features of which he/she has taken notice. This paper assumes that the features of which a user has taken notice are more related to the positive or negative preference than all attributes of the product.

This paper also assumes that a user judges finally his/her preference of a product through a total of preference for the features of the product. In this assumption, this paper has designed a decision process of user's preference that is composed by three steps, i.e. the attention, evaluation and decision step as shown Figure 1.

The attention step is the process that a user pays attention to the principal features of a product. This paper defines the feature related to his/her preference as the principal feature. For example, a user occasionally finds out that he/she has purchased wrong material of clothes after the user has bought or has used the clothes. From this example, this paper assumes that the user has not paid attention to the material when the user has selected the clothes because material is not important. Therefore, as first step for deciding his/her preference for a product, a user only pays attention to product's principal features.

The evaluation step is the process that a user evaluates his/her interest in the principal features. For example, a user often chooses the clothes composed by a favorite color, from several candidate clothes. On the other hand, even if the clothes include favorite features, sometimes, the user does not select the clothes because the combination of them is not good for us. As the second step for deciding his/her preference for a product, a user evaluates his/her interest in the principal features and the combination of them.

The decision step is the process that a user decides his/her preference for a product by using his/her evaluation of each principal feature. For example, a user thinks, " the color in the product is very good, but the shape in it is a little bad. However price of it is low, so I want to buy it ". The user also thinks, "the color and shape of it are very good, so I want the product ". As the third step for deciding his/her preference for a product, a user decides his/her preference for a product by using his/her evaluation.

Table 1: The relation between the features of products and a user's preference for clothes

Product	Features (the attributes, and the value of attributes) of Products						Preference of a user
Clothes	Color	Texture	Category	Neck	Sleeve	Chest Design	
ID_1	Black	Point	Sweater	Turtle	Long	Mark	Positive (Like)
ID_2	Gray	Uniformity	Cut Sewn	Crew	Long	Mark	Positive (Like)
ID_3	Black	Uniformity	Sweater	V	Long	None-Mark	Positive (Like)
ID_4	Brown	Horizontal Stripes	Cut Sewn	Crew	Long	None-Mark	Negative (Dislike)
ID_5	Red	Point	Hood Jacket	Crew	Long	Mark	Negative (Dislike)
ID_6	Deep-Green	Uniformity	Cut Sewn	Crew	Long	None-Mark	Negative (Dislike)

2.2. Design of information processing in each step of the process

This paper designs the information processing of each step in the decision process that a user decides his/her preference of products, through a case study of clothes.

- Attention Step: This paper processes the attention step by detecting the principal features from all features, such as color, shape and so on, of clothes and by calculating Attention index. The attention index indicates how much a user pay attention to the attribute and its value of the principal feature.
- Evaluation Step: This paper processes the evaluation step by calculating Evaluation index. The evaluation index indicates the degree of user's evaluation of the principal feature by unifying attention index of positive and of negative.
- Decision Step: This paper processes the decision step by totalizing the evaluation index of a user. Preference index indicates that the degree of user's preference for the product.

2.2.1. Processing of attention step

In order to process the attention step, this paper extracts principal features of a product by using Rough set (Lech, 2002). The rough set can precisely extract the sets of minimum attributes that certainly distinguish the clothes that a user feels positive preference and the clothes that a user feels negative preference, from whole products. Table1 shows a user's preference for six men's clothes (i.e. ID_1, …ID_6). The user has felt positive preference to three clothes (i.e. ID_1, ID_2, ID_3). Table 1 is called as decision table in rough set. The difference of ID_1 to which he has felt positive and ID_5 to which he has felt negative is only color and chest design of clothes. A color (i.e. dark-brown) and a chest design (i.e. zip-up type) are the minimum attributes and its values to decide the positive preference of the user. The minimum attributes and its values are expressed as IF-THEN rule. The previous example is expressed as "IF the color is dark-brown and the chest design is zip-up type, THEN the user feels positive preference". The rough set describes IF-THEN rules as decision rules. This paper extracts all decision rules from decision table by using the decision matrix based on the reference (Ning, 1995). Table 2 shows all decision rules of positive preference that have been extracted from table 1 using the rough set. The rough set calls the table 2 as a decision matrix. Let $M(D_k)$ denote the decision matrix where D_k ={positive (pos), negative (neg)} is a decision class. Let $M_{ij}(D_k)$ denote the component of $M(D_k)$. For example, each component of $M_{ij}(D_{pos})$ shows minimum attributes that demarcate products related to positive preference of the user. This paper also has extracted all decision rules of negative preference from table 1, in the same way as positive. Let $F(D_k)$ denote the set of all decision rules that belongs to decision class D_k. This paper extracts $F(D_{pos})$ that is inherent in $M(D_{pos})$ by conjunction and disjunction of propositional connective. Equation (1) is $F(D_{pos})$ that has calculated by using Table 2.

Table 2: $M(D_{pos})$: The set of attributes and values that are related to the positive preference of the user

	ID_4	ID_5	ID_6
ID_1	$M_{11}(D_{pos})$ = {(Color, Black), (Texture, Point), (Category, Sweater), (Neck, Turtle), (Chest, Mark)}	$M_{12}(D_{pos})$={(Color, Black), (Category, Sweater), (Neck, Turtle)}	$M_{13}(D_{pos})$={(Color, Black), (Texture, Point), (Category, Sweater), (Neck, Turtle), (Chest, Mark)}
ID_2	$M_{21}(D_{pos})$ ={(Color, Gray), (Texture, Uniformity), (Chest, Mark)}	$M_{22}(D_{pos})$={(Color, Gray), (Texture, Uniformity), (Category, Cut Sewn)}	$M_{23}(D_{pos})$={(Color, Gray), (Chest, Mark)}
ID_3	$M_{31}(D_{pos})$={(Color, Black), (Texture, Uniformity), (Category, Sweater), (Neck, V)}	$M_{32}(D_{pos})$={(Color, Black), (Texture, Uniformity), (Category, Sweater), (Neck, V)}	$M_{33}(D_{pos})$={(Color, Black), (Category, Sweater), (Neck, V)}

Table 3: $F(D_{pos})$: All decision rules of positive preference of the user that have been extracted from $M(D_{pos})$ in Table 2

Rule Number	Extracted rules: $F_i(D_{pos})$
$F_1(D_{pos})$	Color = Black
$F_2(D_{pos})$	Color = Gray
$F_3(D_{pos})$	Neck = Turtle
$F_4(D_{pos})$	Neck = V
$F_5(D_{pos})$	Category = Sweater
$F_6(D_{pos})$	Chest = Mark and Category = Cut Sewn
$F_7(D_{pos})$	Chest = Mark and Texture = Uniformity

$$\begin{aligned} F(D_{pos}) =&((Color, Black) \vee (Category, Sweater) \vee (Neck, Turtle)) \\ &\vee ((Color, Gray) \vee ((Texture, Uniformity) \wedge (Chest, Mark)) \\ &\vee ((Category, CutSwen) \wedge (Chest, Mark))) \\ &\vee ((Color, Black) \vee (Category, Sweater) \vee (Neck, V))) \end{aligned} \quad (1)$$

Table 3 shows $F(D_{pos})$ that has been extracted from $M(D_{pos})$. In this case, we have extracted 7 rules form data in table 2. This paper extracts $F(D_{neg})$ from $M(D_{neg})$, in the same way as positive.

Moreover, this paper uses Covering index (CI) to evaluate the extracted decision rules. Equation (2) is the definition of $CI(F_i(D_k))$.

$$CI(F_i(D_k)) = \frac{F_i(D_k) \cap O(D_k)}{O(D_k)} \quad (2)$$

Let $F_i(D_k)$ denote one decision rule, which is identified as No.i, of all decision rules that belongs to the decision class D_k. Let $O(D_k)$ denote all products that belongs to the decision class D_k. Let $CI(F_i(D_k))$ denote the covering index of $F_i(D_k)$. For example, in table 3, $CI(F_1(D_{pos}))$ is the covering index of $F_1(D_{pos})$. The $F_1(D_{pos})$ is 2/3 because there are two clothes, i.e. ID_1 and ID_3, to include in $F_1(D_{pos})$ within three clothes belonging to the positive group.

This paper defines Attention index of each attribute and its value. The attention index shows how much the user is paying attention to each attribute or its value when the user sense positive feeling or negative feeling. Equation (3) and (4) is the attention index of attribute and of value.

Table 4: The attention index in positive/negative preference of the user that calculated using decision rules in Table 3

Positive

Attention Index for Attribute	Value	The rate of Attention Index
$AI_{Dpos}(Color)$	1.00	0.41
$AI_{Dpos}(Category)$	0.70	0.28
$AI_{Dpos}(Neck)$	0.66	0.27
$AI_{Dpos}(Chest)$	0.04	0.02
$AI_{Dpos}(Texture)$	0.02	0.01

Attention Index for Values	Value	The rate of Attention index
$AI_{Dpos}(Black)$	0.67	0.27
$AI_{Dpos}(Sweater)$	0.67	0.27
$AI_{Dpos}(V)$	0.34	0.14
$AI_{Dpos}(Turtle)$	0.34	0.14
$AI_{Dpos}(Gray)$	0.24	0.14
$AI_{Dpos}(Mark)$	0.05	0.02
$AI_{Dpos}(Cut\ Sewn)$	0.02	0.01
$AI_{Dpos}(Uniformity)$	0.02	0.01

Negative

Attention Index for Attribute	Value	The rate of Attention index
$AI_{Dneg}(Color)$	1.00	0.52
$AI_{Dneg}(Category)$	0.38	0.20
$AI_{Dneg}(Texture)$	0.35	0.19
$AI_{Dneg}(Chest)$	0.09	0.05
$AI_{Dneg}(Neck)$	0.08	0.04

Attention Index for Values	Value	The rate of Attention index
$AI_{Dneg}(Red)$	0.33	0.17
$AI_{Dneg}(Deep\ Green)$	0.33	0.17
AI_{Dneg}(Horizontal Stripes)	0.33	0.17
AI_{Dneg}(Hood Jacket)	0.33	0.17
$AI_{Dneg}(Brown)$	0.33	0.17
AI_{Dneg}(None-Mark)	0.09	0.05
$AI_{Dneg}(Crew)$	0.08	0.04
$AI_{Dneg}(Cut\ Sewn)$	0.05	0.03
$AI_{Dneg}(Point)$	0.02	0.01

$$AI_{D_k}(att) = \sum_{i=1}^{n} \left(\frac{CI(F_i(D_k))}{Len(F_i(D_k))} \times \frac{1}{Len(F_i(D_k))^e} \right) \tag{3}$$

$$AI_{D_k}(v_{att}) = \sum_{j=1}^{m} \left(\frac{CI(F_i(D_k))}{Len(F_i(D_k))} \times \frac{1}{Len(F_i(D_k))^e} \right) \tag{4}$$

Let $AI(att)$ and $AI(v_{att})$ denote the attention index of the attribute (*att*) and its value(v_{att}), respectively. Let the n and m denote the number of rules that include the attribute (*att*) and its value (v_{att}), respectively. Define $Len(F_i(D_k))$ as the number of attribute in $F_i(D_k)$.

In the case of table 3, the attention index of positive preference of "color" is 1.0 because $F_1(D_{pos})$ and $F_2(D_{pos})$ include the attribute "color" in its rule. Table 4 is the attention index of attributes and of values, concerning positive and negative preference. Table 4 shows that the color attribute affects preference than the design of chest and neck. Equation (5) shows the calculation process of the attention index of positive preference of "color".

$$AI_{D_{pos}}(color) = \left(\frac{\frac{2}{3}}{1} \times \frac{1}{1^e} \right) + \left(\frac{\frac{1}{3}}{1} \times \frac{1}{1^e} \right) = 1.0 \tag{5}$$

2.2.2. Processing of evaluation step

This paper defines Evaluation index in order to simulate user's evaluation of the principal features based on the preference of positive and negative for the principal features. The evaluation index is calculated by unifying the attention indexes of positive and negative. Equation (6) and (7) shows the evaluation index of the attribute (*att)*, and the evaluation index of the value (v_{att}), respectively.

$$EI(att_i) = AI_{D_{pos}}(att_i) \times AI_{D_{neg}}(att_i) \quad (6)$$

$$EI(v_{att_i}) = AI_{D_{pos}}(v_{att_i}) - AI_{D_{neg}}(v_{att_i}) \quad (7)$$

Let *EI(att)* and *EI(v_{att})* denote the evaluation index of the attribute (*att*) and its value(v_{att}), respectively.

This paper assumes that the user's evaluation to the principal features of the product is influenced by the preference of positive and negative. As the evaluation index of the attribute, Table 4 proves that *AI_{Dpos}(Color)* is 1.0 and also *AI_{Dneg}(Color)* is 1.0. This case is that the attribute of which the attention indexes of attribute is high in both of positive and negative preference. Color is more important for the user than other attributes when decides his/her preference. Therefore, this paper has designed the evaluation index of attribute *EI(att)* that emphasizes the attribute that a person focused in both of positive and negative preference. As the evaluation index of the value, table 4 proves that the attention index of Cut sewn appears in positive and negative. This result indicates that the evaluation of the user to the value is the uncertain. This paper assumes that the user does not have clearly criteria about his/her preference for the Cut sewn. Therefore, this paper has designed the evaluation index of value *EI(v_{att})* that cuts down the value for which a user does not have clearly preference.

2.2.3. Processing of Decision step

This paper designs Preference index by multiplying the evaluation index of the attribute by the evaluation index of the value of the attribute in order to estimate a user's preference for the product. The preference index *PI(v_{att})* indicates the user's preference concerning each value of each attribute. Equation (8) shows the preference index of the value (v_{att}) of the attribute (*att*).

$$PI(v_{att}) = EI(v_{att}) \times EI(att) \quad (8)$$

In the case that the preference index is a plus value, it indicates that the principal feature is related to user's positive preference. The preference index that is high in a value is more related to preference. Otherwise, in the case that the preference index is a minus value, it indicates that the principal feature is less related to user's positive preference.

This paper also defines Preference model of a user. The preference model expresses the all preference of the user concerning the principal features, i.e. the principal value of the principal attribute. This paper can estimate the decision of the user's preference for the product by the preference model. Equation (9) shows the preference model of the user *X* that is composed by the preference index.

$$PM(X) = \left(PI_1(v_{att}(1)), \quad PI_2(v_{att}(2)), \quad \cdots, \quad PI_i(v_{att}(i)), \quad \cdots, \quad PI_l(v_{att}(l)) \right) \quad (9)$$

$$PM_i(X) = PI_i(v_{att}(i))$$

Let *PM(X)* denote the preference model of the user *X*. Let *l* denote the number of principal features in the user *X*. $v_{att(i)}$ denote principal features of the user X that is equal to the value of the attribute related to his/her preference. *PM_i(X)* indicates the component of *PM(X) and* equals *$PI_i(v_{att(i)})$*.

Table 5: The preference index of the person X

Preference Index	The value of Preference Index	Preference Index	The value of Preference Index
PI(Black)	0.13	PI(Cut Sewn)	0.00
PI(Sweater)	0.07	PI(Crew)	0.00
PI(Gray)	0.06	PI(No-Mark)	-0.01
PI(Turtle)	0.01	PI(Horizontal-Stripes)	-0.01
PI(V)	0.01	PI(Hood Jacket)	-0.04
PI(Mark)	0.00	PI(Red)	-0.08
PI(Uniformity)	0.00	PI(Deep-Green)	-0.08
PI(Point)	0.00	PI(Brown)	-0.08

Table 5 shows the preference matrix of the user X in descending order. This result indicates that the preference of the user X is strongly related to black. In order to estimate the preference of the user for the product, this paper calculates total of the preference indexes that compose the product. This paper defines the total of the preference indexes as the product index. Equation (10) shows the product index of preference of the user *X* for the product *I*.

$$IP(X,I) = \sum_{i=1}^{l} PM_i(X) \tag{10}$$

Let *IP(X,I)* denote the product index of the preference of the user *X* for the product *I*. In the case of the product that is higher in the total value of the preference index than other products, this paper estimates that the product is suitable for the preference of the user.

3. EVALUATION

This paper has evaluated a basic performance of the proposed model in the two points below:

- Objective of experiment 1: This experiment 1 makes sure that Preference index can correctly estimate a user's preference of a principal feature of clothes.
- Objective of experiment 2: This experiment 2 makes sure that Product index that calculated using Preference model can correctly estimate products suitable for the user's preference.

Subjects in both experiments are 9 subjects who are all 20's men. A subject has evaluated his preference for 50 sample clothes that are selected randomly from 520 sample clothes. The sample clothes have been expressed by 6 attributes and its values as shown in table 6.

3.1.1. Experimet 1

This experiment paper has evaluated an estimation capability of Preference index that express subject's preference of principal features. The steps of this experiment is follows:

1. A subject answers the principal feature, e.g. blue and check pattern, of clothes related to his/her preference based on his/her experience before he evaluates his preference for the sample clothes.
2. The subject evaluates his/her preference for 50 sample clothes.
3. This paper evaluates that preference index can estimate the principal feature that the subject has answered.

Table 6: The attributes and its values that express features of sample clothes in this experiment

Attributes (6) (Number)	Values (35)
Color (11)	Black, Blue, Brown, Dark-Brown, Deep-Blue, Deep-Green, Gray, Green, Pink, Purple, Red, Red-Purple, Yellow
Texture (5)	Check, Horizontal-Stripes, Point, Uniformity
Category (5)	T-Shirt, Parka, Polo-Shirt, Y-Shirt, Knit
Neck (7)	Collar, Crew, Henley, High, Hood Jacket, Turtle, V
Sleeve (2)	Half, Long
Chest (4)	Button, Mark, Zip-Up, No-Mark

Table 7: The top 5 preference index of Subject A & B

Subjects	Subject's answer to the preference feature of the clothes	Preference Index (Top 5)	
Subject A	Blue color	Deep-Blue	+0.14
		Blue	+0.11
		Gray	+0.04
		Uniform	+0.01
		Half	+0.01
Subject B	Henley neck design	Henley	+0.26
		Gray	+0.10
		Black	±0.00
		Uniform	±0.00
		Nothing	±0.00

* The subject has answered the principal feature of clothes before the subject evaluates this experiment.

This paper shows the result of the subject A and B in this experiment. The table 7 shows that the subject A has answered that the blue color is the principal feature of the clothes when he decides his preference for the clothes. The subject B has answered that the Henley neck design is the principal feature of the clothes.

In the subject A, the table 7 indicates that the preference indexes of the blue color and the deep blue color are the plus value and higher than other values. The result almost matches the preference that the subject A has answered. In the subject B, the table 7 also indicates that the preference index of the Henley neck design is the plus value and higher than other values. The result also matches preference of subject B has answered. Both of results show that the preference index is effective to estimate a user's preference of clothes.

3.1.2. Experimet 2

In the experiment 2, this paper evaluates the estimation capability of Product index of a subject that calculated using Preference model of the subject. A subject has answered his preference for the 50 sample clothes. The preference model of the subject has been calculated based on the answer data. The product index that estimates the product suitable for the subject is calculated by the preference model of the subject.

Figure 2 shows the order of clothes suitable for preference of the subject C. The order is estimated by the product index for the subject.

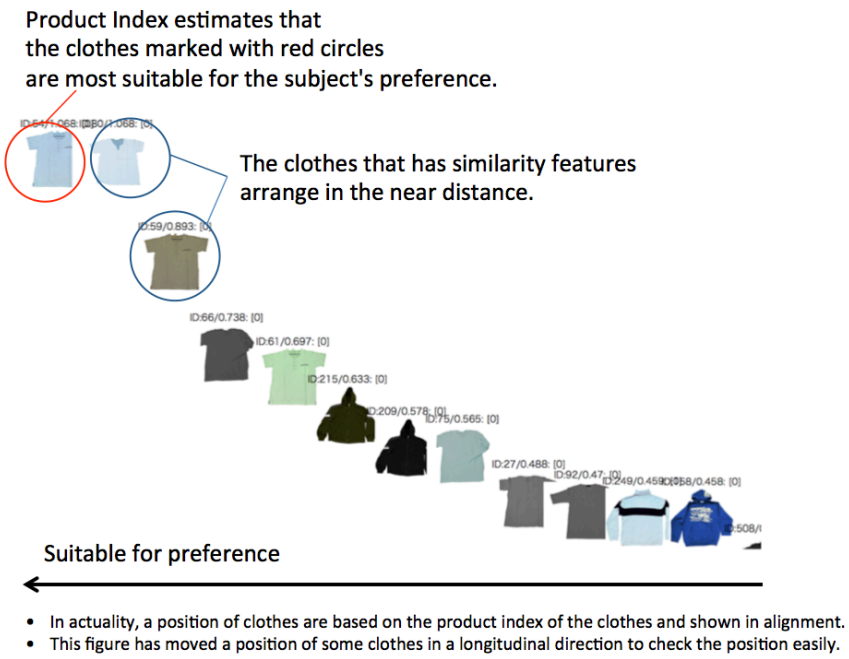

Figure 2: The result shows the estimated clothes based on the product index of preference of the subject C

Table 8: The prediction rate of top 5 & 10 concerning the product index of preference in each subject

Subjects	Prediction rate of Top 5	Prediction rate of Top 10
A	100	100
B	100	100
C	100	100
D	100	90
E	100	90
F	100	100
G	100	70
H	100	100
I	80	90
Average	98	83

The clothes that the product index of preference is the plus value will be suitable for preference of the subject. This study has compared the estimation result by the product index of the subject's preference and the preference that the subject has answered. In the case figure 2, the predicted rate of the product index of preference in top 5 is 100% and in top 10 is 100%. The table 8 shows the predicted rate of clothes index of preference of each subject. The average of the predicted rate in top 5 is 98 % and in top 10 is 83%. This result indicates that the product index calculated by preference index is effective to the recommendation for clothes.

4. CONCLUSION

This paper has proposed a model of user's preference for retrieving preferred clothes. This paper has designed a decision process of user's preference that is composed of three steps, i.e. Attention, Evaluation and Decision step. This paper has made the user's preference model based on indexes calculated in each step in the process.

The attention step is the first step of the process that recognizes the specific attributes of a clothes related to his/her preference from all attributes of the clothes. This paper has modeled the attention step by calculating Attention index that is the degree of attention of a user to a principal feature. The attention index is calculated the principal features that is extracted using the rough set. The evaluation step is the second step of the process that the user evaluates his/her preference of the principal features based on the evaluation of positive and negative preference. This paper has processed the evaluation step by Evaluation index that estimates his/her preference for each principal feature. The evaluation index is calculated by unifying the attention index of positive and negative. The decision step is the final step of the process that the user decides his/her preference for clothes based on his/her evaluation of the principal features in clothes. This paper has simulated the final step by calculating Preference index and Preference model. The preference index is the degree of individual's preference for principal features of clothes. The preference model expresses individual's preference for clothes. This paper estimates the clothes suitable for a user's preference by Product Index that calculated using the preference model of the user.

This paper has had two types of experiment to evaluate the preference index and the preference model. One experiment has shown that the preference index indicates possibility of estimation of the principal feature related to his/her preference. Another experiment has shown that the product index that calculated using the preference model can estimate the clothes suitable for subject's preference. The result has shown the average of the predicted rate about the preferred clothes in top 5 is 98 % and in top 10 is 83%.

In the future works, we will apply to the preference model to other items and will increase the precision of estimation of user's preference.

ACKNOWLEDGMENTS

This work was supported by JSPS KAKENHI Grant Number 25330331.

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BIOGRAPHY

Akihiro OGINO received the B.E., M.S. and Ph.D. degree in industrial and systems engineering from CHUO University, Japan, in 2000, 2002, 2005, respectively. In 2005, he joined the Department of Industrial and Systems Engineering, CHUO University, as an Assistant Professor. Since 2008, he has been with the Department of Intelligent Systems, Kyoto Sangyo University, where he was an Lecturer, became an Associate Professor in 2012. His current research interests include Affective Engineering, Modeling of Emotion and Information retrieval by emotion.

Texture Image Classification using Extended 2D HLAC Features

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Abstract: HLAC (Higher Order Local Autocorrelation) features are popular image descriptors that have been used for various image-processing applications since the 1980s. Examples of the application of the HLAC features include KANSEI retrievals and subjective retrievals of 2D image databases. In this paper, standard HLAC masks are extended for computing a massive number of features. Typical HLAC features are computed by applying 25 masks to a binary image, whereas our Ext-HLAC features are computed by applying 16,241,567 masks. Since there are a high number of mask combinations, we have developed Ext-HLAC mask generation software programs. Ext-HLAC masks were tested by using 2D benchmark image database sets. For each image, the pattern features were extracted by applying Ext-HLAC masks, and the pattern features were analyzed by a k-NN based approach. Our preliminary experiments show high classification rates for certain image databases.

Keywords: HLAC, Ext-HLAC, pattern feature, k-NN, image classification

1. HLAC MASKS

HLAC (Higher Order Local Autocorrelation) features (Otsu and Kurita, 1998) are popular pattern descriptors that have been used for many image-processing applications since the 1980s. Examples of the application of the HLAC features include KANSEI retrievals and subjective retrievals of 2D image databases (Kato, Kurita, and Shimogaki, 1989) (Kato, 1992) (Kurita and Otsu, 1993). HLAC masks are used for extracting HLAC features from images. An HLAC mask consists of 3x3 (9) cells, and a set of standard HLAC masks for analyzing binary images consists of 25 masks as shown in Figure 1. Figure 2 shows the processes for extracting HLAC features. During the first process, a source image is converted into a binary image. HLAC masks are applied to the binary images, and an HLAC image is obtained as output. HLAC features are

computed by counting the number of black pixels and white pixels, and the number of pixels is normalized by the image sizes. Each HLAC mask produces one feature; thus if there are 25 masks, 25 HLAC features are computed. The computations of HLAC features involve simple multiplications and summations of pixel values; thus, the computations are efficient compared to other image feature extraction techniques that require slow complex functions.

order	# of masks	mask patterns (25)
0	1	
1	4	
2	20	

Figure 1: HLAC (3x3) (n=0, 1, 2)

Once the image features are extracted from the image, these features are analyzed by pattern recognition related techniques, and image features are used for various applications, including object recognition, face detections, image retrievals, image segmentations, and image classifications. There are several pieces of research that are related to the extension of the HLAC masks. Toyoda and Hasegawa (2005) introduced extended HLAC (3x3). In their research, the order of the autocorrelation functions are used up to the 8th order, and the number of HLAC masks is increased to 223, whereas standard HLAC uses 25 masks. Since the extended HLAC (3x3) mask can describe more pattern features for images, the research improved texture classification rates. Additionally, Toyoda and Hasegawa (2005) introduced large-size mask patterns for extracting multi resolution feature extractions. Suzuki, Yaginuma, Yamada and Shimizu (2006) introduced 3D HLAC (3x3x3). During research, two-dimensional HLAC masks are extended to three-dimensional HLAC masks that can handle not only 2D image data, but also 3D data, including movie data, 3D polygonal data, and 3D volumetric data. An example of extended HLAC masks (3x3) is shown in Figure 3, and an example of 3D HLAC masks (3x3x3) is shown in Figure 4

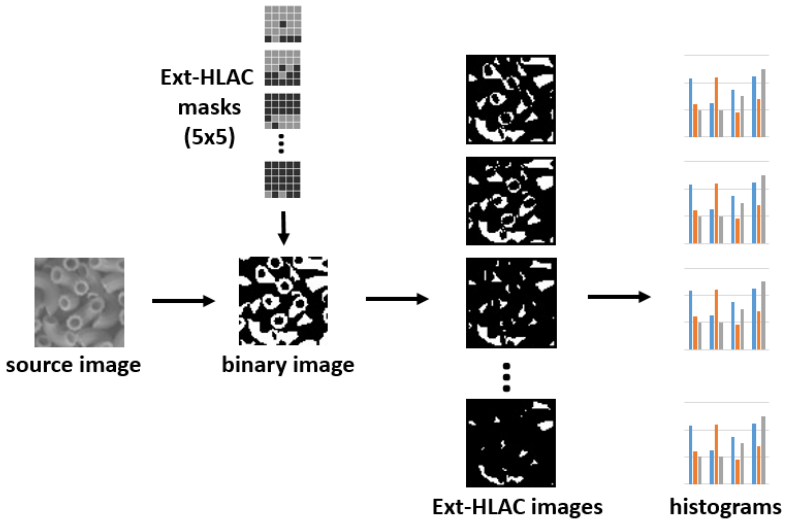


Figure 2: Processes for extracting HLAC features

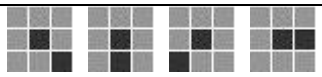
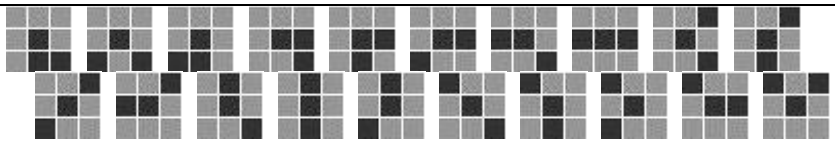
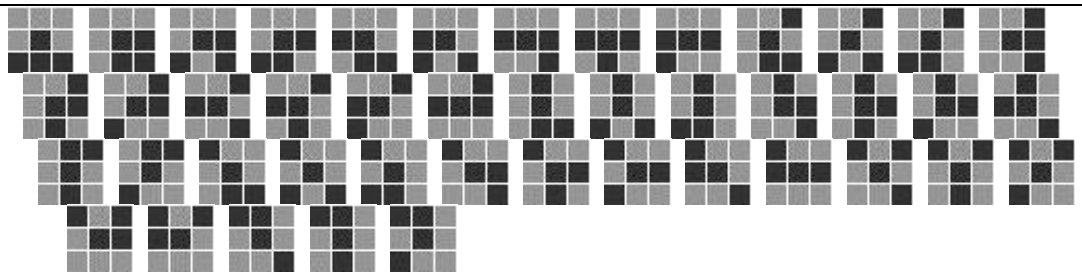
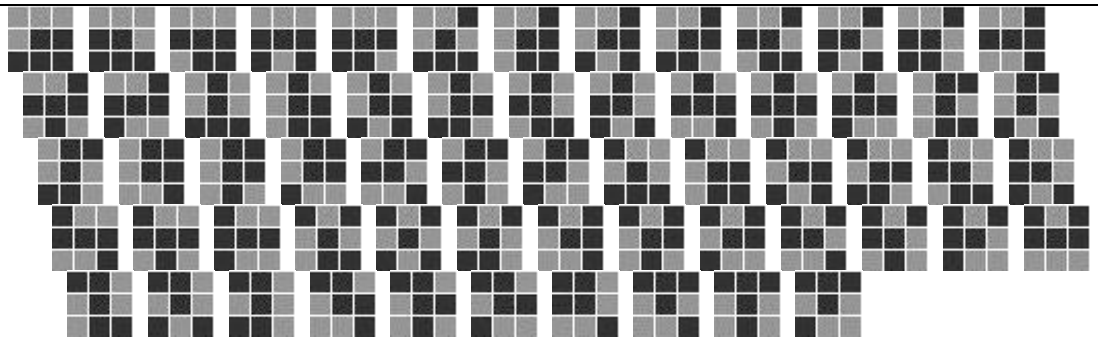
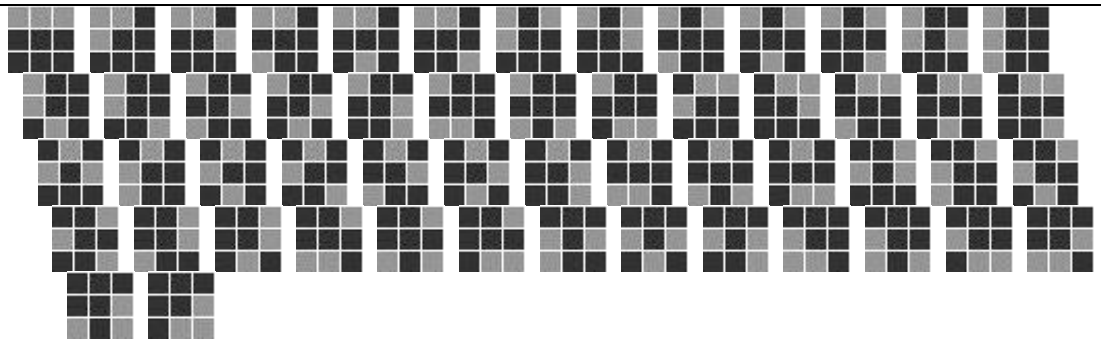
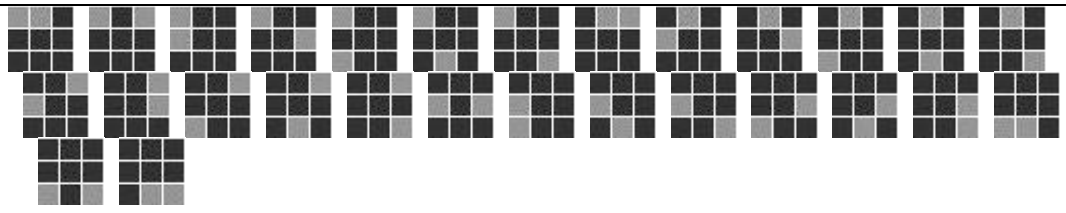
n	#	mask patterns (223)
0	1	
1	4	
2	20	
3	45	
4	62	
5	54	
6	28	
7	8	
8	1	

Figure 3: Extended HLAC (3x3) (n=0,1,2,3,4,5,6,7,8) Toyoda-Hasegawa model

2. EXT-HLAC MASK (5X5)

A standard HLAC mask consists of 3x3 (9) cells. In this research, the number of cells was increased so that an Ext-HLAC (i.e. Extended HLAC) mask would consist of 5x5 (25) cells. These minor cell-size extensions cause the Ext-HLAC to have numerous combinations of the masks. For instance, there are 223 masks for a 3x3 case, but there are 16,241,567 masks for a 5x5 case. Therefore, a software program is necessary for computing these combinations of masks. The program lists all the combinations of mask patterns (16,777,216), and each mask is compared if there are redundant masks in terms of shift invariance. The redundant masks are eliminated from the list, and finally the program determines 16,241,567 masks. These processes are time and memory consuming tasks. The program requires about 16 minutes to complete the processes using a standard desktop computer (Intel Core i7-3930K 3.20 GHz), and over 2.5GB of dynamic memory were used during the execution of the program.

In the program, two-dimensional Ext-HLAC masks are represented as 5x5 arrays, and they are converted into a one-dimensional array with a length of 25. They are treated as a set of binary numbers with a 25-bit width, and each binary number of combinations is represented by 0 and 1. Since these binary numbers have a 25-bit width, there are 2 to the 25th power (33,554,432) of combinations. Since the Ext-HLAC feature concerns the relationship between the center cell and its surrounding 24 neighboring cells, there are in fact 2 to the 24th power (16,777,216) of combinations; however, our program uses a list of 2 to the 25th power of combinations for efficient hashing processes. The program is required to compare these binary numbers with each other, and eliminate redundant binary numbers. The comparisons of binary numbers involve an exhaustive, time-consuming search for a list. For instance, when a simple “linear search” was used for this task, it took over 7.5 days to perform comparisons, whereas a “binary search” took only 30 minutes. In our program, a hashing technique was used for this task to further speed up the process. Since the binary numbers are easily converted to decimal numbers, the program uses these decimal numbers as hash keys for accessing the list. This makes our hash-table based program run quickly, as compared to a linear search based techniques, and comparison of the list using the hashing technique was performed in less than 16 minutes. However, use of the hashing technique requires allocation of a huge amount of dynamic memory during the execution of the program, and over 2.5GB of memory were used in this case.

Figure 5 shows a partial set of Ext-HLAC (5x5) generated from the program. The set of Ext-HLAC can be categorized based on the order of autocorrelation functions. As shown in Figure 5, there are more black cells for the higher order of the autocorrelation functions. Although the limited number of masks is shown in Figure 5, an actual set of the Ext-HLAC contains a high number of masks (16,241,567).

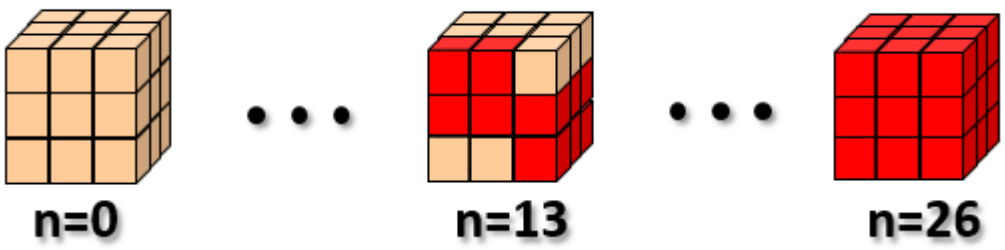


Figure 4: Example of 3D HLAC masks (3x3x3)

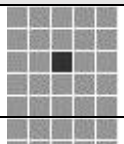
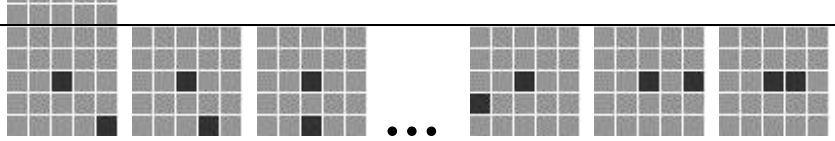
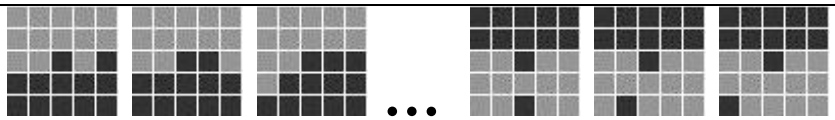
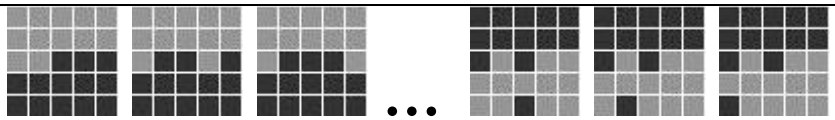
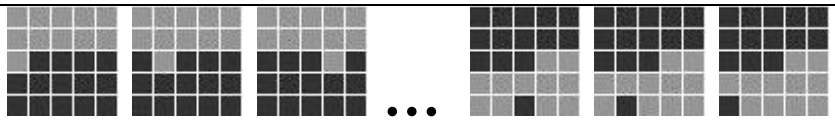
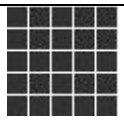
n	#	mask patterns (16,241,567)
0	1	
1	12	
2	180	
3	1449	…
4	8182	…
5	34662	…
6	114804	…
7	306024	…
8	669571	…
9	1218966	…
10	1863932	…
11	2408859	
12	2640680	
13	2459078	
14	1944132	…
15	1301385	…
16	733839	…
17	345798	…
18	134560	…
19	42502	…
20	10626	…
21	2024	…
22	276	
23	24	
24	1	

Figure 5: Ext-HLAC (5x5) (n=0,1,2, …, 22, 23, 24) (limited number of masks is shown in Figure)

The sample set of the Ext-HLAC mask data is downloadable from the following web address (http://goo.gl/87FgUr). These Ext-HLAC mask data are represented in decimal number to reduce the file sizes. Since each Ext-HLAC mask consists of a set of cells, these cells can be represented in a sequence of binary numbers. Each sequence of binary numbers (25bits) is converted into a single decimal number as shown in Figure 6.

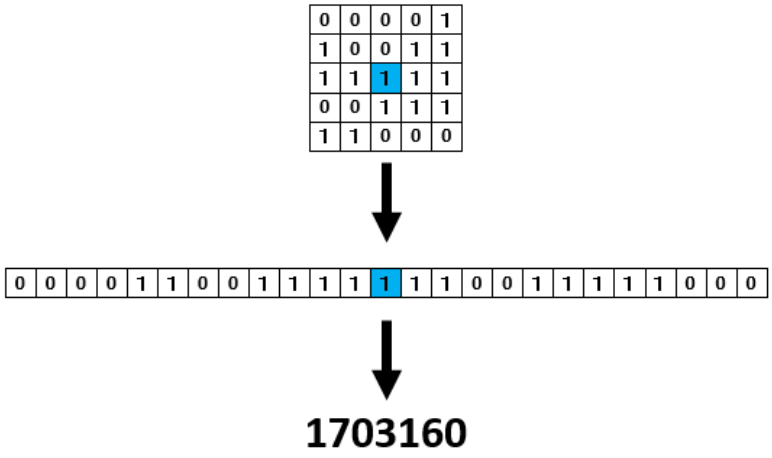


Figure 6: Decimal number representation of Ext-HLAC masks

Ext-HLAC masks shown in Figure 5 are applied for a binary image. Original source images must be converted before the Ext-HLAC feature extraction processes. In the experiment, the P-tile-threshold method was used for binary image conversion. Ext-HLAC masks were applied to each image, and each mask produces one output image (Ext-HLAC image) as shown in Figure 7. Since each input image is a binary image, each Ext-HLAC image is also outputted as a binary image. Ext-HLAC features are computed from the Ext-HLAC images, and the computation involves counting the number of pixels in the Ext-HLAC images.

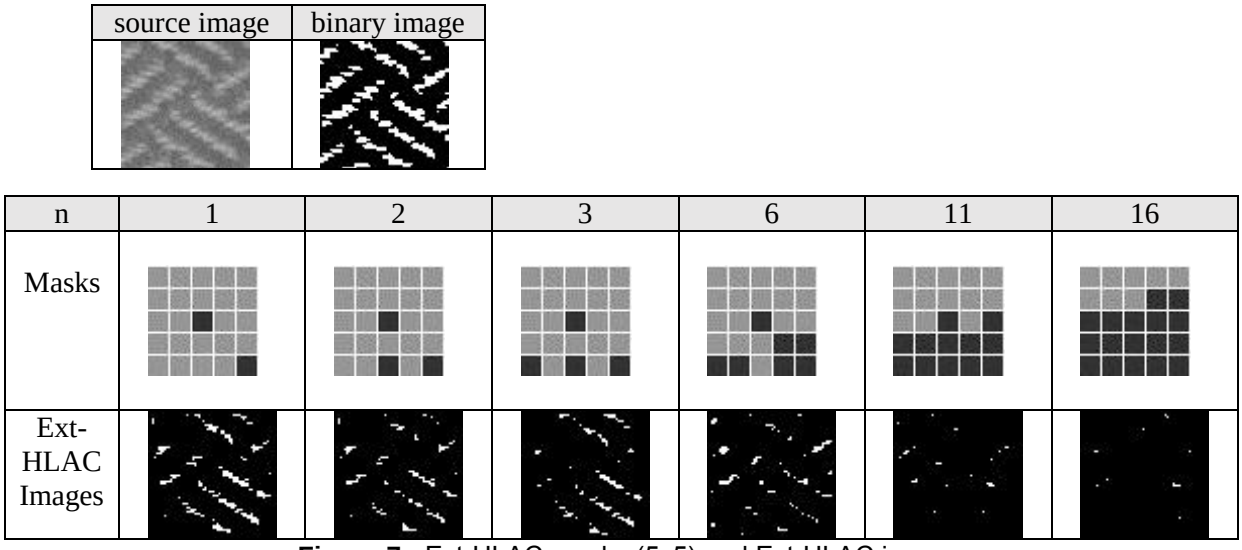


Figure 7: Ext-HLAC masks (5x5) and Ext-HLAC images

3. EXPERIMENTS

3.1. Experimental data sets

Portions of OUTEX (Ojala et al., 2001) texture benchmark data sets were used to test Ext-HLAC masks. Ext-HLAC features were extracted for each image, and features were compared by classification methods. In the experiment, simple k-NN (k Nearest Neighbor) techniques were used for the benchmark image data.

3.2. Classifications of two types of images

The portion of OUTEX data sets ("barley_rice_011" and "canvas_001") were chosen for our classification experiments, and each data set contains 20 images. An example of these 2 data sets is shown in Figure 8.

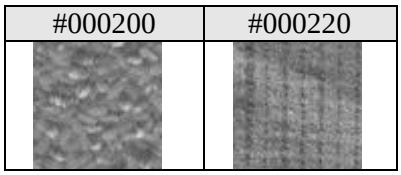


Figure 8: Image data ("barley_rice_011" and "canvas_001")

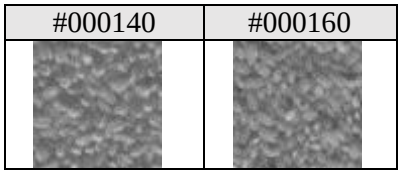


Figure 9: Image data ("barley_rice_008" and "barley_rice_009")

In the experiment, the OUTEX data set was converted to PGM (Portable Grey Map) format. All image sizes are adjusted to 128x128 with color depth 16 (65536 colors). In the experiments, Ext-HLAC masks are tested, while groups of Ext-HLAC masks are used to efficiently classify test image data sets. Two experiments were conducted (A) if relatively dissimilar image data sets were classified, such as images "barley_rice_011" and "canvas_001," and another experiment was conducted (B) of relatively similar image data sets, such as "barley_rice_008" and "barley_rice_009". Samples images are shown in Figure 9.

Ext-HLAC features were categorized into 25 groups based on the order of the autocorrelation functions. For example, there are 180 masks related to the order of the autocorrelation functions with n=2. The number of masks increases from n=0 through n=12, and reaches the maximum of 2,640,680 masks. Since it is difficult to use so many masks for computing Ext-HLAC features, a small number of masks were randomly selected. In the experiment, 25 masks were selected for n=2 through n=22.

Table 1 shows experimental results of (A) and Table 2 shows experimental results of (B). In these tables, the number of Ext-HLAC masks, the number of features used, and classification rates are shown in each row. The k-NN approach with a value of k=3 was used, and a total of 40 images were examined. Cross-validation (10 folds) was used for experiments where data was split into 10 folds, trained on 9 folds 10 times, and tested on the remaining one. For Experiment (A), as shown in Table 1, image classification rates are high at n=4 and n=6 …12 where n represents the order of the autocorrelation function. In Experiment (B), image classification rates are high at n=3 and n=4 as shown in Table 2.

Table 1: Dissimilar image data sets (Ext-HLAC (5x5))

N	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
# of features	1	12	25	25	25	25	25	25	25	25	25	25	25
Classification rates (%)	62.5	75.0	87.5	85.0	95.0	92.5	95.0	95.0	95.0	95.0	95.0	95.0	95.0
N	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
# of features	25	25	25	25	25	25	25	25	25	25	24	1	
Classification rates (%)	92.5	92.5	92.5	92.5	90.0	90.0	87.5	90.0	82.5	80.0	77.5	65.0	

Table 2: Similar image data sets (Ext-HLAC (5x5))

N	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
# of features	1	12	25	25	25	25	25	25	25	25	25	25	25
Classification rates (%)	97.5	95.5	97.5	100.	100.	97.5	97.5	97.5	97.5	95.0	95.0	95.0	95.0
N	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
# of features	25	25	25	25	25	25	25	25	25	25	24	1	
Classification rates (%)	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	92.5	95.0	95.0	95.0	

3.3. Classifications of 5 types of images

In this experiment, classifications of 5 types of images were conducted as shown in Figure 10. Experimental data conditions were similar to previous subsections (3.2), except more data sets were used. The portion of OUTEX data sets (“wall_paper_002” through “wall_paper_006”) were chosen for our classification experiments, and each data set contains 20 images. Thus, there were a total of 100 images for classification tests. As shown in Table 3, classification rates were slightly low compared to previous experiments (3.2).

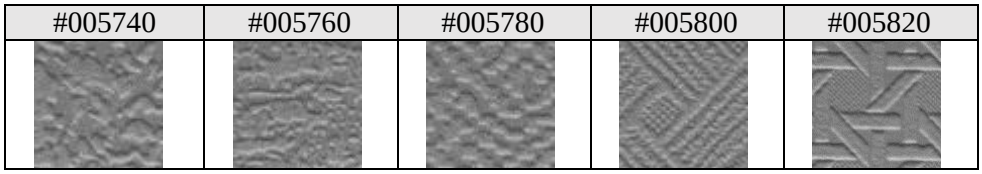


Figure 10: Image data (wall_paper_002, 003, 004, 005 and 006)

3.4. Comparison between standard HLAC (3x3) and Ext-HLAC (5x5)

In this experiment, traditional standard HLAC (3x3) and Ext-HLAC (5x5) were compared using an image data set as described in the previous subsection (3.3). A total of 25 HLAC (3x3) features were used for classifications. In this case, HLAC features with order of n=0, n=1 and n=2 were computed and these features were used as one group of features. For the Ext-HLAC (5x5), 25 features were selected randomly for the comparison purpose. As shown in Table 3, our proposed Ext-HLAC (5x5) features show slightly high classification rates at n=4 and n=5, as compared to standard HLAC (3x3) features (k=3, 45.0%; k=1, 51.0%). Although the use of the Ext-HLAC feature requires selection of adequate Ext-HLAC masks from the high number of mask sets, certain Ext-HLAC features can classify images better than traditional HLAC features.

In this section, simple classification techniques based on the k-NN approach were used for experiments. In a KANSEI classification or a user-oriented subjective classification technique, similarity evaluations of user data are analyzed and applied to classification techniques so that classification results match user preferences. We will investigate these KANSEI-based approaches in future works, and these approaches will involve an analysis of a high number of Ext-HLAC features.

Table 3: Five types of images (Ext-HLAC (5x5))

N	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
# of features	1	12	25	25	25	25	25	25	25	25	25	25	25
Classification rates (%) k=3	22.0	47.0	65.0	63.0	66.0	67.0	60.0	59.0	59.0	51.0	55.0	54.0	51.0
Classification rates (%) k=1	21.0	53.0	71.0	67.0	72.0	78.0	73.0	72.0	65.0	55.0	62.0	57.0	49.0
N	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	
# of features	25	25	25	25	25	25	25	25	25	25	24	1	
Classification rates (%) k=3	41.0	37.0	38.0	31.0	31.0	26.0	28.0	28.0	20.0	22.0	18.0	17.0	
Classification rates (%) k=1	41.0	32.0	36.0	29.0	29.0	30.0	23.0	29.0	28.0	27.0	28.0	14.0	

4. CONCLUSIONS

In this paper, standard HLAC (Higher Order Local Autocorrelation) masks (3x3) were extended to Ext-HLAC (Extended Higher Order Local Autocorrelation) masks (5x5). This simple cell size extension greatly increases the number of generated mask patterns. For instance, standard HLAC (3x3) uses 25 masks, extended HLAC (3x3) uses 223 masks, and proposed Ext-HLAC (5x5) uses 16,241,567 masks. Our software program can generate Ext-HLAC masks using typical desktop computers (Intel Core i7-3930K 3.20 GHz) in about 16 minutes. The program-generated Ext-HLAC masks can be used for image processing related applications. In our experiments, Ext-HLAC (5x5) features are extracted from each texture image from a benchmark database. The Ext-HLAC features are grouped into 25 categories based on the order of the autocorrelation functions. Image pattern classification experiments are conducted for comparing each category of Ext-HLAC. Our preliminary experiments show that a certain set of the Ext-HLAC masks can classify images efficiently. Since the proposed Ext-HLAC (5x5) masks can compute various pattern features more efficiently than classical HLAC masks, the Ext-HLAC (5x5) can be applied to KANSEI retrievals or KANSEI classifications.

ACKNOWLEDGMENTS

This research was partially supported by grants from the KAKENHI (C-24500211).

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BIOGRAPHY

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Concept of Satisfaction

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Abstract: This article examines the concept of satisfaction from various viewpoints including linguistics, psychology, and philosophy as well as Kansei engineering and will pursue how the design of artifacts that will bring the satisfaction can be realized and how the evaluation of satisfaction can be achieved. Of course, there have been some satisfactory measurement scales such as SUS, SUMI and WAMMI. But they simply measure the degree of resulting satisfaction and does not consider the relationships between the satisfaction and other quality characteristics. What is needed is the measurement of satisfaction based on the consideration on the conceptual network including relevant quality characteristics.

Keywords: Satisfaction, UX, usability

1. INTRODUCTION

In the field of user experience (UX), it has not yet clarified how we can measure the quality of UX. Because the UX is an experience of an individual as is stated in UX White Paper (Roto et al. 2011), the measurement should be on the subjective aspect. There are many quality characteristics including both of objective ones and subjective ones. Objective quality characteristics will be independent variables for the measure of UX and some of subjective quality characteristics can be the dependent variable while others will be independent variables.

This paper deals with the concept of satisfaction as the best relevant candidate for the dependent variable of UX and discuss its definition and the temporal structure of dynamic process.

2. CONCEPT DEPENDENCY ANALYSIS

Regarding the concept of satisfaction, one of the authors have proposed the diagram as shown in Figure 1 since 2006. The main purpose of this figure was to re-examine the concept and sub-concepts of usability. “Satisfaction” that was located as one of the sub-concepts of usability in ISO9241-11:1998 seemed to the authors much more fundamental and important concept than to be included as a part of usability.

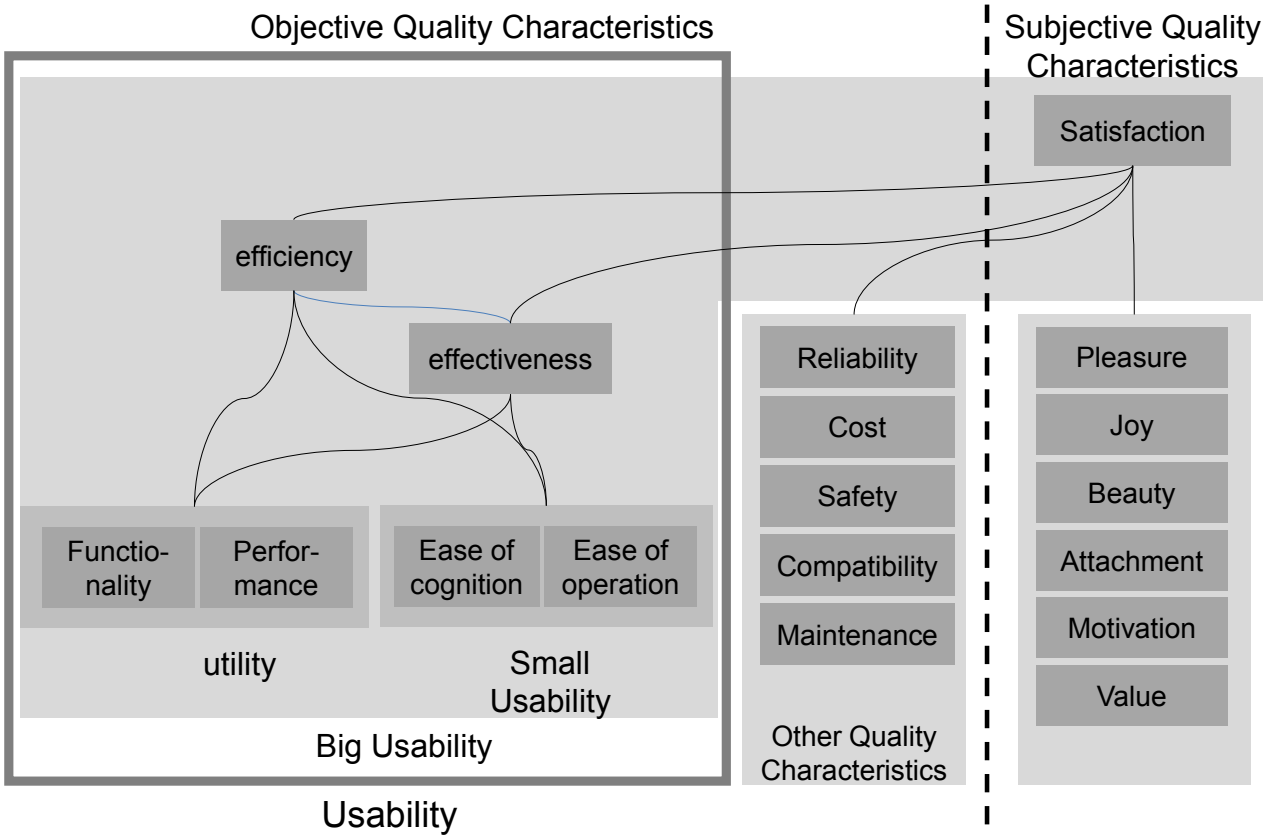

Figure 1. Concept of usability and satisfaction (Kurosu 2006)

The figure simplifies the network structure among objective and subjective quality characteristics and the network relationships were constituted based on the Concept Dependence Analysis (CDA) of which authors have proposed. The idea and the procedure of the CDA is quite simple. Take two concepts and inspect their mutual relationship as

Can concept A always be approved when concept B is achieved? (1)

Can concept B always be approved when concept A is achieved? (2)

Take the relationship between the satisfaction and the effectiveness as an example. When the effectiveness is achieved, the satisfaction will always be approved because the effectiveness will always satisfies people. But the opposite is not true. When the satisfaction is achieved, the effectiveness will not always be approved because the satisfaction can be achieved by other quality characteristics such as the efficiency, reliability, safety, beauty, etc. As a result of the tests between all possible pairs of quality characteristics, the satisfaction was regarded as the top level concept. Thus the satisfaction can be regarded as the dependent variable and the rest including all the objective quality characteristics and other subjective quality characteristics will be regarded as the

independent variables for the satisfaction. And this figure, though putting much emphasis on the usability, can be regarded as the concept structure for the measurement of the UX.

A bit more explanation on the CDA will be explained here. There are 5 dependency patterns as in Figure 2.

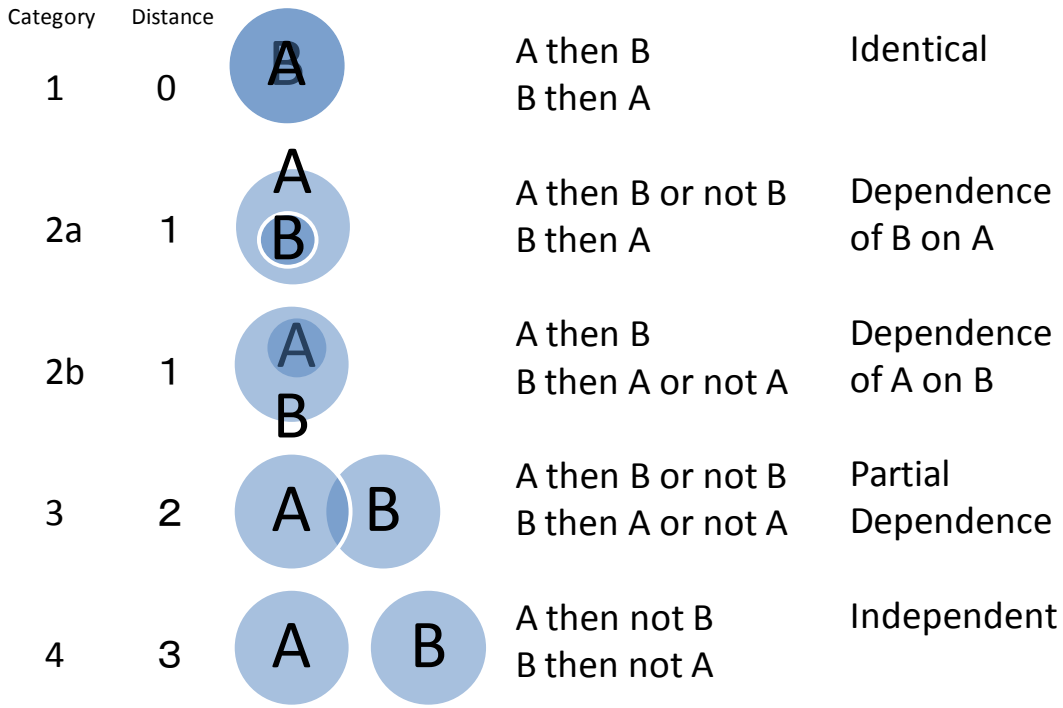

Figure 2 Dependency patterns of concept A and concept B

Table 1 is the dependency distance matrix for concepts described in Figure 1. Each cell contains the distance between concept A and concept B based on the pattern classification on Figure 2.This table is the symmetric matrix because each entry represents the dependency of A on B as well as the dependency of B on A. In figure 2, category 2a and 2b are symmetrical by including the relationship of A to B as well as that of B to A.

A \ B	functionality	performance	ease of cognition	ease of operation	effectiveness	efficiency	reliability	cost	safety	compatibility	maintenance	pleasure	joy	beauty	attachment	motivation	value	meaningfulness	satisfaction
functionality	0	3	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	1
performance	3	0	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	1
ease of cognition	2	2	0	3	2	2	3	3	3	3	3	3	3	3	3	3	3	3	1
ease of operation	2	2	3	0	2	2	3	3	3	3	3	3	3	3	3	3	3	3	1
effectiveness	2	2	2	2	0	1	3	3	3	3	3	3	3	3	3	3	3	3	1
efficiency	2	2	2	2	1	0	3	3	3	3	3	3	3	3	3	3	3	3	1
reliability	3	3	3	3	3	3	0	2	2	3	3	3	3	3	3	3	3	3	1
cost	3	3	3	3	3	3	2	0	3	3	3	3	3	3	3	3	3	3	1
safety	3	3	3	3	3	3	2	3	0	3	3	3	3	3	3	3	3	3	1
compatibility	3	3	3	3	3	3	3	3	3	0	2	3	3	3	3	3	3	3	1
maintenance	3	3	3	3	3	3	3	3	3	2	0	3	3	3	3	3	3	3	1
pleasure	3	3	3	3	3	3	3	3	3	3	3	0	0	2	3	2	2	3	1
joy	3	3	3	3	3	3	3	3	3	3	3	0	0	3	3	2	2	3	1
beauty	3	3	3	3	3	3	3	3	3	3	3	2	3	0	2	2	2	3	1
attachment	3	3	3	3	3	3	3	3	3	3	3	3	3	2	0	3	3	3	1
motivation	3	3	3	3	3	3	3	3	3	3	3	2	2	2	3	0	2	2	1
value	3	3	3	3	3	3	3	3	3	3	3	2	2	2	3	2	0	2	1
meaningfulness	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	0	1
satisfaction	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0

Table 1. Dependency Matrix

The clustering (Group Average Method) was applied to the dependency matrix in Table 1. Although the clustering method itself does not process the directional data, table 1 represents the mutual relationship of dependency hence the clustering method could be thought to be valid to process the data. The resulting dendrogram is shown in Figure 3.

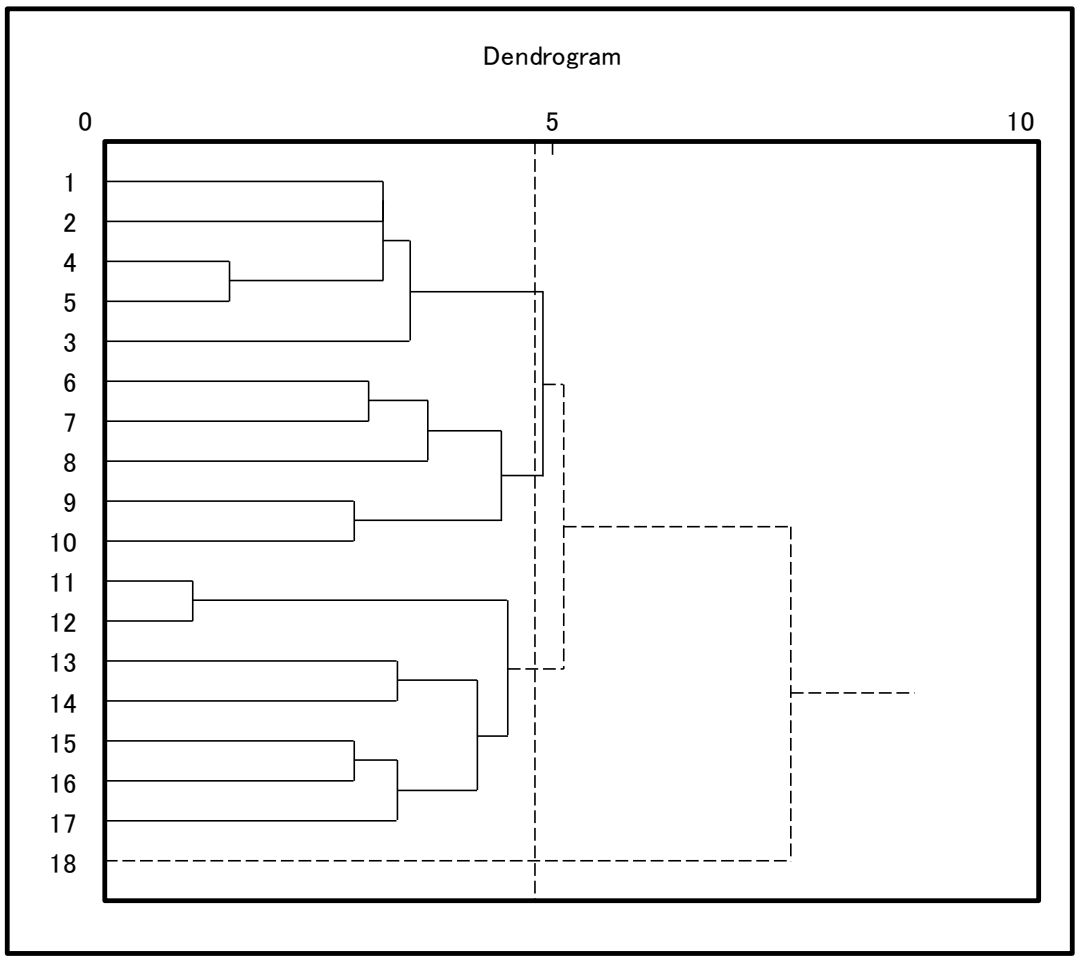

Figure 3 The dendrogram showing clusters among 18 quality attributes.

It is obvious that the satisfaction (No. 18) is regarded as the ultimate dependent variable among 18 quality attributes.

3. LINGUISTIC ANALYSIS

According to “The Random House Dictionary”, the word “satisfaction” means “1. the act of satisfying; fulfillment; gratification. 2. the state of being satisfied; contentment. 3. the cause or means of being satisfied. 4.confident acceptance of something as satisfactory, dependable, true, etc. ..”. And the verb “satisfy” means “to fulfill the desires, expectations, needs, or demands of a person, the mind, etc.); to give full contentment”. A Japanese dictionary “Kohjien (広辞苑)” lists almost the same definition to the word “manzoku (満足)”. Hence, we can almost neglect the linguistic difference between the connotations of these two words; one in English and another in Japanese.

4. CONCEPT OF SATISFACTION

4.1. Satisfaction in ISO Standards

In ISO9241-11:1998 on the usability engineering, the satisfaction is included in the concept of usability because the artifact that has the effectiveness and the efficiency will give users the satisfaction. This notion has been inherited to succeeding standards such as ISO13407:1999 (now

revised as ISO9241-210:2010), ISO/TR18529:2000, ISO/TR16982:2002, ISO20282-1 to 4:2006 to 2007, and ISO25010:2011.

On the contrary, the author has been claiming that the satisfaction is not such a small concept but the top level concept regarding the total quality of artifacts as can be seen in Figure 1. It is because the user can be satisfied by other objective quality characteristics such as reliability, cost, safety, compatibility and maintenability as well as the subjective (Kansei) quality characteristics such as pleasantness, joy, beauty, attachment, etc. in addition to the usability.

The satisfaction, in this sense, is not just a subjective (Kansei) quality but an integrated notion covering both of the objective and the subjective quality and is different from other subjective (Kansei) qualities. In other words, objective quality and subjective quality are mutually independent.

4.2. Framework for the Experience Engineering

Furthermore, authors proposed the concept of experience engineering. The idea of experience engineering emerged based on the consideration that the concept of UX does not cover the whole everyday experience of the people but only the experiences with the products and the systems. As is stated in ISO9241-210, we should include the service activity when considering the daily experience. But in the field of service engineering, people are not the users but are the customers as can be found in the term of customer experience (CX).

Furthermore, based on the idea that good experiences can only be achieved when products, systems and services are meaningful. Meaningless products, systems and services will not bring good experiences even though they are full of usability, Kansei quality, etc. Meaningfulness is strongly related to the real (and in most cases covert) needs of the people and will bring the significance in the real life.

This idea is shown in Figure 4 and the revised version is shown in Figure 5 where the objective /subjective quality characteristics and meaningfulness are categorized as independent variables and the satisfaction is located as the dependent variable.

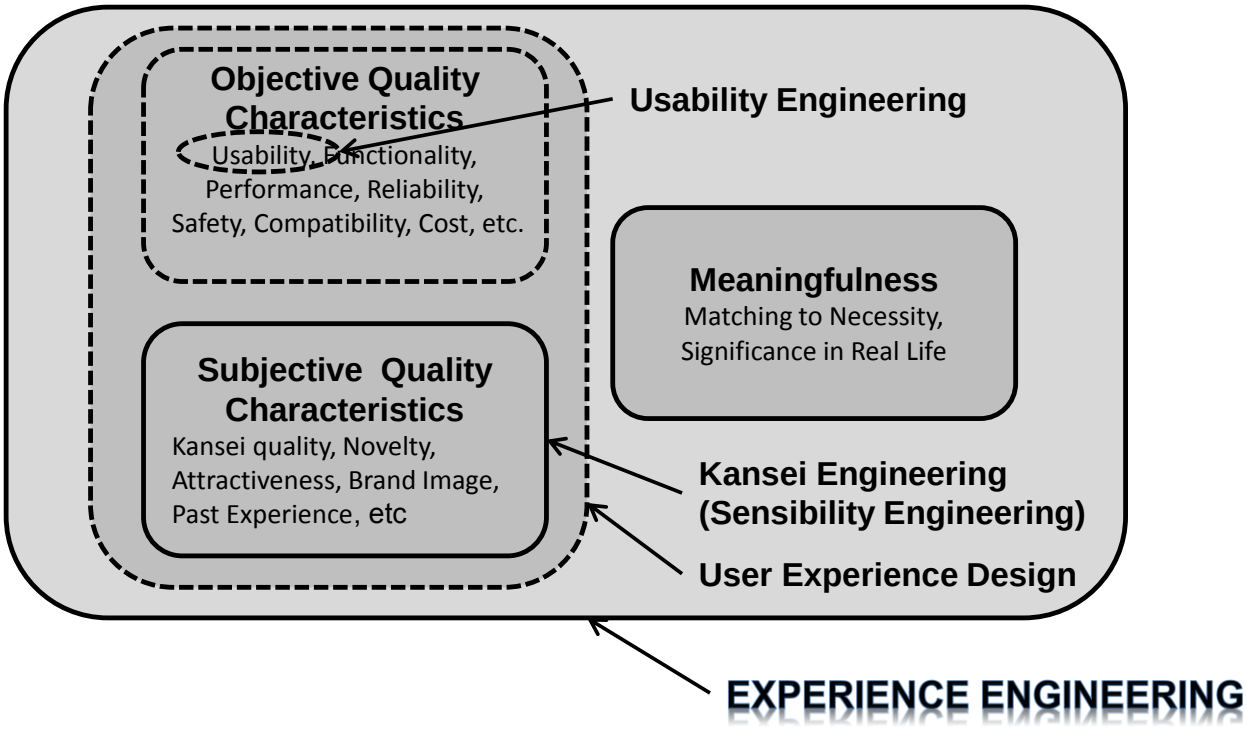

Figure 4 Key Concepts of Experience Engineering (Kurosu 2013)

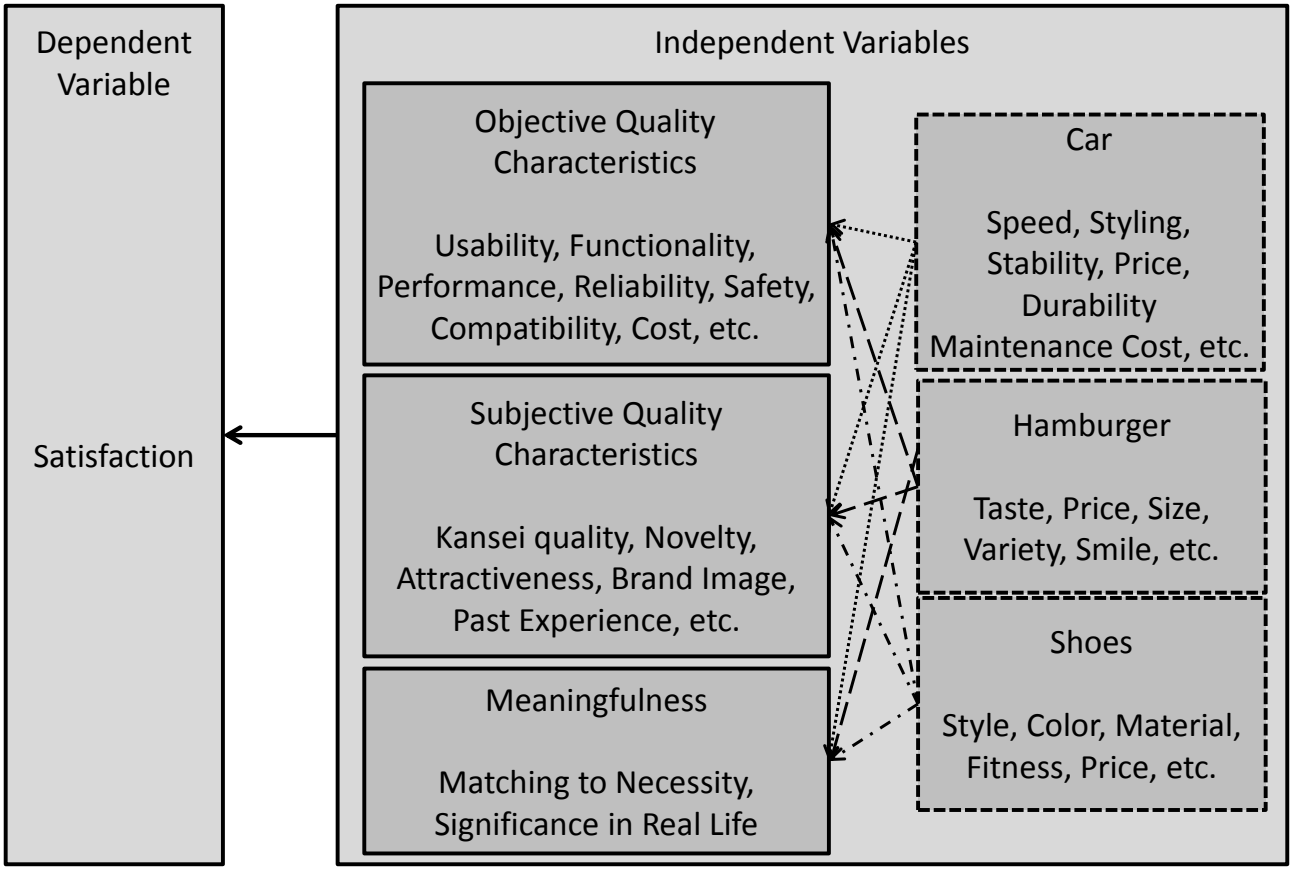

Figure 5 Objective Quality Characteristics, Subjective Quality Characteristics and Meaningfulness as Independent Variables and the Satisfaction as the Dependent Variable

As can be seen, the objective quality characteristics include usability, functionality, performance, reliability, safety, compatibility, cost, etc. and the subjective quality characteristics include Kansei quality, novelty, attractiveness, brand image, past experience, etc. Meaningfulness is the degree of matching to necessity and is the significance in the real life.

The figure also includes three examples; the car, the hamburger, and the shoes. Quality characteristics that are important for each of them are different. For example, speed, styling, stability, price, durability, and the maintenance cost are important for cars, but the taste or the material are not important for them. The importance of these characteristics may vary depending on the type of products and systems, and finally will be converted into the objective/subjective quality characteristics and the meaningfulness.

4.3. Dynamic Process of Satisfaction

In Figure 6, temporal processes in the industry and in the market are described. The process in the market can be regarded as the temporal process of the UX where the previous process, the obtaining process and the post process are included. The previous process is mainly the expectation, the obtaining process is mainly the direct impression at the purchase, and the post process is mainly the accumulation of impression in the course of the long-term usage.

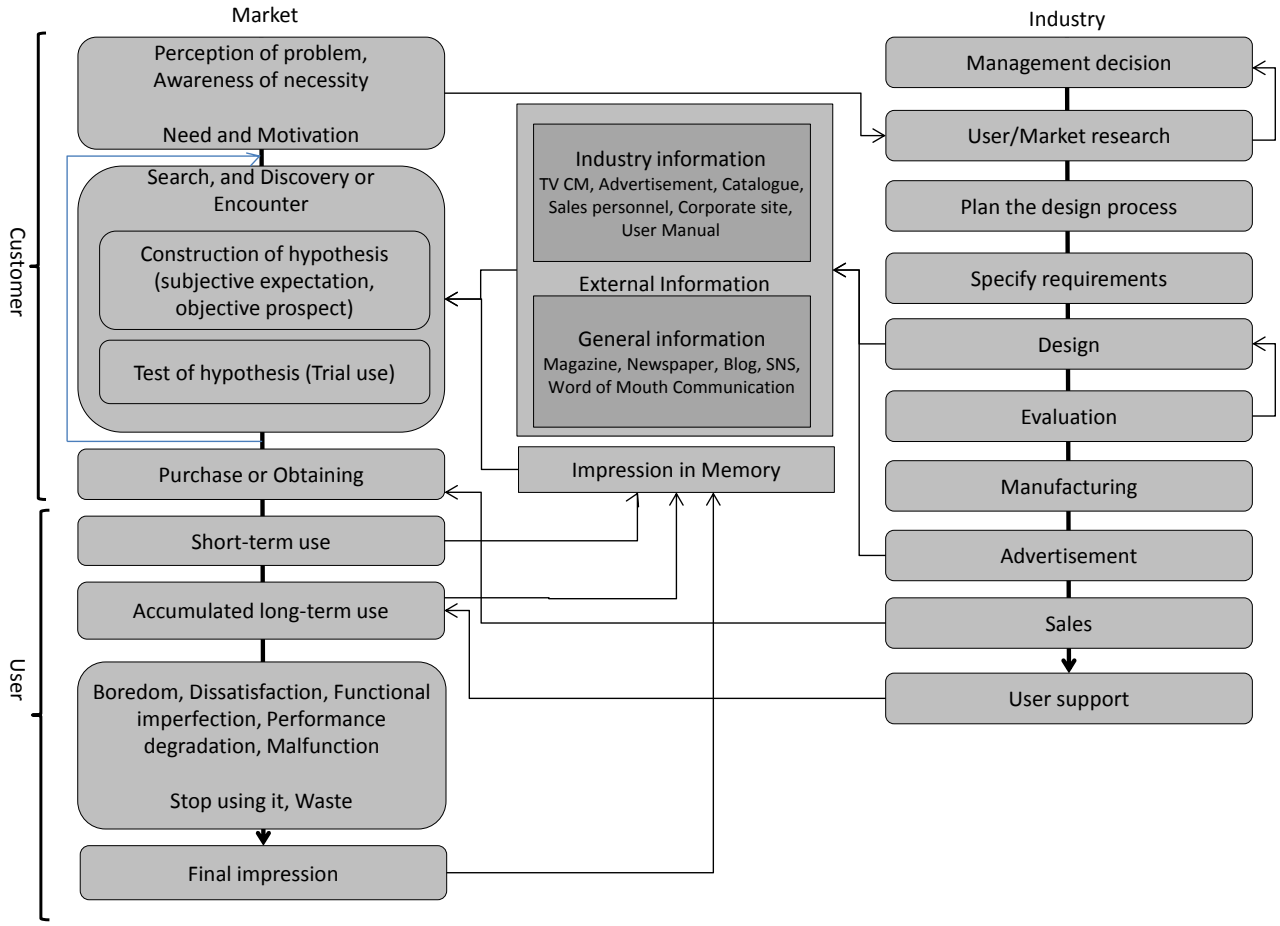

Figure 6. Temporal Process in the Industry and in the market for products. (Kurosu 2013)

In Figure 7, the dynamic process of satisfaction is described based on the concept of Figure 6. In this figure, three psychological concepts are included. The first one is the adaptation level by Helson (1948). The accumulation of past experience will form the frame of reference or the adaptation level (AL) and will bring the expected level of evaluation as

$$\log AL = \sum_{i=1}^{n} wi \cdot logAi \qquad \left(\sum_{i=1}^{n} wi = 1\right)$$

where Ai is the strength (of experience) of i-th experience and wi is the weight. The initial level of satisfaction will thus be the difference between the expected level (AL) and the actual level. And people can be satisfied if the difference is positive and be dis-satisfied if the difference is negative.

In this comparison process, the second psychological concept of the level of aspiration (Levin et al. 1944) is related. According to this concept, people may lower their expected level so that the result of subtraction be positive.

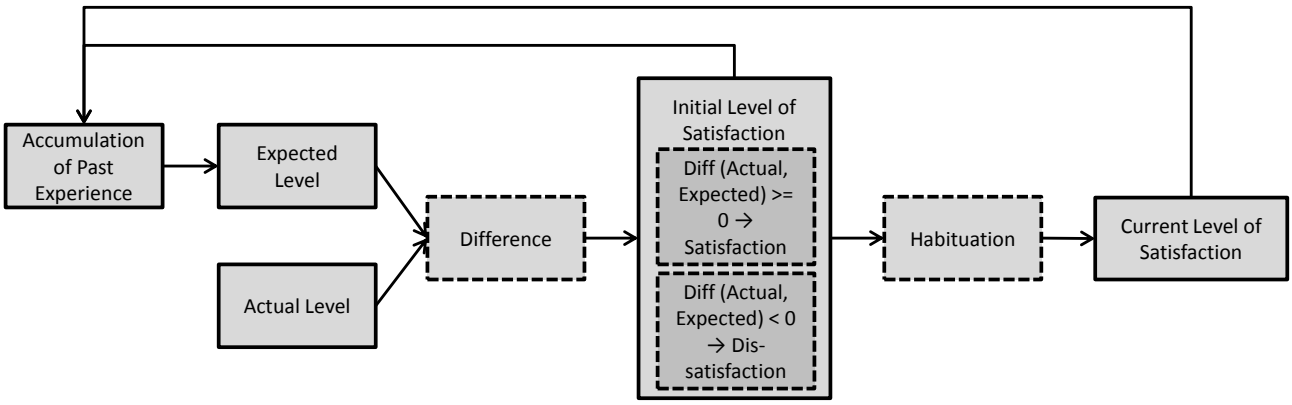

Figure 7. Dynamic Process of Satisfaction

The third psychological concept is the habituation that is defined as “the weakening of a response to a stimulus, or the diminished effectiveness of a stimulus, following repeated exposure to the stimulus” (APA Dictionary of Psychology). This tendency can generally be seen in the UX curve (Kujala et al. 2011) although, in some cases, the curve goes upward based on some positive event. The dynamic process of satisfaction, thus, can be expressed using three psychological concepts.

5. CONCLUSION

In this article, authors proposed that the satisfaction is the dependent variable that is representing the UX and all other objective/subjective quality characteristics are the independent variables. This functional relationship will depend on the temporal factors to which three psychological concepts are related, namely, the adaptation level, the level of aspiration and the habituation.

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BIOGRAPHY

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5D - Culture

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Rite de transition

A Design Choreographic exploration of cultural value exchange, through development of intercultural ritual artefacts

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Abstract: This research project is called *Rite de transition*. By means of DesignChoreography, an approach developed by Sietske Klooster, we explore the rituals revolving around traditional Turkish marriage. In due course, inspired by an emotional and auto-ethnographic interpretation of the explored rituals, Klooster designs a novel ritual and artefact that intend to embody shared values, hence intercultural exchange. We choose for a bodily first person approach as we estimate that the complexities of the modern world – i.e. cultural clashes and the breakdown of cultures - require a radical change in tackling these issues. We suggest to move away from pure rational analytic approach our society adhered to. We are on the verge of a new era that embraces diversity and organic interaction that cannot and does not have to be standardized, fixed or rigidly defined anymore. Our approach is based on embodiment and phenomenology, allowing us to diverge from narrowing down broad societal and cultural issues to mere rational thinking and judging. We use DesignChoreography as a vehicle, since the knowing and making body can experience meanings and values that lie underneath visual appearance. By doing so we bring about our bodily understanding for intercultural interaction and exchange.

Keywords: Cultural values; experience-based interaction design; DesignChoreography; embodiment; phenomenology

1. CULTURE

Culture is becoming more complex, hidden in the small details of our transcultural society and in the subtleties of human behaviour. As Victor Turner mentions: ‘We have been too prone to think, in static terms, that cultural superstructures are passive mirrors, mere reflections of sub-structural

productive modes and relations or of the political processes that enforce the dominance of the productively privileged. If we were as dialectical as we claim to be, we would see that it is more a matter of an existential bending back upon ourselves: the same plural subject is the active superstructure that assesses the substructural and structural modalities that we *also* are. Our concreteness, our substantiality is with us in our reflexivity...' (Turner, 1977: vii)

Cultural differences usually are explained and thought of in studies on anthropology, sociology or psychology, amongst others. They seldom are physically experienced and researched with and through our bodily senses. We estimate that cultural complexity – from the perspective of design - makes a first person perspective essential in order to gain a more thorough understanding of what cultural values are about. A first person perspective requires a more intuitive and sensorial exploration of culture, both for designers and non-designers to gain common knowledge on culture.

We look for DesignChoreography and bodily interaction to touch upon the meaning of marriage rituals within a small Turkish community from Emirdağ, living in Brussels. Marriage migration between Turkish communities living in Europe and emigration regions in Turkey is a current academic issue. In Belgium the majority of immigrants with a Turkish background come from this region. Scholarly research has been delivered, especially at the Universities of Antwerp and Ghent, from the field of social sciences, anthropology and ethnography on the question why young people, born and raised in western Europe, till recent years opted for a partner from a region that is largely unknown to them but proves to be their parents', or even grandparents', region of origin? The existence of a 'culture of migration' binding the region of origin with the region of destination in which the family as an institution builds a bridge between tradition and everyday reality, caught our attention and was the initial start for this project. (Timmerman, 2009)

We implement auto-ethnography and DesignChoreography as an emotional research method to start interaction with this culture that seems remote from ours. Its remoteness and difference attracted us to find the deep-rooted values that lie within. Instead of keeping an observational view (which we believe may also be one of the causes of this remoteness or isolation) we are interested to interact with the deep-rooted values this culture must have. As bodily understanding (Abram, 1996) and crafting artefacts is a universal human interaction mode, we estimate that DesignChoreography, as a medium, brings us closer to the essence of what rituals are and what they stand for within the context of this community, in relation to our 'secularised' western society.

2. RITUAL

What is the ritual upholding? What function does it serve? What social structures does it maintain? How do we understand them?

The importance of rituals within culture cannot be minimized nor underestimated. Rituals relate to decisive moments in life. Lifecycle rituals are rituals that accompany and assure crucial transitions in human life. The French ethnographer and father of formal 'processual' analysis, Arnold Van Gennep, called them 'rites de passage'. In his major work *Les Rites de Passage*, originally published in 1909, Van Gennep defines rites de passage as rituals, which accompany every change of place, state, social position and age. They mark forgiveness, reconciliation or transitions to adulthood, married life, divorce, healing from sickness, and death. Van Gennep: 'The life of an individual in any society is a series of passages from one age to another and from one occupation to another.' (Van Gennep, 1977: 2-3)

Because of the importance of these transitions in life, Van Gennep thinks it legitimate to single out

rites de passage as a special category, which under further analysis may be subdivided into rites of separation, transition rites and rites of incorporation. These three subcategories are not developed to the same extent by all peoples or in every ceremonial pattern. Rites of separation are prominent in funeral ceremonies, rites of incorporation at marriages.

Thus, although a complete scheme of rites de passage theoretically includes 'preliminal' rites (rites of separation), liminal rites (rites of transition), and 'postliminal' rites (rites of incorporation), in specific instances these three types are not always equally important or equally elaborated. (Van Gennep, 1977: 10-11) According to Turner: 'Van Gennep has shown that all rites of passage or 'transition' are marked by three phases: separation, margin (or limen, signifying "threshold" in Latin) and aggregation. The first phase comprises symbolic behaviour signifying the detachment of the individual or group either from an earlier fixed point in the social structure, from a set of cultural conditions (a "state"), or from both. During the intervening "liminal" period, the characteristics of the ritual subject (the "passenger") are ambiguous; he passes through a cultural realm that has few or none of the attributes of the past or the coming state. In the third phase (reaggregation or reincorporation), the passage is consummated. The ritual subject, individual or corporate, is in a relatively stable state once more and, by virtue of this, has rights and obligations vis-à-vis others of a clearly defined and "structural" type; he is expected to behave in accordance with certain customary norms and ethical standards...'. (Turner, 1977: 94-95)

In his thought provoking book *The Ritual Process,* Victor Turner states that society seems to be 'a process rather than a thing' –a dialectical process with successive phases of structure and communitas. (Turner, 1977: 203) In line with Van Gennep, Turner further developed the concept of liminality, besides that of communitas, structure and antistructure. Liminality, as he calls it, is a state of being in between phases. In a rite of passage the individual in the liminal phase is neither a member of the group he previously was part of, nor is he member of the group he will belong to upon completion of the rite. Turner characterizes this second phase in the ritual process, also called the transitional phase, as one of 'ambiguity': the ritual subjects are suspended between their former and future positions. He equates the transitional phase as the ambiguous 'liminal' period in which the 'passenger' passes through a cultural realm that has few or none of the attributes of the past or coming state. (Turner, 1977: 94)

3. AUTO-ETHNOGRAPHIC EXPLORATION OF MARRIAGE RITUAL

To support human functioning in these different states of being, conscious transitional moments are essential to embody the new state-of-being and to be able to function accordingly. Transitions are an important matter in life. These rites de passage are supported by artefacts, which become vehicles of transformational action and movement. Ritual artefacts are literal matter for transition or transformation.



Figure 1: Performance of henna ritual in Brussels

Within the lifecycle rituals, marriage - according to Van Gennep- constitutes the most important of the transitions from one social category to another, and for at least one of the spouses it involves an economic, (Van Gennep, 1977: 119) territorial (Van Gennep, 1977: 192) and essentially a social act. (Van Gennep, 1977: 117)

The marriage ritual is a complex issue. It is very confusing to understand from the perspective of our culture. In this research project we interacted in an auto-ethnographic way with the Muslim lifecycle ritual of marriage, transposed and adapted to western living circumstances in Brussels. The Muslim ritual of marriage consists of several ceremonies. "*Turkish marriage ritual*", Sietske Klooster observes, "*seems more of a process of transformation in family relations, instead of a moment of bonding, such as our moment with the rings. Choosing an object from the beginning was not an option. The Turkish marriage ritual is not built around one clear moment, point or object, but is a whole chain of events and places incorporating many accessories. I had planned to soon choose one object and investigate through that. While working I discovered I could not do so, yet had to go through the maximum confusion about all things that happen. Even with the Turkish there was a lot of confusion, having different ways of doing the same and also interpreting the values behind.*"

Klooster continues: "*I decided to dive into this confusion, give it time to settle and sink down to the pattern, principle that would emerge through taking time to see, listen and hear all this information. Here I decided to let my own process of feeling honest connection develop: where does it trigger a fundamental feel for common ground. Taking time to also let the feels of social cultural difference and even rejection happen, to sense where I felt an appealing ground for exchange*."

"*Not where we are the same, not where we are different, but where I feel space for exchange and mutual insights…making a puzzle differences that fit with each other. Such as combining the notion of equality between man and woman with the notion of both being fundamentally different and combining these to become a basis for family bonding*."

Why choosing the henna ritual? "*The henna ritual triggers recognition of an important moment in life that is not ritually supported by our culture: the moment of a woman, saying goodbye to her daughter-mother relationship, to make place for becoming a mother herself. This ritual in marriage focuses on the relating of families and the transformations in there. It also brings in the combination of saying goodbye and being welcomed at the same time; grief and joy happening almost at the same time. Grief because of the loss of the childhood mother by the future bride; joy because of the future bride becoming wife and member of the new family of her husband. Feasting this dichotomy of emotions feels as a very strong concept, which I recognize as a beautiful aspect of life, yet not so much celebrated in our culture.*"

4. DESIGN CHOREOGRAPHY

With *Rite de transition* we explored the possibilities of cultural interaction and transformation through combined design and choreography, i.e. DesignChoreography, also known as Choreography of Interaction within the field of interaction design. (Klooster, 2005) Here the design of an artefact originates from the design of an action or activity, i.e. a movement, with inherent physical involvement, dynamic quality and experienced meaning. The formation of the movement is done in a bodily way. The designer, just like a choreographer, explores and defines the movement to elicit. Then the artefact is created through making and exploring its affordance of the intended movement.

In this case a novel ritual is created, inspired by the traditional Turkish Muslim marriage ritual, and interpreted in a western European way. Bodily communication between these two cultures here is essential.

Sietske Klooster is DesignChoreographer. The combination, moreover integration of design and choreography is her communication vehicle *par excellence* to facilitate societal transformation. Her approach involves movement as the pivotal modality to bodily reveal shared values and to co-create from this common ground. Her DesignChoreographies evolve through experiments and iterations of moving, making and reflecting on action, in close interaction with different stakeholders. This bodily way of creative interaction enables people to engage and participate in a process of embodied transformation, tuning in to inherent motivation to do so. Sietske literally choreographs matter of transformation (Hummels, 2012); i.e. an iterative process of events and inherent artefacts (and/or installations) that make people feel and embody possible societal transformation.

Here the created objects are not the goal of the process, but a means. They are vehicles to explore where societal values can evolve. Moreover, where transformational ideas are accepted and thus engaged with, based on intrinsic values and motivations. Consequently identity is not lost, yet supported to further develop in interaction with 'the other'. We believe this process might even enhance cultural diversity.



Figure 2: Henna try-out



Figure 3: The future bride's henna hand

5. DESIGN CHOREOGRAPHIC EXPLORATION OF MARRIAGE RITUAL

During this project, Klooster 'travelled' between the Turkish community living in Schaerbeek, Brussels and her own western European culture. She created a novel DesignChoreographic ritual, cross-pollinating the values behind traditional Turkish marriage ritual and our Western notion of it. After investigating the different ritual moments and artefacts of the Turkish Muslim community, she choosed the henna rite as her source of DesignChoreographic transformation. The henna rite, according to Klooster, is about a woman letting go of her childhood and daughterly ties with her mother, to make place for a relationship that belongs to the state of maturity; becoming wife with her husband. By undergoing this ritual, facilitated by a Turkish mother and her daughters, Klooster realised how this transformational moment was lost in our own culture, as a consequence of societal change that was never ritually supported. In western society we move out of the

mother-daughter relation to become an independent, self-sufficient woman. From that state a woman finds and chooses her partner, as her own individual choice, to then move into a woman and man relationship.

However, this societal change - an increase from two to three states, bringing in the state of being independent - was never ritually supported in our culture. A conscious ritual moment of letting go of motherly care and deliberately go out to become autonomous is non-existent. Klooster therefore chose to bodily investigate how to ritualize this forgotten yet essential transitional or liminal moment, inspired by a deeper physical understanding of the Turkish Muslim marriage ritual.



Figure 4: Movement exploration by Sietske Klooster with beads

To further develop her interpretation of the henna ritual, Klooster explored the role of hand palm, as this body part is central in the Turkish Muslim ritual. The reason for henna application on this body part is not univocal and involves a myriad of practical and symbolic levels. Yet instead of rationally determining the pragmatic and symbolic origin of this body part, Klooster explored to experience her interpretation of movement pivoting around the palm of the hand, both in the act of separation (mother-daughter) and in the bonding (husband-wife). She primarily searched for the meaning experienced through the movement since movement provides a common understanding or, as Schwartz mentions within the context of the relationship between the dancer or performer and her stage, ‘the body must be realized as a matrix of meaning. We learn to think from the body outward’. (Schwartz, 1996: 79) Because of this matrix, people who speak different languages may often be able to communicate with the language of gesture. Schwartz: ‘Everyone shares a common repertoire of action schemes, even though there are instances in which specific gestures convey different or even opposite meanings in different cultures.’ (Schwartz, 1996: 81)



Figure 5: Film stills of further movement explorations by Sietske Klooster

Through her bodily investigations she explored the existing movements and impulsively transformed these into her interpretation, to the point where she started to resonate and felt a connection and meaning arising. It became a movement of letting go of the hand palm contact, by untangling of the arms and fingers and hence literal loosening of the mother-daughter relationship.

From there she improvised the movement into the state of being on ones own, becoming an independent woman. Here her arms that just moved out of the entanglement fall into relaxation, hanging, grounding and looseness. This is the contemporary intermediate western European state that developed over the last decades.

After first having accommodated to this state, feeling stable yet flexible in it, she chose the moment to start a new bonding. The bonding of a woman that chooses a man to be with is about entangling arms and fingers and joining the palms of the hands in an act of symmetry thus mutuality. The reverse of the untangling she previously chose to go through with her mother; a bilateral entanglement.

To facilitate this movement, Klooster iteratively made an artefact that literally incorporates all three states, and can be passed on over generations of time, evolving from one state to the other endlessly. She made several design explorations that she evaluated in physical interaction with different members of the Turkish community. The process resulted in a sleeve that covers wrist and hand. This sleeve facilitates the transition moments between the three states, and ‘preserves’ the states between the transition moments.



Figure 6: Intertwining movements with the designed artefact

The sleeve affords the intertwining moment of alliance with a man to start a new family. The movement ends with the bride having her hand covered in the flower-shaped entanglement, centered in the palm of her hand. An entanglement-glove that can be stored till the moment when the bride has become a mother that has to let go of her own daughter.

In the untangling moment of letting go, the entanglement-glove is put on again, transferred to the hand of the daughter, and untwined to become a light and free hanging sleeve around her hand; an airy sleeve with literal space to move into independence, and open for a new entanglement with a man, when she chooses too.

As said, in between these moments the sleeve can be kept as a frozen symbol of the transitions. Either as the loosened sleeve while living alone for a while, until the right novel relationship is found, or as entangled sleeve, while founding a family and until the daughter will leave the house. A novel symbolism is initiated here, through bodily investigation and through interactive interpretation with the Turkish community members.

When making a novel ritual object, Klooster mentioned, there is the danger of becoming enticed by known symbolism and of the object as such. Klooster specifically tried to feel the delicate difference between the object as carrier of symbolism and the factual experience of a ritual movement and its inherent meaning, facilitated by a ritual object. By material retrenchment and embodied investigation, the designer escapes the existing ‘frozen’ symbolism and finds what lies underneath it and felt in the physical experience of the ritual movement. From this bodily basis it is possible to investigate the experience of shared values, or at least values that are mutually understood. This is where contemporary living and thus dynamic symbolism and tradition can arise, in close connection with a mutual embodied understanding of ritual meaning and values between cultures.

6. FURTHER EXPLORATIONS

With *Rite de transition* we interactively explored what the henna ritual within the traditional Turkish Muslim context is about. We experientially investigated from a western European perspective, using DesignChoreography as a means to communicate with the other culture and distil a mutual understanding. Body language and communication through making literally brings connection and concrete bodily understanding of exchanging ideas about cultural values. In this particular case, design and choreography bring about interaction between cultures and thus exchange, instead of trying to understand in a cognitive, verbal and thus more distant observational way. By making and doing the transfer, the transformation literally happens, while learning about each other at the same time.

We focused our attention on culturally embedded aesthetic values and how to realize a contemporary understanding of this, (r)evolving between cultures. We worked with the DesignChoreography approach based on our belief in embodiment and phenomenology, to stimulate societal transformation. Within this process, we looked for novel ways and venues to enhance mutual respect and appreciation as a basic attitude to cultural dialogue and understanding. This physical approach is what we consider to be our new language in the intercultural context, including the importance of reflection on action instead of mere rational observation and communication.

We estimate that *Rite de transition* introduces a novel approach and level to cultural studies: creative bodily interaction as a way to explore common ground and value exchange. Designers here can facilitate and contribute to cultural studies to become interactive, more than being merely a study of finding facts and why they are the way they are. Cultural studies here become dynamic, just like cultures are as a phenomenon in itself.

Rite de transition is not a finished story. It is meant as a starter. We intend to further reflect on this first part of the project with a Turkish Muslim family and a western European family. This we plan to do as a bridge to a second trajectory, where a designer with roots in Turkish Muslim culture takes over the current DesignChoreography and brings about a next iteration, manifesting his/her embodied explorations and interpretations. Thus DesignChoreography on rituals becomes a matter of intercultural development and transformation. The first person perspectives and interactions of designers and involved cultures thus bring about tangible cultural dialogue and consequently development.

ACKNOWLEDGMENTS

This research process could never have happened without the interaction with a family with Turkish Emirdag roots, living in the vicinity of Schaerbeek. Gulay K. kindly invited us to her house in Schaerbeek, Brussels. Together with her daughter, daughter-in-law and assisted by Cani N., she initiated us into the bodily expressions and dress codes of henna and Turkish marriage ritual. She also invited us to the marriage festivities of her son and his future wife, Hatice. We further like to thank Gülcan Bozdag, coordinator of Cultures-Elles in Brussels and EYAD, La Maison de Turquie, for their kind support.

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BIOGRAPHY

Dr. Johanna Kint has a background in art history (KULeuven) and design history. She obtained a PHD at the Delft University of Technology, on a thesis contextualising the World fair of 1958 as embodiment of humanistic modernism. She coaches and teaches at Bachelor and Master's level at the TU/e and at LUCA campus Brussels. More recently, her research focuses on socio-cultural issues related to the multicultural neighborhood of Brussels and reflection and action upon culturally embedded aesthetic and ethical values and their relevance on the language of dynamic form and gesture.

Sietske Klooster graduated in 2003 at the faculty of Industrial Design Engineering of the University of Technology in Delft. Here she started to develop her own design approach during her graduation project 'design moves'. She further developed this approach in close cooperation with the faculty of Industrial Design of the TU Eindhoven, focusing on Choreography of Interaction. Next she moved into the combination of farm and city life, with food incorporated in her embodied design work. The choreography of food production and consumption became her core business. Currently 'The MilkSalon' is running as a case study to illustrate her design principles.

A Spontaneous Cross-Cultural Emotion Database: Latin-America vs. Japan

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Abstract: In this paper, we present a new database to support the cross-cultural studies. Two cultural groups are selected: Latin America and Japan, to represent *western* and *oriental* cultures. Emotions are elicited through an experiment in which participants observe emotionally loaded stimuli and then rate their feelings in a *valence* (how positive or negative is the experienced emotion) and *arousal* (how intense is this emotion) scale. The interactions are recorded using audiovisual and thermal devices. This database features three innovative characteristics: *spontaneous emotion expressions*, *multiple synchronized sources of interaction*, *cross-cultural comparison support*. This set of characteristics is missing in the currently available emotion databases, making our database a unique open option for studying spontaneous expressiveness of emotions in a cross-cultural context.

Keywords: cultural specificity, universality, multimodal corpus, affect.

1. INTRODUCTION

Imagine you are observing a conversation between two individuals. They are talking when one of them suddenly frowns strongly; his body slowly tenses up… You can hear him saying some words in a rough tone, rushing to leave. The expression on the face of the person left behind makes you think this person did not understand why the first one had such a strong reaction and left. You seem to grasp a lot about their feelings just by observing two people in the distance, even without listening to any of the spoken words in detail.

Expression of emotions is a key component in the communication among people (Mehrabian, 1971). For decades now, emotions and their expression and understanding have been studied in

several fields and the evidence shows the important role they play in our daily lives (Gratch et al., 2009). Along with the study of emotions, the study on *development* of systems that can *automatically* recognize human emotions has increased as well in the last decade (Gunes et al., 2011). The widespread use of computers in daily life and the desire of making them easier to use, have encouraged the inclusion of human emotion recognition systems for human computer interaction (Beale & Peter, 2008).

The interest on the degree of universality of emotions arose actively more than half a century ago (Ekman & Friesen, 1971) and since then several hypothesis on the universality of emotions have been presented (Izard, 1994). The vast majority of works done on automatic recognition of emotions *assume* that emotions are universal and the cultural variable of each individual is ignored. Still, current works in psychology show that there is no agreement on the *universality hypothesis*. Further studies on the effect of individual cultural background are required in order to settle whether emotions are really universal or specific to each culture.

Emotion databases are widely used in the studies of emotion expression. There are some databases currently available for this purpose (Gunes et al., 2011) but none of them can support the study of cross-culture variables. Our goal is to provide the scientific community with a robust database aimed to support such comparisons, thus, bringing the solution to the current lack of data to analyze the problem of universality or specificity of emotions.

Kashima (2000) defines culture as "a *relatively stable system of shared meanings, a repository of meaningful symbols, which provides structure to experience*". The database introduced in this paper comprises two cultural groups: *Japanese* and *Latin-American*. These two cultures are selected to represent the western and oriental populations, following psychological studies carried out to compare cultural differences (Scherer et al., 2011). Both chosen cultural groups comply with the definition of culture. Our database presents spontaneous expressions of emotion: participants are not led to show a specific expression or enact any emotion. The database includes emotional labels of the emotions portrayed in each interaction as well as labels for facial features and head position in space. The database is open and distributable for the research community.

A review of our database background is presented in the following section. Section 3 explains the details of the data collection, methods and materials. In section 4 the actual database contents are explained and finally the conclusion in section 5.

2. BACKGROUND

Broadly accepted studies on the hypothesis of *universality* of emotions (Ekman & Keltner, 1997) suggest there is a group of *basic* and universal emotions that are equally expressed and recognized in all the different cultures around the globe. The initial methods used to support these studies are based usually in still photographs of subjects and comparison among them.

New break through studies in psychology (Jack et al., 2012) neurology (Chiao et al., 2008) (Adams et al., 2010) and affective computing (Quiros-Ramirez & Onisawa, 2013) (Kamaruddin et al., 2012) have presented new evidence to support the *specificity* of emotions: culture seems to play an important role on the expression and recognition of human emotions.

Even though there are a handful of open emotion databases, most of them do not consider cultural factors. The work of Caridakis et al. (2012) presents a gesture database with participants from Germany (21 subjects), Greece (11 subjects) and Italy (19 subjects) who go through a mood

immersion procedure by speaking emotionally loaded phrases aloud. The work of Makatchev et al. (2012) presents another cross-cultural corpus showing *receptionist encounters* with participants from English and Arabic speaking countries. Yet as they warn in their paper, the small amount of participants in the corpus makes it unsuitable for cross-cultural comparisons.

3. DATA COLLECTION METHODOLOGY

In this section we explain the details of execution and contents of our Latin-American/Japanese cross-cultural database.

3.1. Participants

Individuals from Japan and the Latin American countries are recruited to participate in the data collection experiment. In total 57 participants join the experiment: 30 Latin-American subjects (12 female – 18 male) and 27 Japanese subjects (10 female – 17 male) currently living in the city of Tsukuba, Japan. The average age of the participants is 29.8 years old (22 – 45 years old).

The recording sessions are carried in a period of two weeks. Each participant proceeds individually and voluntarily to the data collection session.

3.2. Experimental materials

The data collection is carried in an empty dark room conditioned for the task. A group of cameras, display and microphone are set up to record the reactions of the participants during the experiment.

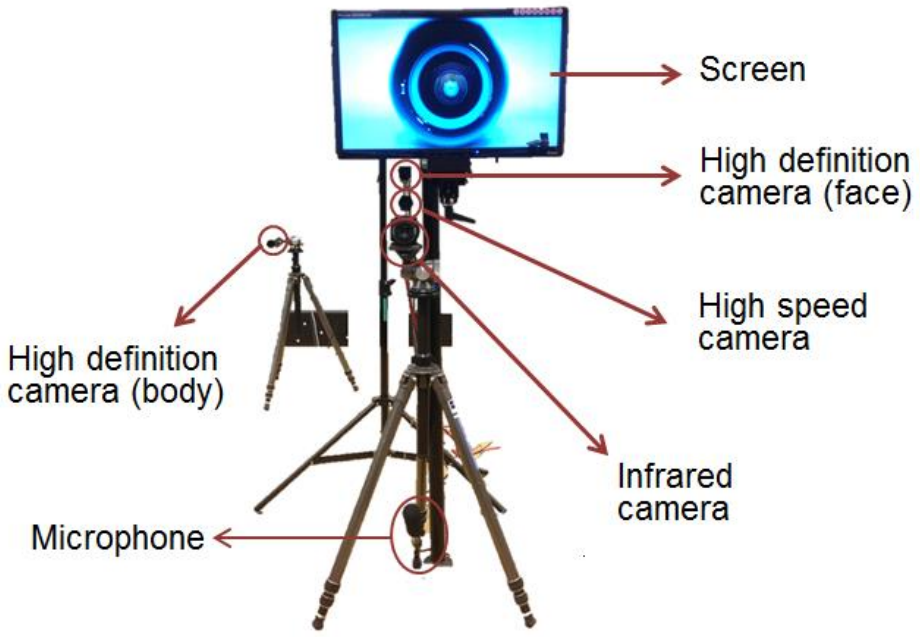

Figure 1: Set of devices utilized for the data collection

Figure 1 shows the array of devices used for the experiment. First, a screen (ProLite E2208HDS Widescreen) is placed 125cm over the floor. Below this screen is a set of cameras all focused to the participant's face: high definition camera (PointGrey Flea2CCD), high speed camera (PointGrey Grasshoper CCD) and infrared camera (FLIR SC300). Under this set of cameras there

is a directional microphone to record the subjects' utterances. In the back (left side of the picture), one more high definition camera is placed to record the participants' full body reactions. All the devices are synchronized to assure that the recorded data in the different channels can be accessed simultaneously in the same point in time for analysis (Quiros-Ramirez et al., 2012).

In front of the screen, at a distance of 130cm a chair is placed for the participant to sit and take the experiment. Three sources of light are used to improve and stabilize the room illumination. Two lights are placed aside the cameras and one above the display screen. The layout of the experimental room can be seen in figure 2.

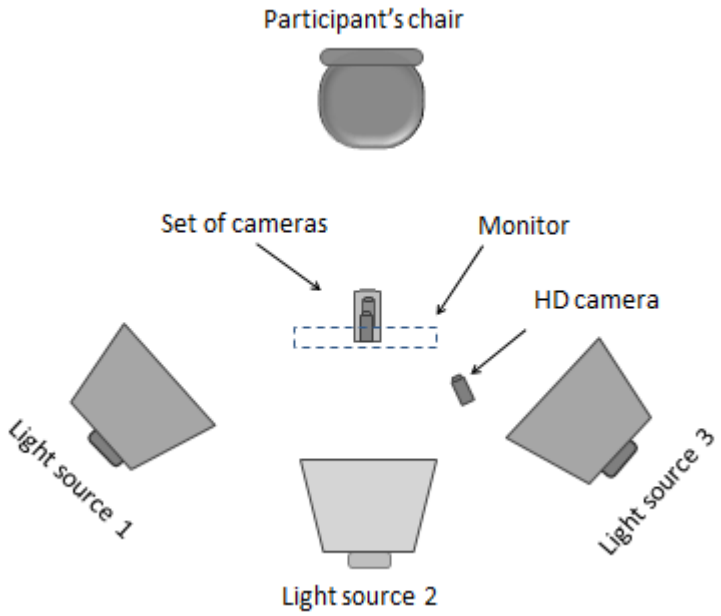

Figure 2: Layout of the experimental room

3.3. Data collection experiment

Previous research has shown the importance of natural or spontaneous emotions (Wilting et al., 2006) (Hoque & Picard, 2011). When emotions are enacted, they tend to be exaggerated or stereotyped making the resulting data not fit for emotion analysis or studies. Our goal in this database is to provide robust data for cross-cultural comparisons, therefore spontaneous emotion elicitation techniques are used to allow the participants to express freely even under laboratory conditions.

An emotion elicitation technique refers to experimental conditions that might induce the participant into an emotional state without any explicit guidance or request him or her to enact an emotion expression. The participant is not hinted about the final emotional goal.

3.3.1. Experimental Flow

The participant is guided to the experimental room and asked first to fill up two questionnaires about current mood and cultural traits. After this, the experimenter explains the experimental task to the participant. The experimenter informs to the participant that the interaction will be recorded and that the experiment can stop at any moment by request of the participant.

If the participant agrees to the conditions, he or she then signs a consent experimental form and is guided to the task area. First, the participant makes a short practice of the experiment to familiarize with the task. After answering any questions from the participant, the experimenter

leaves the room and the participant performs the task alone.

Once the experiment is finished, the experimenter returns to the room and the participant is asked to sign once again the consent form.

3.3.2. Experimental Stimuli

Emotionally loaded images (Dan-Glauser & Scherer, 2011) and videos (Hewig et al., 2005) are used as stimulus for the experiment. These are initially classified by valence content in positive, negative and neutral. Each participant is presented with 8 positive, 8 negative and 8 neutral images and one video of each category. Participant self-emotional rating could differ from the original label of the stimulus.

3.3.3. Experimental Task

The experimental task consists in rating images and videos that are presented for the participant in the screen. A total of 24 loaded images and 3 videos are then presented randomly. A grey screen is displayed between stimuli for 3 seconds to let the participant rest in between.

The participant is asked to observe each image or video (stimuli) and answer two questions: 1. his/her current emotion; 2. the intensity of this emotion. Both questions are rated in a 5 point scale (from -2 to 2). For the first question, the emotional *valence* is inquired: how positive or negative is the emotion he or she feels as a product of the image. In this question, the rating -2 represents a very negative feeling and 2 represents a very positive feeling. In the second question emotional *arousal* (intensity of the emotion he or she felt) is checked, -2 means a very weak feeling and 2 stands for a very strong feeling. The participant should answer to the questions aloud.

4. CROSS-CULTURAL EMOTION DATABASE

After all the data is collected, the segmentation and database creation process are started. The first step to shape the database is to segment the recorded data in short session. Each observation and evaluation of a stimulus is considered a *session* in the database. Thus, 27 sessions are obtained per participant. Using FaceTracker toolbox through *Open Frameworks* toolbox (Saragih, 2012) the participant's facial features as well as head position information are tracked and recorded. Table 1 explains the information contents of each session stored in the database.

Table 1: Contents per session in the database

Information	**Detail**
Observed stimulus	Information on the type and valence of observed stimulus
Emotional tag	Corresponds to the emotional valence and arousal self-report evaluated by the participant immediately after observing a stimulus
High definition videos	30FPS videos of the face and body of the participant
High speed video	180FPS video of the participant's face during the session
Infrared data	60FPS infrared data of the participant
Sound	Recorded utterances (includes the spoken evaluation)
Facial Feature Points Data	Frame by frame tracking of 68 facial points
Head Position	Frame by frame tracking of the head position in space

The database is stored in SQLite (Owens, 2006); this makes it easy to browse through the data. Relevant non-private information about the participant is stored as well for example nationality, gender, wears glasses or not, etc.

Figures 3 presents still frames of expressions captured by the high speed camera focused to the participant's face. The frames are grouped in three clusters: positive, negative and neutral emotions. This classification corresponds to the emotion reported by the participants themselves and they might differ from the original emotional tag of the stimuli they saw; we consider the participant's self-report as the "real" emotional valence. The participants on the top row are Japanese and the participants from the bottom row are Latin-American. Even though the participants are not aware of the emotional goal of the experiment and they complete the stimuli rating task alone, expression changes can be observed in each emotional valence block.



Figure 3: Still frames from the high definition videos. Each block represents the emotion reported by the participant: negative, neutral and positive emotions respectively. All the participants in the top row are Japanese, and in the bottom row Latin-American.

Database characteristics and usability

The database introduced in this paper has a set of characteristic that makes it suitable for emotion analysis in different fields, such as psychology and affective computing. The following is an explanation of each characteristic and how it can support emotion expression studies.

Cross-cultural: Spontaneous emotional data from participants of two separate regions (Japanese and Latin American) is successfully recorded making this database the first open database of its kind. Up until now there is no available open and spontaneous data that can be used to analyze and compare differences and similarities between western and oriental population groups.

Spontaneous expressions of emotion: Given the results on previous studies (Wilting et al., 2006) (Hoque & Picard, 2011), the need for non-posed expressions is clear. The current database provides the community with a dataset of spontaneous expressions which is a robust tool to study the emotion phenomenon.

Multiple synchronized data channels: One important aspect of emotions is the timing and relation between different cues. The current database allows comparison between cues in time thanks to the 1ms order synchronization between data channels achieved through our data recording set-up

(Quiros-Ramirez et al., 2012). The synchronization issue is a key factor in the analysis of emotions, it is necessary to study the time correlations between different cues and movements when an emotion is being displayed in order to achieve a deeper understanding of the expressions of emotion (Scherer et al. 2011).

Open for research purposes: Our database is open and distributable online for research purposes. This database covers the current lack on open spontaneous and cross-cultural emotional data. By providing emotion and feature tags, the database is ready to be used in the analysis and training of emotion systems. Also, the structure of the database allows the extension of emotion and feature tags, allowing the users to create new labels to fit their own research needs.

We consider the construction of communication models using emotion recognition as one of the applications of the presented database because, as mentioned in the Introduction section, expression of emotions is a key role in the communication among people. Even though the current database is yet to be tested in the construction of automatic emotion recognition systems, its success is anticipated based on the results obtained previously employing the same data collection techniques for emotion recognition (Quiros-Ramirez & Onisawa, 2013).

5. CONCLUSION

The construction of an automatic emotion recognition system is a broad task with several problems in the middle. Several variables come to play while trying to understand the meaning of human behavior and expressions. Even though individuality comes to play in the expression of emotions, based on psychological studies culture seems to have a strong influence in our expression of emotions. In order to study and find the answers to this phenomenon it is necessary to have access to data fit for the problem. In this paper we introduce an open database to support the study of the cultural factor in emotions. The set of characteristics of our database is missing in the currently available emotion datasets, making our database a unique open option for studying spontaneous expressivity of emotions in a cross-cultural context.

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Study on Cultural Differences of Users' Perception towards Shape Characteristics

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Abstract: In the recent marketplace, it's necessary but no longer sufficient to offer a good functioning product. The emotional quality of products plays an important role for differential advantage. Particularly, globalized markets mean more intense competition than ever before. Understanding the users' real emotional needs in different cultures is becoming a key strategy for the adaptation of products in overseas market. This proposed study elicits insights on cultural differences between European and Asian values and investigates how these affect user's reaction to designed products. Two experimental studies of products' emotional quality are carried out on European and Asian participants via Semantic Differential Method: one case is conducted with the shape contours (pellet burners) represented by Europeans and South Asians (Indian) respectively for the investigation of their shape preferences; another case is organized with prototype model defined with geometrical design attributes (eyeglasses frames) represented by Europeans and East Asians (Chinese) respectively in order to reveal the structure of shape meaning comprehension. After conducting statistical analysis, the result of this study helps to improve user satisfaction both within national and overseas markets. It's useful for designers to identify and emphasize these shape features of new products which will stimulate the positive responses to required user preferences.

Keywords: cultural differences, Kansei Engineering, Semantic Differential Method, shape.

1. INTRODUCTION

Globalized markets and the increasing technological sophistication mean more intense competition

than ever before. Not only cultural variation is seriously conflicting with the uniformity principle of mass-production (Diehl & Christiaans, 2006), but also a good functioning product is sufficient any longer (Lu, 2013).

Considering that users from different cultures may employ different preferences and bias on a product, an effective design requires consideration of this cultural variation and should be planned to accommodate the needs of people with diverse cultural backgrounds. Understanding the users' real needs in different cultures is becoming a key strategy for the adaptation of products in overseas market.

Consumer research has shown that the emotional quality of products plays an important role for differential advantage in the marketplace (e.g. Dumaine, 1991). It is a challenge for design engineers to transfer consumers' emotional needs into technical and design specifications. Designers don't know how users react. A product's value can be perceived and interpreted in many different ways (Hsu et al., 2000). Conversely, users don't know what designers are up to (Crilly, 2011). This miscommunication can be particularly problematic when considering different cultural backgrounds or rather expensive for companies when not considering cultural backgrounds. Cultural differences strongly influence the understanding of product emotion (e.g., Uchida et al., 2004; Chandrasekaran and Tellis, 2008).

Nowadays product designers are seeking to satisfy user's emotional needs within product in several ways (Cho & Lee, 2005). According to Desmet & Hekkert (2007) the product shape has to express functionality, usability and pleasant feeling. The physical shape of a product plays a critical role in the perception of designed objects and its market success (Luo et al., 2012). The manipulation of product shape is therefore an important way through which designers communicate messages and elicit affective responses from users (Hsiao et al., 2006). However, the same shape could elicit totally different association between groups of individuals. Cultural context is usually side construct of consumer positive and negative product evaluation (Cho et al., 2011).

This proposed study elicits insights on cultural differences between European and Asian values and investigates how these affect a user's reaction to designed products. It carries out an experimental study of products' emotional quality towards shape in European and Asian markets. The proposed study is situated within the new product development research area called Kansei Engineering, often synonymously used with Design for Emotion.

In order to achieve the goal effectively, the structure of this study consists of two major parts with user's perception data. One is to investigate the shape preferences (angular and rounded), and the other is to understand the structure of shape meaning comprehension (combined shape characteristics). Results are a step towards helping designers to identify and emphasize these shape features of new products and improving product adjustments to overseas market. In this paper, we present the description of method in section 2, while the organization of experiments is described in section 3. In section 4, we present the analysis and discussion of the results. Finally, conclusions and perspectives are drawn in section 5.

2. METHODS

Although, several techniques have been developed to compose mapping and quantify Kansei qualities, the most common approach is Semantic Differential (SD) technique (Osgood et al., 1957). Originally, the Semantic Differential Method was proposed to analyze semantic structures and the

affective meaning of things. Relying on this methodology, Kuller (1975) developed for the first time semantic scales for product design, where 36 adjectives are validated and grouped into seven factors. Since the semantics and the emotional content of design have inseparable relationship with each other (Demirbilek & Sener, 2004), more than 30 years later it became one of the foundations of Kansei Engineering, and it is also used in the context of Affective Design.

Semantic differential (SD) technique has been successfully applied to find the semantic structure of designs. It consists of defining a list of attributes, and carrying out user-tests in which the user must assess the product on measurement scales. The attributes, usually called Kansei words, are often defined by pairs of antonymous adjectives, which lie at either end of a seven point qualitative scale. A semantic space, Euclidean and multidimensional, is then postulated. After gathering SD data and analyzing them statistically (univariate or multivariate analysis), engineer makes suggestions to the designer to amend his design.

This initial research employed two cross-cultural surveys with European and Asian participants based on Semantic Differential Method, aimed to study and compare members of two different culture groups who speak different languages that might lead to significant differences in shape preference and comprehension.

3. EXPERIMENTS

3.1. Experiment 1 – shape preference

We carried out an experiment on European and South Asian students comparing their preferences toward angular and rounded shape contours, to investigate their shape preference. According to Zhang et al. (2006) research finding from comparison experiment conducted with American and Asian participants, individuals with independent self-construal should perceive angular shapes as more attractive, whereas individuals with interdependent self-construal should find rounded shapes more attractive. We assume two hypotheses as follows:

H1.1: South Asians will have greater mean towards rounded shape in comparison to Europeans by all Kansei words.

H1.2: Europeans will have greater mean toward angular shape in comparison to South Asians by all Kansei words.

3.1.1. Contour shape samples

The survey was conducted on 2 samples of contour shapes. In this experiment we intentionally did not associate the shape with any shape symbolism. The basic idea was to create an angular and rounded contour shapes based on real product design form characteristic. Selected images of pellet burners were transformed into 2D geometric shape contours which are shown on Figure 1.

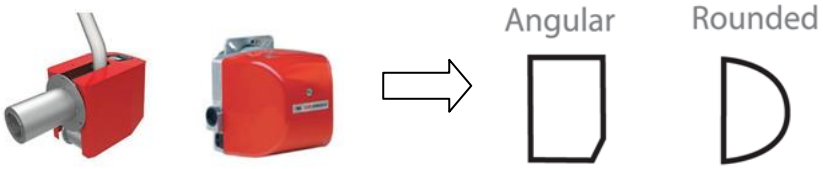

Figure 1: 2D contour shapes: Angular and Rounded (based on two real Pellet Burners).

3.1.2. Selection of Kansei words

There were several criteria for Kansei words collection and selection. Crucially, Kansei words

have to be common and daily used and they have to be clearly understandable or familiar to all participating students. Therefore, the most representative and general Kansei words were selected and included in questionnaire for further evaluation: beautiful-ugly, simple-complex, reliable-unreliable and comfortable-uncomfortable.

3.1.3. Subjects and procedure

Working with the hypothesis, the experiment 1 was carried out involving Hungarian, Croatian, Slovenian and Indian participants, represent for European and South Asian groups. A total of 106 students (25 females and 81 males) were invited to take part, including 16 Hungarians, 19 Croatians, 18 Slovenians and 53 Indians. They are undergraduate, master and PhD students, aged between 25 and 40, who have similar educational background: mechanical engineering, industrial design engineering and product design.

The research was performed using paper questionnaires in English language so all students had the same evaluation forms. Surveys were conducted in the classroom during the daily light. The participants received clear instructions about the test. Test was made using semantic deferential procedure. Subjects had to fulfill a blank point on 5-level likert chart where for example was “1-very complex, 5-very simple”.

3.2. Experiment 2 – shape meaning comprehension

Another experiment is organized with prototype model (eyeglasses frames) defined with geometrical design attributes, represented by Europeans and East Asians (Chinese) respectively in order to reveal the structure of shape meaning comprehension. We assume two hypotheses as follows:

H2.1: Europeans and E. Asians will have different mean towards these eyeglass frames by all Kansei words.

H2.2: Europeans and E. Asians will have different shape comprehension towards specific shape characteristic.

3.2.1. Geometrical prototype samples

To illustrate the approach, we propose to study eyeglass frames, which are very interesting products from a design perspective. An eyeglass frame is a complex product that not only integrates functionality, but also aesthetics, individuality and transmits to the owner a controlled affective image (Inoue et al., 2004; Yanagisawa & Fukuda, 2004; Huang et al., 2010).

Although an eyeglass frame is a product with a limited number of parts, there are still a lot of geometrical details. In our study, we selected the common and ordinary full-frame samples. In order to facilitate the CAD modelling, the digital model of the eyeglass frame has been simplified. We supposed that the bridge and the two rims are flat and in the same plane rather than cambered in the space. Referred to the research findings for eyeglass frame form generation (Lo & Chu, 2009), four shape factors with different levels to control the design variables with a general digital model are defined as follows: frame leg width (Factor A), rim profile (Factor B), rim aspect ratio (Factor C), and rim thickness (Factor D). An experimental design with 22 samples size was proposed, which we consider of reasonable size to limit the fatigue of the subjects. The 22 digital models of the eyeglass frame were defined with CATIA V5R19, which information of material, color or texture are irrespective, so that the participants could focus the their attention on shape only (Lu & Petiot, 2012), shown in Figure 2.

Factors	Level Settings
A: frame leg width	A1: wide A2: narrow
B: rim profile	B1: B2: B3: B4: B5: B6: B7: B8:
C: rim aspect ratio	C1: 0.75 (high) C2: 0.5 (wide)
D: rim thickness	D1: thick D2: thin

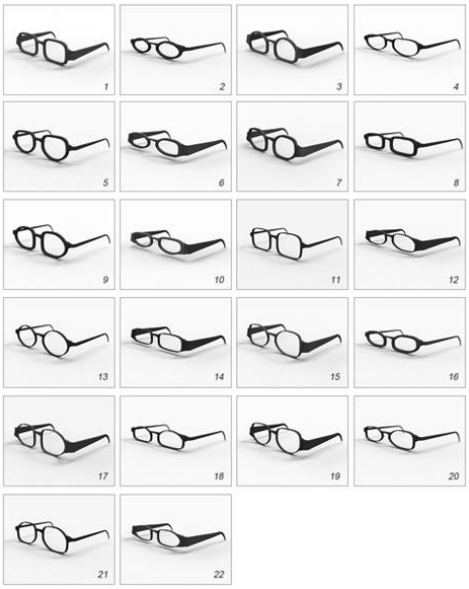

Figure 2: Product space defined with four design factors

3.2.2. Selection of Kansei words

The choice of the semantic attributes for this experiment was made by analysing previous papers in Kansei Engineering, in particular on the perception of eyeglass frames (Inoue et al, 2004; Lo and Chu, 2009). Eight pairs of Kansei words were selected, shown in Table 1, with their English translations listed.

Table 1: List of Kansei words in Experiment 2

No.	Adjectives
1	feminine – masculine
2	common – special
3	original – dull
4	delicate – rough
5	funny – serious
6	obedient – rebellious
7	modern – retro
8	smart – ordinary

3.2.3. Subjects and procedure

Eighty-eight college students (22 French, 22 Slovenians, and 44 Chinese) participated in this survey. They are between the ages of 18 and 30, with 21 females and 67 males. They are undergraduate, master and PhD students, who have similar educational background: mechanical engineering and industrial design.

The experiment was conducted in a calm computer room to avoid any external disturbance. In a short introduction, the subjects were informed about the purpose of the experiments and an explanation of the functioning of the interfaces was given. Three different language versions of the Kansei words were provided, in French, Slovenian, and Chinese. Subjects were advised that they could take their time to make the assessment on an unstructured scale (0-100), but that an intuitive and quick response was preferable. The presentation order of the eyeglass frames used a Williams

Latin Square in order to control the order and carry-over effects. The experiment was fully balanced because had 22 products and 88 subjects. In order to make the task of the test as user-friendly as possible, Matlab graphical interface was designed, shown in Figure 3.



Figure 3: Interface of the Experiment 2

4. RESULTS AND DISCUSSIONS

4.1. Experiment 1 – shape preference

In order to get clearer information, we run descriptive statistic, see table 2.

Table 2: Descriptive statistics of observed participants

	Europeans			**S.Asians**			**Europeans**			**S.Asians**		
	Angular			**Angular**			**Rounded**			**Rounded**		
	Mean	**SD**	**SE**	**Mean**	**SD**	**SE**	**Mean**	**SD**	**SE**	**Mean**	**SD**	**SE**
Beautiful-ugly	2.70	1.07	.147	2.79	1.01	.138	3.64	1.15	.157	4.08	.958	.132
Simple-complex	4.09	.925	.127	3.89	1.05	.144	3.75	1.19	.164	4.13	1.11	.153
Reliable-unreliable	3.53	1.25	.172	2.98	1.39	.190	3.15	1.39	.191	3.34	1.39	.190
Comfortable-uncomfortable	2.51	1.22	.167	2.92	1.39	.191	3.89	1.12	.154	3.68	1.37	.188

We used independent t-test to compare means. The independent t-test assumes the variances of the two groups you are measuring to be equal. First we assessed homogeneity of variance using Levene's Test for Equality of Variances. There were all variances equal except in one case. Further, a special interpretation of that case (Figure 4) was provided:

- **Kansei pair (beautiful-ugly)**: Regard on descriptive analysis, there was no significant difference with t(104) =.468, p=.641 between Europeans and S. Asians towards angular shape contour, which was perceived to be ugly by both groups. Rounded contour shape was perceived to be beautiful by both groups. At this case, S. Asians have higher mean in comparison to Europeans which is statistically significant with t(104)= 2.116, p=.037.

- **Kansei pair (complex-simple)**: Both Europeans and S. Asians found angular shapes to be simple so there was no statistically significant difference in their means with t(104)= -1.080, p=.283. Similarly, rounded shapes were found to be simple with no statistical significant difference with t(104)=1.691,p=.094.
- **Kansei pair (unreliable-reliable)**: Statistically significant difference was discovered at reliability of angular contour shape with t(104)=-2,123, p=.036. Europeans found angular contour shape to be reliable while S. Asians were neutral at this point. There was no statistical significant difference found at rounded shape perception with t(104)=.699, p=.486. Both Europeans and S. Asians think that rounded shape contour is reliable.
- **Kansei pair (uncomfortable-comfortable)**: Similar perception of angular and rounded shape towards Kansei word "comfortable-uncomfortable" was discovered. Both Europeans and S. Asians perceive angular shape as uncomfortable so there is no statistically significant difference in means with t(104)=1.634, p=.105. Special case where Levene's Test for Equality of means was significant happened to be rounded shape at Kansei pair "comfortable-uncomfortable". At this particular case we should consider that equality of variances was not assumed. Thus, both participants perceived rounded shape as comfortable so there is no statistically significant difference as well with t(104)=-.854, p=.395.

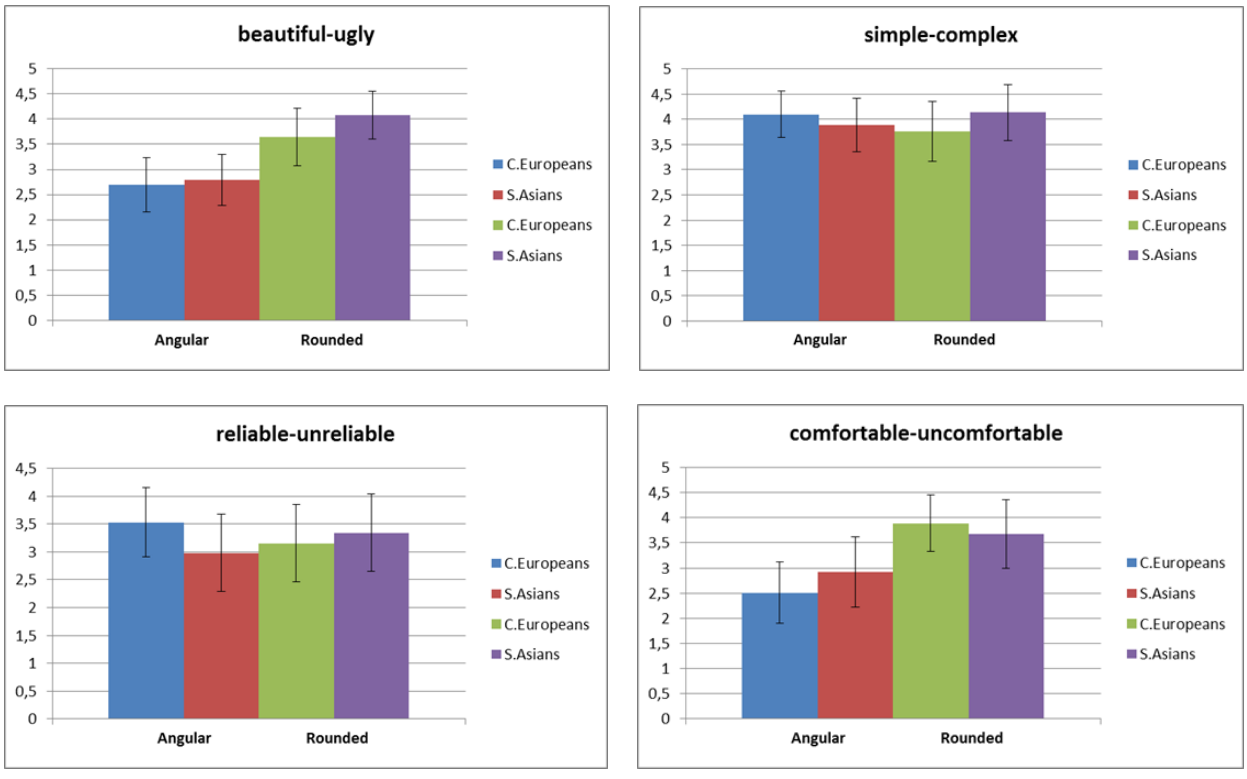

Figure 4: Comparison of Europeans and S.Asians means towards Angular and Rounded shape contour

Generally, there were discovered some minor differences between Europeans and S. Asians participants. Within first Kansei pair (beautiful-ugly) and rounded shape a difference in mean between S. Asians and Europeans was discovered. S. Asians found rounded shape slightly more beautiful than Europeans. Another, difference was found at Kansei pair (reliable-unreliable) and angular shape. Europeans perceive angular shape to be reliable or have higher mean in comparison to S. Asians which were neutral. Hence, even thought we did find some statistically

significant differences between both groups, we can't confirm our hypothesis 1.1 and 1.2 for all Kansei pairs. Regard on results for both cultures angular shape was perceived to be ugly, simple and uncomfortable. Contrary, rounded shape was perceived as beautiful, simple, reliable and comfortable.

4.2. Experiment 2 – shape meaning comprehension

4.2.1. Comparison of mean value

We calculated the mean values of each group, shown in Table 3. The mean values of European group are informative, revealing the tendency of their shape comprehension towards specific shape characteristic. Unfortunately, the mean values of E.Asian group are around the median value (50), although the individual evaluations are diversity.

Table 3: Mean values of European group and E.Asian group

European	feminine - masculine	common - special	original - dull	delicate - rough	funny - serious	obedient - rebellious	modern - retro	smart - ordinary
P01	73	47	56	69	59	42	58	46
P02	26	53	52	51	47	43	48	47
P03	58	73	39	51	32	54	50	57
P04	43	31	57	47	67	36	47	35
P05	55	54	52	49	51	46	58	47
P06	34	61	46	48	55	55	44	48
P07	55	70	39	54	38	54	52	53
P08	66	34	63	61	68	38	42	32
P09	49	68	38	44	35	52	55	51
P10	40	51	50	52	61	45	38	46
P11	69	51	56	57	57	37	70	49
P12	40	47	51	51	55	37	42	47
P13	54	49	56	54	47	36	69	45
P14	64	38	61	56	65	42	40	37
P15	53	64	41	48	36	50	54	48
P16	36	53	45	46	60	51	48	48
P17	60	63	42	51	33	49	54	55
P18	41	52	47	42	53	42	50	41
P19	59	58	42	49	47	51	57	50
P20	41	42	51	50	63	41	47	36
P21	62	55	49	49	47	47	60	50
P22	46	54	47	47	53	51	35	48

E.Asian	feminine - masculine	common - special	original - dull	delicate - rough	funny - serious	obedient - rebellious	modern - retro	smart - ordinary
P01	63	49	51	53	51	51	49	51
P02	41	58	46	45	45	53	44	48
P03	57	49	49	51	46	45	44	46
P04	40	47	46	43	40	43	46	45
P05	52	53	45	43	41	46	50	47
P06	45	52	44	38	46	45	38	45
P07	58	45	46	43	54	46	51	49
P08	53	49	45	43	47	46	41	47
P09	58	60	44	39	45	44	47	47
P10	48	48	47	48	50	43	44	48
P11	58	51	49	41	45	53	53	49
P12	52	53	52	46	44	56	44	50
P13	54	52	41	41	41	44	53	47
P14	59	46	57	48	58	43	52	52
P15	59	48	46	44	47	48	49	50
P16	47	58	45	44	40	48	42	46
P17	55	56	45	48	42	44	46	48
P18	48	55	40	43	42	45	45	51
P19	57	54	50	44	49	48	51	49
P20	40	47	54	49	48	39	41	50
P21	51	58	43	50	43	50	46	51
P22	46	52	48	47	48	54	42	54

The results indicated that the two groups have totally different mean values, so that the people from these two locations have different interests and evaluations towards the same designed products. Although hypothesis 2.1 is verified, the flattened mean values of E.Asian group are uninformative. Thus, poor results with Chinese subjects don't allow an efficient characterization of the differences and similarities of the eyeglass frames. Moreover, whether any of the shape factors has statistically significant effect in changing the participant's affective responses to the eyeglass frames cannot be identified with statistical analysis (e.g., Analysis of Variance). We consider that there are three main causes driving this:

- **Value conflict**: In comparison with European consumers, the Chinese consumers are just at a crossroads of modernism and traditionalism, faced with both traditional Chinese culture and other cultures. Obviously, while changes to traditional cultures are occurring, the traditional segments and values still remain. In China, some people are satisfied in the fashionable society with rapid changes, while some people cling to conservative values.
- **Increased individuality**: The presence of this young Chinese generation (college students), children of the "one child policy", who received special attention from doting parents and grandparents, explains the rise of individualism and conspicuous consumption (Hawkins & Mothersbaugh, 2011). They prefer distinctive identity rather than concerns with in-group norms, which lead to the discrepancy in the evaluation.
- **Regional disparity**: Given China's expanses and large population, it has strong regional cultures (e.g. the rich coastal area; western depressed area), as well as sharp differences in urban and rural cultures, associated with income, dialect, and custom. Although the

participants are college students at similar ages, they are from different regions with different backgrounds, which cause variation assessments, even opposite views and interests.

4.2.2. Comparison of Coefficient of Variation

In order to observe the degree of dispersion and the diversity of shape comprehension, we calculated the Coefficient of Variation (CV) for each product sample on each Kansei pair, see Table 4 and 5. Obviously, European group has lower CV values than E.Asian group, thus it's easier for Europeans to reach a consensus than E.Asians.

Table 4: CV values of European group

CV of European Group									
	feminine - masculine	common - special	original - dull	delicate - rough	funny - serious	obedient - rebellious	modern - retro	smart - ordinary	
P01	0.25	0.56	0.46	0.28	0.42	0.55	0.53	0.48	**0.44**
P02	0.70	0.48	0.46	0.39	0.48	0.49	0.51	0.37	**0.48**
P03	0.32	0.21	0.53	0.46	0.57	0.37	0.52	0.27	**0.41**
P04	0.39	0.55	0.32	0.39	0.22	0.46	0.43	0.49	**0.41**
P05	0.35	0.38	0.37	0.41	0.40	0.42	0.37	0.35	**0.38**
P06	0.53	0.35	0.41	0.44	0.34	0.36	0.51	0.39	**0.42**
P07	0.42	0.24	0.40	0.39	0.44	0.30	0.36	0.29	**0.35**
P08	0.26	0.54	0.27	0.32	0.23	0.52	0.39	0.48	**0.38**
P09	0.46	0.25	0.51	0.48	0.61	0.47	0.36	0.33	**0.43**
P10	0.45	0.37	0.36	0.37	0.27	0.42	0.50	0.33	**0.38**
P11	0.31	0.54	0.48	0.45	0.47	0.62	0.29	0.41	**0.45**
P12	0.42	0.46	0.33	0.37	0.32	0.44	0.52	0.36	**0.40**
P13	0.44	0.54	0.45	0.44	0.57	0.66	0.32	0.39	**0.47**
P14	0.24	0.58	0.27	0.31	0.27	0.49	0.48	0.55	**0.40**
P15	0.41	0.23	0.36	0.41	0.42	0.29	0.32	0.36	**0.35**
P16	0.60	0.33	0.39	0.41	0.33	0.41	0.43	0.37	**0.41**
P17	0.33	0.30	0.49	0.41	0.57	0.40	0.43	0.28	**0.40**
P18	0.44	0.35	0.36	0.50	0.33	0.44	0.44	0.38	**0.40**
P19	0.39	0.32	0.48	0.50	0.46	0.45	0.50	0.37	**0.43**
P20	0.55	0.43	0.38	0.36	0.29	0.41	0.44	0.46	**0.42**
P21	0.34	0.40	0.42	0.46	0.47	0.44	0.38	0.29	**0.40**
P22	0.38	0.38	0.48	0.44	0.29	0.38	0.49	0.42	**0.41**
	0.41	**0.40**	**0.41**	**0.41**	**0.40**	**0.44**	**0.43**	**0.38**	

Max
Min
Mean

For European participants, the Kansei pair "obedient-rebellious" is the least understood, while the Kansei pair "smart - ordinary" is the most unified. According to the CV values, the extreme samples of European group are introduced in Figure 5. Europeans have identical ideas towards eyeglass frame samples P07 and P15, which have big rim with wide frame leg, considered as neutral, special, original and funny design. The eyeglass frame samples P02 and P13 (round rim profile with narrow frame leg) are most controversial, typically "feminine-masculine" for P02 and "obedient-rebellious" for P13. Although Experiment 1 verified that rounded shape was perceived as beautiful, simple, reliable and comfortable for both western and eastern people, the sophisticated of designed product (multifactor with interactions) are much more difficult to understand. The change of a single factor even evoke opposite view.



Figure 5: Extreme samples of European group

For E.Asian participants, they tend to diversity attitudes towards the same designed product for the CV values are high. Comparatively, the assessments on Kansei pair "feminine-masculine" and

"common-special" are more consistent, while the assessment on Kansei pair "modern-retro" is the most controversial item. This can be explained by the value conflict of the Chinese consumers, who have conflict views of modernism and traditionalism.

Table 5: CV values of E.Asian group

CV of E.Aisan Group									
	feminine - masculine	common - special	original - dull	delicate - rough	funny - serious	obedient - rebellious	modern - retro	smart - ordinary	
P01	0.33	0.44	0.48	0.46	0.47	0.48	0.49	0.49	**0.46**
P02	0.60	0.45	0.59	0.54	0.53	0.49	0.56	0.52	**0.53**
P03	0.39	0.52	0.46	0.44	0.50	0.53	0.56	0.47	**0.48**
P04	0.58	0.53	0.57	0.55	0.61	0.62	0.58	0.54	**0.57**
P05	0.48	0.48	0.58	0.59	0.59	0.56	0.58	0.56	**0.55**
P06	0.63	0.52	0.55	0.59	0.58	0.57	0.63	0.55	**0.58**
P07	0.45	0.54	0.52	0.55	0.45	0.48	0.47	0.50	**0.50**
P08	0.46	0.51	0.57	0.52	0.50	0.57	0.54	0.47	**0.52**
P09	0.37	0.36	0.57	0.58	0.56	0.56	0.54	0.52	**0.51**
P10	0.55	0.51	0.55	0.51	0.46	0.60	0.57	0.49	**0.53**
P11	0.46	0.51	0.58	0.62	0.63	0.49	0.53	0.53	**0.55**
P12	0.48	0.46	0.49	0.55	0.60	0.46	0.59	0.50	**0.52**
P13	0.51	0.53	0.61	0.58	0.62	0.56	0.58	0.59	**0.57**
P14	0.44	0.58	0.43	0.52	0.47	0.50	0.58	0.47	**0.50**
P15	0.40	0.52	0.55	0.53	0.52	0.48	0.51	0.47	**0.50**
P16	0.58	0.42	0.51	0.50	0.53	0.47	0.60	0.55	**0.52**
P17	0.45	0.45	0.60	0.52	0.62	0.57	0.53	0.54	**0.54**
P18	0.52	0.43	0.60	0.55	0.52	0.53	0.57	0.45	**0.52**
P19	0.40	0.46	0.51	0.53	0.51	0.49	0.51	0.51	**0.49**
P20	0.61	0.53	0.45	0.47	0.49	0.52	0.56	0.47	**0.51**
P21	0.44	0.43	0.61	0.45	0.57	0.47	0.57	0.52	**0.51**
P22	0.57	0.46	0.54	0.52	0.44	0.41	0.58	0.44	**0.50**
	0.49	**0.48**	**0.54**	**0.53**	**0.54**	**0.52**	**0.56**	**0.51**	

Max
Min
Mean

These related results show that Europeans and E. Asians have different shape comprehension towards specific shape characteristic, although the complexity connections between shape characteristics and affective responses are different to fully reveal. The hypothesis 2.2 can be verified as well.

5. CONCLUSIONS

In this paper, two experimental studies of products' emotional quality towards shape characteristics are carried out on European and Asian participants via Semantic Differential Method. The experiment 1 indicated that there is no special preference for western or eastern culture towards angular and rounded contour shapes. Both cultures appreciate rounded shape to be beautiful, simple, reliable and comfortable rather angular shape. The Experiment 2 uncovered that the shape meaning comprehensions are totally different for European and Asian participants. Unfortunately, the connection between shape characteristics and affective responses cannot be predicted due to the flattened mean values of E. Asian group. The main reasons are summarized as the value conflict, increased individuality and regional disparity of Chinese participants.

This initial study shows that cultural backgrounds influence users' attitudes and comments towards designed products, and strongly suggest that awareness of cultural cognitive style is necessary for the improvement of product adaption in overseas market. The results of the two experiments can help designers to identify and emphasize shape features of new products which will stimulate the positive responses to required user preferences. Moreover, the results provide guide points for further study on cross-cultural identification on product shape.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of the NUAA Research Initiative Grant (No. 1005-56YAH13037). We also appreciate the contributions of the students from Nanjing University of Aeronautics and Astronautics, China; Ecole Centrale de Nantes, France; University of Ljubljana, Slovenia; Indian institute of Technology Madras, Chennai, India; Indian institute of Science, Bangalore, India; Industrial Design Centre at IIT Bombay, Mumbai, India; Budapest University of Technology and Economics, Hungary; Slavonski Brod University of Osijek, Croatia, who took part in the user-tests.

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BIOGRAPHY

Weihua Lu is a lecturer on Industrial Design of Nanjing University of Aeronautics and Astronautics, China. She got her doctoral degree in engineering from Ecole Centrale de Nantes, France, and her research interests include design methodology, user-centered design, especially Design for Emotion and Kansei Engineering. Her cross-culturally experience and interdisciplinary educational background (Design Art & Mechanical Engineering) endow with the complementary abilities essential in researches concerning the cultural and demographical influences on product design.

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KEER2014, LINKÖPING I JUNE 11-13 2014
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Kansei and Iranian Cultural Challenges; The use of traditional motifs in design

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Abstract: Often customers make their purchase decision based on price, quality and functionality of the product. Sometimes the decision is influenced by the perceived value, which is always subjective and emotion-driven. In order to ensure successful launch of a product, it is extremely important to predict the perceived value of design alternatives systematically based on the common language understood by both target users and designers. It was believed that human verbal expression could not be quantified with absolute values and should be more adequately interpreted. Kansei is a method which does this interpretation. This cross-sectional study was done based on Kansei method and it consists of three stages: First, through newspapers, magazines, web pages, users, interviews and other related sources Kansei words were collected, and four different motifs were tested on the product which is car. One of these samples has been designed with Iranian motifs. A focus group was invited to identify the essential elements that influence the perceived value of product. Third, the perception differences of sample products were conducted to verify the validity of culture index. The findings of this study demonstrated that culture was effective for decision making in product design.

Keywords: kansei, design, traditional Motifs, culture, user behavior.

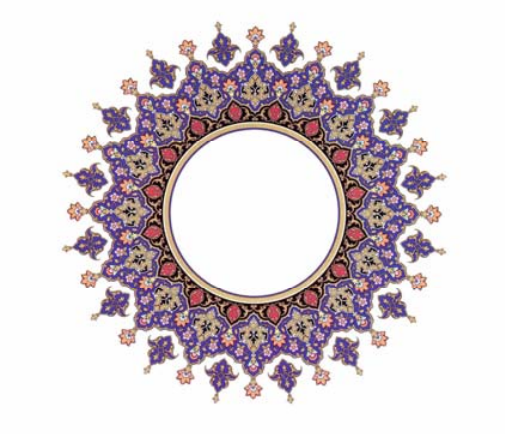
1. Introduction

1.1. Persian designs and motifs

Over the centuries, Iran has borne the brunt of periodic invasions. Elements of these foreign cultures, including Greek, Arabic, Turkish, Mongolian and European influences, were incorporated into the native artistic tradition but transmuted by Persian artists into a highly original and uniquely Iranian style. This outstanding collection of motifs comprises over 244 examples of this rich tradition, ready for use in a multitude of design areas. Ranging from prehistoric pottery painting to 4th-century calligraphy, this volume spans the full spectrum of Iranian art, including the Achaemedians, Parthian, Sassanids and Safavids eras. Included are designs drawn from textiles (weaves, printed fabrics, embroidery and carpets), ceramics (pottery and tile), carved and incised work (stucco, stone, and metal), miscellaneous ornament, book illustration and calligraphy.

1.2. Persian motifs

Persian motifs have a rich history and the Persian language has an extensive terminology concerning the design and sorts of these motifs. The motifs include floral designs, geometrics, arabesques, mythical creatures, rosettes, paisley patterns, palmettos, medallions, border and marginal decorations, scrolls, curves and hunting scenes. Embodying the sumptuous detail, rich texture and elaborate ornamentation that constitute the glory of Persian art, these motifs also exemplify the Iranian artist's traditional devotion to symmetry, harmonious pattern, and purity of line and form.



Picture No1 - Shamseh, an Iranian Motif

Motif in a work of art is a distinctive recurring pattern, design and shape or form. Some artists and artisans choose to expose elements of nature, such as leaves, in their works of art. Some leaf designs are traditional, handed down through generations, while others are original with the artist. By noticing and identifying natural elements in works of art, viewers can think about the significance of the element to the artist, culture, religion, and to himself.
There are a lot of different motifs in the Iranian culture; the designs are inspired from the shapes of plants. The names of motifs are considered from the way of craftsmen’s decoration or artists.

1.3. The Contemporary usage of Traditional Persian Motifs

Traditional Persian motifs are being used in the design of everyday products. They are used in a wide variety of areas, such as decoration art, tiles, ceramics, glass, printed cloth, enamel, emboss

and lighting products. Today, many countries are using technology to reintroduce traditional craft work in an attempt to revisit their own cultural roots. The aim of these countries is to introduce diversity and their own cultural identity to the world whilst remaining competitive. In Iran there are several products that have been inspired by traditional cultural products and a number of designers using these motifs in their designs to protect of their cultural treasures.

2. Method

Kansei method is used in this project, which consists of three stages: First, Kansei words were collected, identifying Kansei structure and communicate Kansei features and physical characteristics. Initially, four different motifs were tested on the product which is car. One of these samples has been designed with Iranian motifs. Firstly relevant words from various sources such as newspapers, magazines, web pages, users, interviews and other related sources were extracted. These words were then grouped into eight key words in two sets. Then, using the semantic differences, 10 men were questioned that are associated with the vehicle and its design.



Picture No2 - inside the cars

Results are presented graphically and the average score was determined for each plot according to the words of Kansei. The words of Kansei were compared with physical attributes needed for product and the most influential product design features were identified. In the final stage, design was done according to the key words and after comparing superior concepts gained with the characteristics of Kansei engineering methods, the effectiveness of cultural motif was measured.

3. Results

Firstly, according to the categories of Kansei words, five groups were selected as keywords (Table 1).

Table 1 - Classification of Kansei words

Kansei words	Collection of words
Local-New	Urban - New- Iranian - regional - global - Rural - native structures - Local

Domestic-none domestic	Identity - home - personal - identifiable - belongs to - know - Twin - both at home - like
Lovely-unlovable	Great - Positioning - large - small - visible - impossible to see - special - unique - space - Prospective - Dream - Fantasy - mentally - tangible - intangible - false - true - incomprehensible - Complexity - incomprehensible size - simple - minimalism - simple levels - by volume - organic volumes- complex forms
Strength - frailty	Tight - weak - weak - power - powerful - powerless - vulnerable - susceptible - stable - unstable
Familiar-none familiar	Kind - companion - Helper - friend - friendship - unfriendly - far - near - surface
Luxury-cheap	Cheap - you can buy - available - low price - Expensive - cost - low cost - public - be far behind - the inability to buy
Beautiful-ugly	Attractive - lovely - nice - notable - attracting attention - brilliant - different - ugly - hateful - detestable - makeup - chunky

After reviewing the questionnaire, which was designed using semantic differential, the rating of each product according to the Kansei words was obtained. (Fig 01)

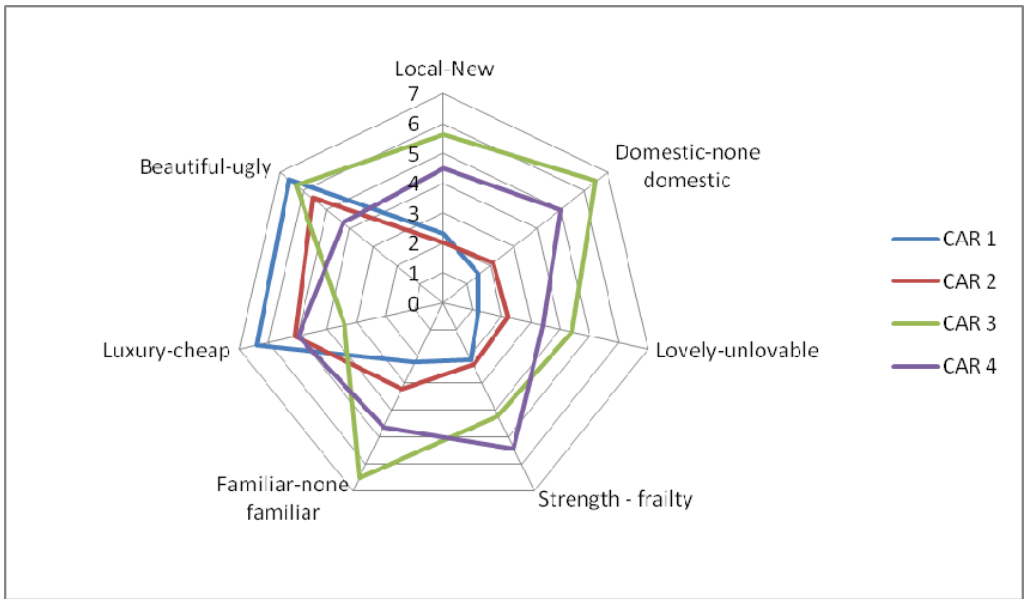


Figure No1 - Semantic differential questionnaire results

According to the obtained scores concept No.3 with the highest score was selected. Concept No.3 was most loved, most familiar, most domestic and most native concept among all the concepts.

Concept No.1 was the most beautiful concept from the perspective of the users.

Table No2 - rated products according to the Kansei words

Kansei words	CAR 1	CAR 2	CAR 3	CAR 4
Local-New	2.3	2	5.6	4.5
Domestic-none domestic	1.5	2.1	6.5	5
Lovely-unlovable	1.2	2.2	4.4	3.4
Strength - frailty	2.1	2.3	4.2	5.4
Familiar-none familiar	2.2	3.2	6.5	4.6
Luxury-cheap	6.4	5.1	3.4	5
Beautiful-ugly	6.6	5.6	6.3	4.3

After this step, to achieve the brief-list for design physical characteristics of the product were located next to Kansei words for comparison. (Table No3)

Table No3 - Comparison of physical characteristics and the words Kansei

Kansei words		1	2	3	4	Local-New	Domestic-none domestic	Lovely-unlovable	Strength - frailty	Familiar-none familiar	Luxury-cheap	Beautiful-ugly
body	steering wheel	1	1	1	1	3.2	5.6	2	6.1	5.1	2.1	6.2
	Dashboard	1	1	1	1	2.2	6.2	2.1	4.1	6.4	1.5	6.6
	Gear	1	1	1	1	4.2	4.3	4.5	2.6	5.1	5	3.5
detail	Controllers	1	1	1	1	6.5	6.3	5.6	3.2	3.4	6.5	4.3
	texture	1	0	1	1	4.12	5.6	3.6	4	4.97	3.77	5.15
	color	0	1	1	0	2.2	6.2	2.1	4.1	6.4	1.5	6.6

	pattern	0	0	1	0	4.12	5.6	3.6	4	4.97	3.77	5.15
Sum						27	40	24	28	36	24	30

At this stage the most important words according to physical characteristics were Domestic, beauty, and familiar.

4. Discussion

The results obtained show the importance of designer's role in translating the culture into product. Cultural and local motifs attract more users and make well communicate with them. This emotional connection is not only the familiarity of users with motifs but also represents a new area in the design world. In many cases, the motifs associated with specific cultures are not only looking for a local audience but also wants to export the products of these motifs. The situation exists for many different symbols of different countries. Cars are the products which show cultural translation in the streets and many people see them moving and cars also transfer concepts of modern cultural in "FORM' type.

5. Conclusions

Native forms for many years have been seen by users, and users are familiar with the concept. A familiar form can help users better understand the product and it invites them to interact more with the product. Sense of intimacy with the knowledge unconsciously gives users a sense of complacency that can keep users satisfied with the product. The more users well-communicate with the product they would love it more and as a result the product is used more. Local forms help the primary connection. These motifs can be used in different products with different features. Understanding these motifs can help designers to represent more local and native products.

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KEER2014, LINKÖPING | JUNE 11-13 2014
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Perceptual Richness and Aesthetic Sensibility in Traditional and Modern Product Designs

A Cross-Cultural Kansei Study using African Inspired Product Designs

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Abstract: Why do people tend to value an old product over a modern one? This study aims to explore cross-culturally, the conceptual basis of perceiving aesthetic values in product design characterized as being traditional and modern. To this end, a quasi-experiment was designed to evaluate the cognitive and affective richness in the aesthetic appreciation of both traditional and modern objects. For this experiment, 15 culturally inspired African products were pre-selected and classified into three categories, each class representing the different level of visibility of cultural elements in the sampled objects. 20 African subjects and 20 East-Asians including Japanese and Koreans studying at the University of Tsukuba participated in the survey test by doing a visual evaluation for the selected product samples using semantic differential and self-assessment manikin questionnaires. Having subjects from two distinct regional cultures provides a platform for cross-cultural comparison and discussion on the value perception style for typical traditional and modern products. The result outlines similarities and disparities of two cultural domains for the three product categories.

Keywords: Product design evaluation, Visual perception, Aesthetics, Kansei value, Cross-cultural study

1. INTRODUCTION

> *Handcraftsmanship, if it be alive, justifies itself at any time as an intimate expression of the spirit of man. Such work is an end in itself and not a means to an end. If, however, it ceases to serve a functional need, it runs the risk.* (Yanagi, 1989)

Humans, the world over, share a deep history in the development of artefacts which have today

become an inseparable component of everyday life, a totem of cultural identity and an important source of reference for the modern society. These artefacts stood as hallmark of civilization, cultural medium for aesthetic expression and socio-cultural interaction even within a local context. As the human history unfolds in layers of development and technological advancement, the making of objects of use has shaped lifestyle. Design culture in the twenty-first century is set to take a remarkable direction where materiality and technological innovation is not pursued as an end in itself but rather as a means towards the reinvigoration of meaningful value and quality experience into product, systems and services. With this in view, product framework is being redefined to transcend beyond functionality, ergonomics, and styles to enhancement of modern life while providing inspiration for meaningful and rich lifestyle. This true essence of a value-oriented design was encapsulated in the opening remark of the 2013 Good Design Award:

> *Though society may grow sophisticated, industries and economies may undergo dizzying changes, and remarkable technological advances may unfold, the wide-ranging designs that won this year's award, which emphasizes the beauty of relationships, the beauty of balance, and overall harmony, can give us a sense of the way design contributes to overall harmony and embodies the existential value of the whole as well as the beauty of beneficial relationships with the things in which that value is found.*

Design is an appealing process that creates inspiration that is engendered by empathy among human beings in our values and spirituality (Kenya, 2007). However, as much as design is a problem-solving tool used by the designers, the arising question is that what is it that matters now to address a rapidly growing and complex society, or perhaps, how humans could find a point of balance between materialism and essence, intricacy and simplicity, centrism or extremism, individualism or collectivism, tangibility or intangibility for the overall welfare of the ecology and humanity.

Culture is rooted in the values that pervade the historically derived ideas that form a particular tradition (Kluckhohn, 1951). These ideas and values create patterned ways of thinking, feeling and reacting, which constitute the distinctive character of a human group (Moalosi, Popovic, & Hickling-hudson, 2007). Essentially, it can be described as totality of all the knowledge and ideals shared by a society. It is dynamic and multilayered. The understanding of users' kansei (sensibility) over cultural diversity can be explored as a key factor in recognizing new gaps for designing culturally inspired products that transcend cross-cultural borders. Towards fostering creative economy in a global market, it is imperative for designers to gain a deeper understanding of users' culture and find ways to use culture as a potential resource in product development and innovation. The implication for this orientation in design approach will be a paradigm shift from creation of 'imposed product' to 'impactful product'. Hence, design outputs can be improved to harmoniously embody both tangible and intangible qualities that result into more beneficial user - artefact relationship. While the richness of cultural values can be used as a tool to inspire design for meaningful product experience, understanding the mechanism of perception with traditional and modern products might provide a new way to promote kansei values in product design and a drive towards seamless integration of users' in-depth psycho-physiological needs.

1.1. Theories of Perception and Aesthetics

Essentially, perception in humans describes the process whereby sensory stimulation is translated into organized experience, whether that is on a top-down or bottom-up basis. It is a process by which organisms interpret and organize sensation to produce a meaningful experience of the world. While sensation usually refers to the immediate, relatively unprocessed result of

stimulation of sensory receptors, perception, on the other hand, refers to one's ultimate experience of the world and typically involves further processing of sensory input.

According to the top-down theorists, perception begins from the top, focusing on expectancies, prior knowledge, and other higher-level cognitive processes and then work their way down to considering the sensory data such as perceptual stimulus. The kansei science provides models that support this view on perception. However, the bottom-up theorists has propounded that perception starts from the bottom and consider the perceived physical stimulus, the observable form or pattern, and work their way up to higher-level cognitive processes such as the organizing principles. James Gibson's theory of “direct perception” designates perception as bottom-up. According to Gibson's theory of direct perception, the information in our sensory receptors is enough to perceive anything. We thus perceive "directly" because we do not need any higher-level cognitive processes to mediate between our sensory experience and our perception (Sternberg, 1996). The Gestalt approach can be said to be a "bottom-up" theory as it starts from the bottom (the aspects of the stimuli that influence perception) and work its way up to higher-order cognitive processes. Gestalt psychology attempts to understand psychological phenomena by viewing them as organised and structured wholes rather than the sum of their constituent parts. The investigations in this subject crystallised into "the gestalt laws of perceptual organization which includes - law of proximity, law of similarity, law of symmetry, and law of closure.

On the other hand, the term "aesthetics" today may broadly cover (1) the study of all the aesthetic phenomena, (2) the study of the perception of such phenomena, (3), the study of art or what is considered to be artistically worthwhile or notable or "good," as a specific expression of what is perceived as being aesthetic (Gracyk, 2003). While it appears that there are several theories on aesthetics with multifarious subjective interpretations, the subject was classified into two parts: the philosophy of art, and the philosophy of the aesthetic experience and character of objects (non-art phenomena) (Budd, 1998). The recurrent theme centers on the standard and theory of beauty, taste, pleasurable values appreciable through sensory, emotional or intellectual perception. In a neuro-psychological view, aesthetic experience touches on cognition and emotion; inciting our sense of judgment and influencing our behaviour. A fundamental definition that has fascinated this study was drawn from Koren (2010): *Aesthetics or the aesthetic is a cognitive mode in which you are aware of, and think about, the sensory and emotive qualities of phenomena and things.*

1.2. Theoretical Framework

Kansei has been described as a dynamic and advanced function of the brain that can be the source of emotion, inspiration, intuition, pleasure/displeasure, taste, curiosity, aesthetics and creativity [Yamanaka in (Beuttel, 2010)]. It is a fundamental tacit process of human mind which involves several emotional feelings such as sensation, perception, and cognition (Lévy & Yamanaka, 2009).

Aesthetics fills an important role in the evolutionary trend of design as the design of objects in-turn has taken a key position in shaping culture, and impacting lives in far-reaching ways. As designers get more aware of the emotive powers of design, the aesthetic quality of products is increasing becoming a pervasive factor in the design process and a promise that must be kept towards the user's satisfaction. Today, Kansei and aesthetics have become tangible concepts in the product design domain. Lee (2010) asserted that aesthetic differences and similarities among cultures are obviously one of the very important issues in cultural design.

In previous related study, Norman expounded on three-dimensional theory of emotional design namely *visceral*, *behavioural* and *reflective* (Norman, 2004). Hekkert (2006) also distinguished three

components or levels of product experience as aesthetic pleasure, attribution of meaning, and emotional response. Meanwhile, Lin (2007) presented a synthesized framework for studying cultural objects and further identified three layers and levels of cultural objects and design features as (1) the inner level (containing special content such as stories, emotions, and cultural features), (2) the mid-level (dealing with function, operational concerns, usability, and safety) and (3) the outer (covering color, texture, form, decoration, surface pattern, line quality, and detail). In this study, we hold the view that aesthetics is part of kansei experience which can be anchored on the cognition of perceptible qualities and emotions evoked through relationship between humans and artefacts within situated contexts either through immediate sensory perception or bodily interaction. Therefore, we construe aesthetic perception as a kansei factor and an emotive cognition in the construction of products' values. Hence, we proposed that this phenomenon traverses all layers of product experience in both intrinsic and extrinsic ways, with cultural distinctions. The three levels of aesthetic expressions in product design are defined here as surficial, functional and symbolic. (Adelabu & Yamanaka, 2014)

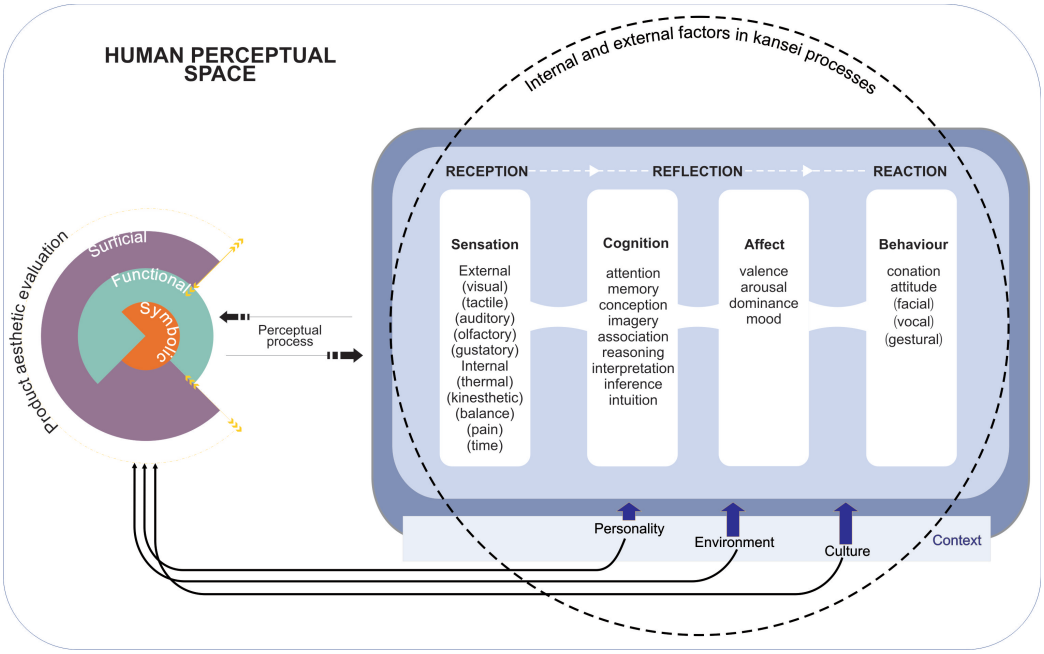

Figure 1: Perceptual space for aesthetic evaluation and kansei processes

This study at large is targeted at exploring cross-culturally, the richness of value perception and aesthetic experience – including a range of traditional and modern oriented product designs.

2. EXPERIMENT

2.1. Stimuli

The stimuli for the experiment is composed of 15 samples of product images pre-selected from a wide range of everyday products considered to be African inspired. These items were sorted and visually characterized into three main categories (traditional, semi-modern and modern) based on the level in typicality of tangible cultural qualities and design elements such as can be physically observed in the product form, surface treatments, material and level of technological sophistication (Figure 2).

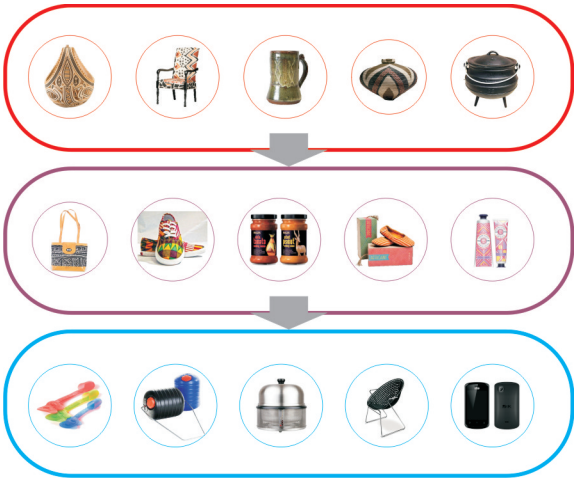

Figure 2: Selected product images classified under 3 categories (traditional, semi-modern and modern)

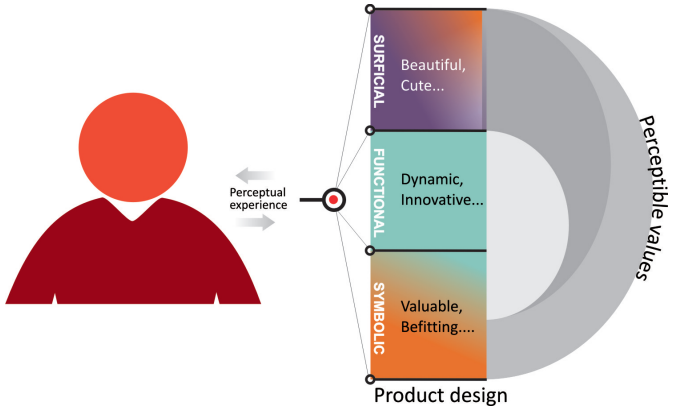

Figure 3: Semantic mapping for perceptible aesthetic values in product design

2.2. Participants

In this study, 20 African subjects (male=16, female=4) and 20 Asian subjects (male=17, female=3) who were non-design students at the University of Tsukuba between the age of 18 and 35 voluntarily participated in a product evaluation task for an average time of 30mins per subject. This African subjects include nationalities of Ghana (1), Kenya (2), Tunisia (2), Mozambique (1), Ivory Coast (1), Malawi (2), Angola (1), Senegal (1), Benin (1), Zimbabwe (1), Ethiopia (1), Eritrea (1), Nigeria (4), Guinea (1). The Asian subjects were mainly Japanese (16) and Korean (4).]

2.3. Procedure

The experimental test made use of a paper-and-pencil version of Semantic differential (SD) scale method proposed by (Osgood, Suci, & Tannenbaum, 1967) to investigate subject's aesthetic perceptions through product visual appearance. Alongside this, the Self-Assessment Manikin (SAM) scale developed by (Bradley & Lang, 1994) adopted to measure the progression of affective experience in the course of evaluating the three product categories. SD and SAM have been used effectively in Kansei research to measure perceptive and emotional responses in a variety of situations, including reactions to visual stimuli [Miyong & Seunghee (2007); Kim, Cho, Niki, & Yamanaka (2012); Sanabria Zepeda (2012)]

In the test questionnaire, the SD evaluation scale consists of selected contrasting adjective pairs (modern-traditional, beautiful – not beautiful, cute – not cute, fun to use – not fun to use, dynamic – static, innovative – not innovative, intuitive – not intuitive, valuable – not valuable, befitting – not befitting, and desirable – undesirable), listed on opposite ends of a bipolar 7-point scale. Appended to this lists is a 7-point Likert scale (1= Extremely, 7= Not at all), which includes rating for object familiarity and indigenousness (association with the design culture of the subjects).The adjective pairs for the Semantic differential scale were selected to reflect the 3 pre-defined levels of aesthetic perception in product design include a few pairs from each layer. Following are some examples for bipolar word connected to each of the layer (Figure 3).

1. Surficial aesthetic (beautiful – not beautiful, cute – not cute)
2. Functional aesthetic (dynamic – static, innovative – not innovative)
3. Symbolic aesthetic (valuable – not valuable, befitting – not befitting)

The SAM, which is a pictorial assessment scale, basically has 9-point rating scales for the affective dimensions of valence, arousal and dominance with 3 bi-polar words (happy – unhappy, calm – excited, dependent - independent). In order to show the differentials in change of emotional feeling in the progression of item evaluation, the SAM scale was presented to the subjects at a fixed interval from the start of their assessment and after the semantic evaluation of each of the item category.

Finally, the subjects are asked to freely respond to a 3 sets of an open-ended question.

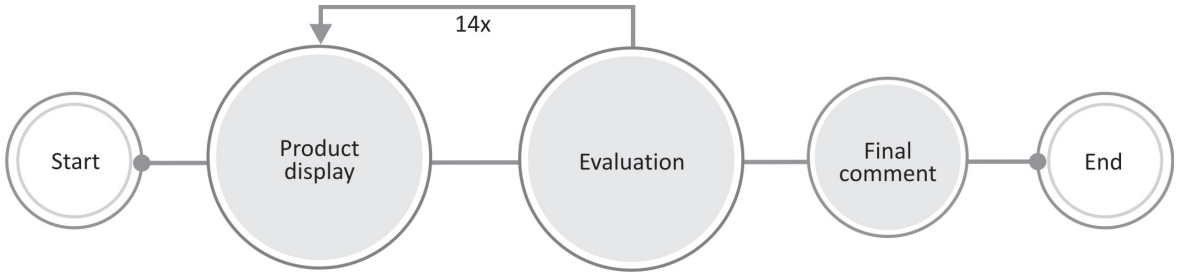

Figure 4: Procedure of experiment

3. ANALYSIS

In this paper, we only present different analytical results based on the evaluation of semantic differential scale of 10 bipolar adjective pairs that were rated along a 7-point scale. This also covers the evaluation results of the 7-point Likert scale which were integrated in the SD evaluation results. The semantic differential charts in Figure 5 below show the distribution of the average mean scores for the 15 items classified under 3 main categories (traditional, semi-modern and modern) as rated by the 2 regional cultures – African and East Asians. It is based on the comparative relationships of items values as visually perceived by the subjects.

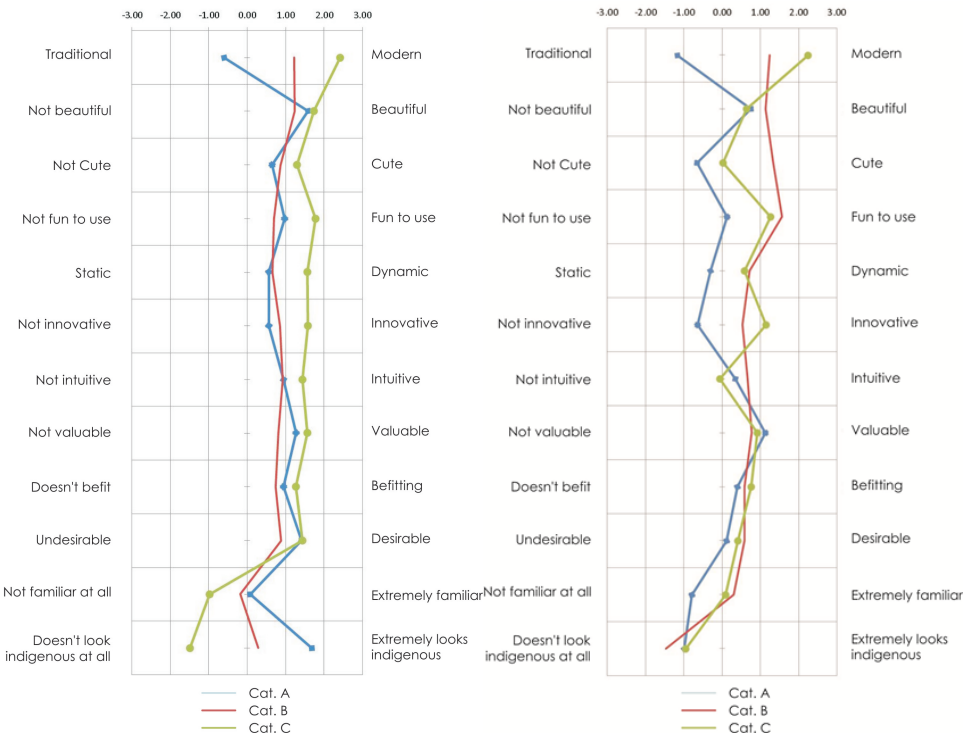

Figure 5: Semantic Differential Charts (Left chart shows rating by African respondents and on the right is rating by East-Asian respondents)

3.1. Analysis of Variances and Multiple Comparisons

To characterize the quality of perception between the two cultural regions (Africa and East Asia) based on the 3 pre-defined levels of items category (traditional-A, semi-modern-B and modern-C), the results of the SD evaluation was analysed with one-way ANOVA and Tukey post-hoc comparisons to further determine which of the groups differs from one another on the semantic scale. The items category constituted the independent groups while the semantic evaluations made up a list of dependent variables.

This table below shows the output of the ANOVA analysis and statistical difference between the group means based on responses obtained from African and Asian subjects.

Table 1: One-way ANOVA test for mean comparisons between product categories

Set of SD & Likert scales		Sum of Squares		F		Sig.	
modern-traditional	Between Groups	23.121	30.727	23.195	12.691	**.000**	**.001**
	Within Groups	5.981	14.527				
	Total	29.102	45.254				
beautiful – not beautiful	Between Groups	.630	.711	.832	.518	.459	.608
	Within Groups	4.543	8.235				
	Total	5.173	8.946				
cute – not cute	Between Groups	1.122	10.288	1.552	4.276	.252	**.040**
	Within Groups	4.340	14.436				
	Total	5.462	24.724				
fun to use – not fun to use	Between Groups	3.177	5.744	5.967	6.119	**.016**	**.015**
	Within Groups	3.195	5.633				
	Total	6.372	11.377				
dynamic – static	Between Groups	3.161	3.057	8.977	1.413	**.004**	.281
	Within Groups	2.113	12.981				
	Total	5.274	16.038				
innovative – not innovative	Between Groups	2.792	8.182	11.840	5.829	**.001**	**.017**

	Within Groups	1.415	8.422				
	Total	4.207	16.604				
intuitive – not intuitive	Between Groups	.840	1.374	2.656	2.097	.111	.166
	Within Groups	1.898	3.933				
	Total	2.738	5.307				
valuable – not valuable	Between Groups	1.460	.329	2.682	.382	.109	.691
	Within Groups	3.267	5.173				
	Total	4.727	5.502				
befitting – not befit	Between Groups	.692	.307	3.787	1.489	.053	.264
	Within Groups	1.097	1.237				
	Total	1.789	1.544				
desirable – undesirable	Between Groups	.937	.574	1.958	.588	.184	.571
	Within Groups	2.872	5.857				
	Total	3.809	6.431				
extremely familiar – not familiar at all	Between Groups	3.045	3.353	6.251	2.543	**.014**	.120
	Within Groups	2.923	7.910				
	Total	5.968	11.263				
Extremely looks indigenous – Doesn't looks indigenous at all	Between Groups	25.110	.822	14.002	.785	**.001**	.478
	Within Groups	10.760	6.283				
	Total	35.870	7.105				

Significance level alpha=0.05

African | East-Asian

Table 2: Post-hoc Test Result for the Perceptual Ratings of Product Categories by African and East-Asian subjects way ANOVA test for mean comparisons between product categories

Category A	**Category B**	**Category C**
Modern – Traditional		
-.600$_a$ [-1.735, .535]	**1.220 $_b$ [.329, 2.111]**	**2.420$_c$ [1.946, 2.894]**
-1.160 $_a$ [-2.921, .601]	1.250 $_{bc}$ [-.037, 2.537]	2.250 $_{bc}$ [1.332, 3.168]
Beautiful – Not beautiful		
1.580 $_{abc}$ [.770, 2.390]	1.240 $_{abc}$ [.605, 1.875]	1.730 $_{abc}$ [.899, 2.561]
.750 $_{abc}$ [.022, 1.479]	1.140 $_{abc}$ [.291, 1.990]	.630 $_{abc}$ [-.756, 2.016]
Cute – Not Cute		
.640 $_{abc}$ [-.056, 1.336]	.870 $_{abc}$ [.153, 1.587]	1.300 $_{abc}$ [.4787, 2.121]
-.654 $_{ac}$ [-1.542, .234]	**1.340 $_b$ [.213, 2.467]**	.020 $_{abc}$ [-1.852, 1.892]
Fun to use – Not fun to use		
.960 $_{abc}$ [.408, 1.513]	.700 $_{ab}$ [-.011, 1.411]	**1.780 $_c$ [1.131, 2.429]**
.130 $_{ac}$ [-.773, 1.033]	**1.570 $_b$ [1.068, 2.072]**	1.260 $_{abc}$ [.209, 2.311]
Dynamic – Static		
.550 $_{ab}$ [.2157 .8843]	.650 $_{ab}$ [.069, 1.231]	**1.570 $_c$ [.966, 2.175]**
-.300 $_{abc}$ [-1.9052, 1.3052]	.720 $_{abc}$ [-.133, 1.573]	.580 $_{abc}$ [-.724, 1.884]
Innovative – Not innovative		
.550 $_{ab}$ [.059, 1.041]	.860 $_{ab}$ [.327, 1.393]	**1.580 $_c$ [1.437, 1.723]**
-.640 $_{ab}$ [-2.044, .764]	.530 $_{abc}$ [-.323, 1.383]	**1.140 $_c$ [.400, 1.880]**
Intuitive – Not intuitive		
.930 $_{abc}$ [.357, 1.503]	.926 $_{abc}$ [.491, 1.361]	1.430 $_{abc}$ [.968, 1.892]
.340 $_{abc}$ [-.507, 1.187]	.670 $_{abc}$ [.053, 1.287]	-.070 $_{abc}$ [-.7161, .5761]
Valuable – Not valuable		
1.260 $_{abc}$ [.814, 1.706]	.810 $_{abc}$ [-1.735, .535]	1.570 $_{abc}$ [-1.735, .535]
1.260 $_{abc}$ [.814, 1.706]	.810 $_{abc}$ [-1.735, .535]	1.570 $_{abc}$ [-1.735, .535]
Befitting – not befitting		
.930 $_{abc}$ [.672, 1.188]	.740 $_{ab}$ [.4045, 1.076]	**1.2600 $_c$ [.766, 1.754]**
1.130 $_{abc}$ [.361, 1.899]	.770 $_{abc}$ [.428, 1.112]	.9100 $_{abc}$ [-.224, 2.044]
Desirable – Undesirable		
1.410 $_{abc}$ [.713, 2.107]	.890 $_{abc}$ [.414, 1.366]	1.430 $_{abc}$ [.802, 2.058]
.114 $_{abc}$ [-.217, .445]	.590 $_{abc}$ [.098, 1.082]	.400 $_{abc}$ [-.981, 1.781]
Extremely familiar – Not familiar at all		
.078 $_{ab}$ [-.412, .568]	-.172 $_{abc}$ [-.520, .176]	**-.978 $_c$ [-1.853, -.103]**

-.788 $_{abc}$ [-1.5433, -.0327]	.310 $_{abc}$ [-.4659, 1.0859]	.080 $_{abc}$ [-1.290, 1.450]
Extremely looks indigenous – Doesn't looks indigenous at all		
1.680 $_{ab}$ [.646, 2.714]	.284$_{ab}$ [-1.145, 1.713]	**-1.482$_{c}$ [-2.500, -.464]**
-.978 $_{abc}$ [-2.169, .213]	-1.460 $_{abc}$ [-2.290, -.630]	-.950 $_{abc}$ [-1.511, -.390]
	African	East-Asian

Note. Evaluations in bipolar adjectives "modern-traditional", "beautiful – not beautiful", "cute – not cute", "fun to use – not fun to use", "dynamic – static", "innovative – not innovative", "intuitive – not intuitive", "valuable – not valuable", "befitting – not befitting", and "desirable – undesirable" were made on a 7-point semantic scales and the rating on familiarity and association of product with design related to African culture was done on a 7-point Likert scale (1= Extremely, 7= Not at all). The contents of the evaluation sheets were presented in English to the African subjects, Japanese for Japanese subjects and Korean for Korean subjects. Means that do not share subscripts differ at $p < .05$ in the Tukey honestly significant difference comparison. Numbers in brackets are 95% confidence intervals of the means.

For the African response, the mean comparisons for the evaluation of product categories A to C according to one-way ANOVA result presented in table above shows significant differences in the perceptual rating of "modern-traditional" F (2, 12) = 23.195, p = .000, "fun to use – not fun to use" F (2, 12) = 5.967, p = .016, "dynamic – static" F (2, 12) = 8.977, p = .004, innovative – not innovative" F (2, 12) = 11.840, p = .001, "Extremely familiar – Not familiar at all" F (2, 12) = 6.251, p = .014 and "Extremely looks African – Doesn't looks African at all" F (2, 12) = 14.002, p = .001. Considering the evaluation for other descriptive variables, there was no significant difference between groups.

For the East-Asian response, the mean comparisons for the evaluation of product categories A to C according to one-way ANOVA also shows significant differences in the perceptual rating of "modern-traditional" F (2, 12) = 23.195, p = .001, "cute – not cute" F (2, 12) = 4.276, p = . 040, "fun to use – not fun to use" F (2, 12) = 6.119, p =. 015, and "innovative – not innovative" F (2, 12) = 6.119, p = .017. There was no significant difference for other descriptive variables.

Moreover, to identify differences in-between groups with multiple comparisons, the Tukey honestly significant difference (HSD) test was also applied. It is to be noted that the post-hoc result for "modern - traditional" scale was found to differ significantly across the three groups at p< .05 in the case of the African subjects - A (M = -.600, 95% CI [-1.735, .535]), B (M = 1.220, 95% CI [.329, 2.111], p=.004), and C (M =2.420, 95% CI [1.946, 2.894], p= .048). In the result obtained from the East Asian subjects, the "modern - traditional" scale differed significantly for category A when compared to both categories B and C, though, the comparison between category B and C do not show a significant difference. This result has reasonably validated the reliability of the products classification prior to the experiment showing that it also aligned with the perception of the respondents irrespective of the region. An exception was only noted for item 2 under product category A, which showed that it was perceived to be modern than traditional by the African subjects. Also for the East Asian subjects, we found a consistency in mean difference though it was much higher in the evaluation result. For other ratings in the multiple comparisons between the three product groups based on the post-hoc tests, the results are shown in table above.

3.2. Analysis of Principal Factors and Semantic Relationships

In order to explore the correspondence and reduction of semantic variables, a Principal components analysis was applied to the SD result. Here we analyzed the data for the following explanatory variable set: beautiful – not beautiful, cute – not cute, fun to use – not fun to use,

dynamic – static, innovative – not innovative, intuitive – not intuitive, valuable – not valuable, befitting – not befitting, and desirable – undesirable. Barlett's test of sphericity was significant, thus the hypothesis that the inter-correlation matrix involving these eight variables is an identity matrix is rejected. Thus from the perspective of Bartlett's test, factor analysis is feasible. The KMO scores for the data set were significant to also support factor analysis. This test was also carried to confirm the principal factors which account for most of the variance in the analyzed variables. Also, it was considered to determine whether the variables chosen are sufficiently representative of the construct of perceptual value and selection of more appropriate adjective sets to create our measurement scale in future study.

Table 3: Factor loadings after Varimax rotation

Variables	D1	D2	D3
beautiful – not beautiful	0.223	**0.711**	0.655
cute – not cute	0.515	0.231	**0.788**
fun to use – not fun to use	**0.749**	0.227	0.459
dynamic – static	**0.864**	0.449	0.134
innovative – not innovative	**0.877**	0.194	0.272
intuitive – not intuitive	**0.805**	0.272	0.318
valuable – not valuable	0.426	**0.871**	0.131
befitting – not befitting	0.628	**0.726**	0.010
desirable – undesirable	0.144	**0.899**	0.381
Eigenvalue	6.483	1.124	0.663
Variability %	40.393	33.540	17.957
KMO	0.684		

Variables	D1	D2	D3
beautiful – not beautiful	0.433	0.584	0.514
cute – not cute	**0.839**	-0.057	0.271
fun to use – not fun to use	**0.882**	0.375	0.107
dynamic – static	**0.804**	-0.345	0.238
innovative – not innovative	**0.829**	0.318	0.063
intuitive – not intuitive	0.310	0.025	**0.907**
valuable – not valuable	-0.256	**0.789**	0.348
befitting – not befitting	0.194	**0.872**	-0.231
desirable – undesirable	0.125	**0.891**	0.076
Eigenvalue	4.070	2.448	0.994
Variability %	35.764	32.025	15.679
KMO	0.669		

African | East-Asian

In the of African evaluation, component D1, “fun to use – not fun to use”, “dynamic – static”, “innovative – not innovative”, and “intuitive – not intuitive” (hereafter referred to as the “Technical value”) were associated with the technical aspects/functional or engineering quality of the product items. For component D2, “valuable – not valuable”, “befitting – not befitting”, and “desirable – undesirable”, were associated with the symbolic or worth value of the product items including a reflection of the variable “beautiful – not beautiful”. Component D3 was also considered though the eigenvalue is less than 1 because we want to establish the effects of other variable which interplay in the holistic valuation of product design aesthetics. In this dimension, the variable “cute – not cute” showed an associative connection with beauty of the product form.

Whereas for the East Asian evaluation, component D1, “cute – not cute”, “ fun to use – not fun to use”, “dynamic – static”, and “innovative – not innovative” were associated with the technical but in addition to the playful aspect or quality of the product items. For component D2, valuable – not valuable”, “befitting – not befitting”, and “desirable – undesirable”, were associated with the symbolic or worth value of the product items. Here also, component D3 was also considered though

the eigenvalue is slightly less than 1 to establish the effects of the variable “intuitive – not intuitive” which shows an association of the ease of recognizing the items. This also includes some reflection of the variable “beautiful – not beautiful” for components D2 and D3.

Furthermore, components were graphically displayed on an orthogonal map to investigate the semantic relationships that existed between the characteristics of product items as perceptually evaluated by both African and East-Asian subjects (Figure 6).

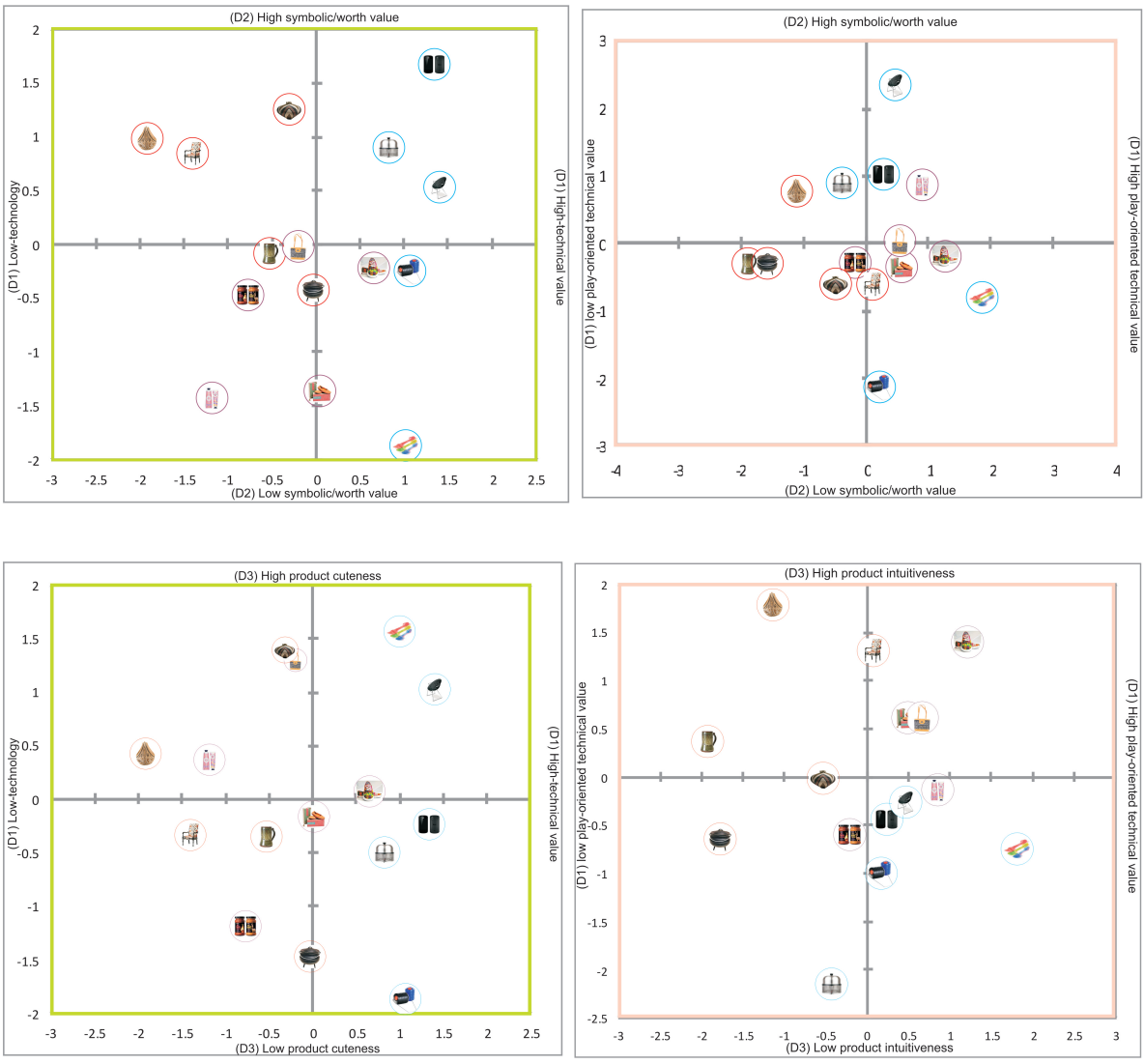

Figure 6: Semantic relation map – PCA score plots for African (left) and East-Asia (right) products evaluation

4. DISCUSSION AND CONCLUSION

Hypothetically, we expected a significant difference in the perception of modernity across the three product categories and this was almost completely proved with two regional groups of culture. In the case of the evaluation on attached value, there was no significant difference across groups. However, we could confirm in the comparison of mean ratings that products in category A (traditional class) were valued more than the products in category B (semi-modern class) and less than when compared with evaluation obtained for product categories C (modern class). This means that the effect of physically expressing visual cultural elements in modern products may not

guarantee proportionate increase in the sense of their value when compared to the real traditional products. Remarkably, the evaluation result for Africans in perceiving products relatedness to African design culture, we found no significant difference between product categories A and B, but both in turn when compared with category C indicate statistical significance in difference of product perception as not been African oriented at all at $p < .05$. Here, we found it interesting to observe a persistent tendency to the notion that advanced industrial products cannot be made in Africa. Despite growing design possibilities achievable through technology transfer and product development through co-creation and collaborative approaches, African users might not see the appearance of modern products as progress in this regard. More so, in our foremost study towards the kansei evaluation of African product design, we noted that in the new age of design, an African country such as South Africa, which is a highly industrialized country in Southern Africa with much Western influence, started exploring a way of grafting the African identity onto Western European technology towards a new synthesis. It is also noteworthy that the country has served as the design origin for almost all the product items grouped under category C except for the smartphone. The wave of design breakthrough is believed to be spreading across the continent as we can see in the case of the VMK smartphone purported to be the first African designed smartphone developed by a Congolese entrepreneur Verone Mankou, but manufactured in China.

Some differences in the aesthetic perception of product samples were observed between the African and East Asian when we referred to the outcome of the Principal Component Analysis. Despite having similar tendency in the characterization of products based on the evaluation carried out using the variables provided, we found that there variation in the aspect of product attributes being focused on. For instance, component D1 for African evaluation focused more on the technological value of the product items whereas for the East Asian evaluation, we discovered a subtle tendency of placing more consideration for playful dimension of product technology. Furthermore, our consideration to include D3 as one of the principal factors further shows that while a cuteness of product may interest an African user relatively to other qualities; an East Asian user may prefer to base his consideration on the intuitiveness of the product. Alternatively, the unfamiliarity of the product samples being more related to Africa design culture might also be a contributing reason to why the East Asian subjects has considered the product intuitiveness important in the process of recognizing the product.

In essence, this study has demonstrated that the impression users get through perceiving products visually can be far-reaching in determining the value they place on them. (Crilly, Moultrie, & Clarkson, 2004) rightly noted that the visual appearance of products is a critical determinant of consumer response and product success. To a large extent, the elegance (surface aesthetics), functionality (functional aesthetics) and social significance (symbolic aesthetics) of products as perceived through visual information influences the evaluative judgments and frequently centre on the satisfaction of consumer wants and desires, rather than their needs. Today, there is an over-emphasis on production of high-tech industrial products made of synthetic materials that are seen as superior in quality over locally crafted products that have sustained everyday living from time immemorial. It is a popular opinion that one of the biggest challenges of local design is recognition and acceptance by the local and even international users. As most countries are now emphasizing and developing their creative industries (small medium and micro enterprises), this orientation is expected to change. However, in order for local design industry to thrive in a global market, there has to be a drive to achieving a holistic balance and seamless integration of aesthetic values throughout the tangible and intangible aspects of product design. The semantic and emotional evaluation of the products is thought not only to be exuded by the product visceral

composition but much more inextricably connected to their impact on lifestyle and socio-cultural practices. Since product designs are seen as a tool of cross-cultural understanding, the growing need to have better understanding of cross-cultural perception will not only have a far-reaching effect for the global market, but also will play an important role in engendering untapped potentials for globalization of local product designs.

In our future study, we anticipate for further exploration into cross-cultural understanding of the mechanism of perceptual richness and aesthetic sensibility in traditional and modern product designs using common products inspired by an East-Asian culture.

4.1. Acknowledgement and Reference section

ACKNOWLEDGMENTS

This work was supported by the Japanese Government Scholarship (Monbukagakusho).

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BIOGRAPHY

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6A - Evaluation 4

KEER2014, LINKÖPING | JUNE 11-13 2014
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Consideration of Expression Method of the Entropy Concept

Correlation between the entropy for a given binary format image and the psychological quantity from verbal expression

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Abstract: The concept of entropy which was firstly introduced as a thermodynamic property has been extended to the economics theory, information theory, and others. Even though entropy is used in many fields of science and technology, it is not easy to understand and represent the concept of entropy, as well as describing it by words/terms. We assume that one of the causes of such difficulty is the gap between psychological quantity caused by words/terms used in explaining the concept of entropy and actual entropy value. We have been investigating the correlation between the thermodynamic entropy and the psychological quantity obtained by showing contents such as particle animations simulating the molecular motion to participants. We had found that the verbal expressions such as "degree of diffusion", "degree of randomness" and "elusiveness" are relatively suitable in representing the entropy concept than other verbal expressions. In this report, we investigated the correlation between the entropy and the psychological quantity obtained by showing several contents which show binary dot pattern images to participants. We examined the correlation between the entropy values calculated by several different algorithms and the psychological quantity by above three verbal expressions. In the comparisons between the binary dot patterns which have natural randomness that may exist in real photo picture, we obtained that the psychological quantity by above three verbal expressions have high correlation with entropy values. We found that the entropy values calculated by means of measuring the length between each black pixel has highest correlation to the psychological quantity.

Keywords: Entropy, Thermodynamics, Information Theory, Language Expression, Visual Expression.

1. INTRODUCTION

The concept of entropy, which is known as measure of fuzziness, disorder, or value now, was firstly established as the second law of thermodynamics by Clausius and Boltzmann in 1850 and has been extended to the economics theory, information theory, and others (Greven, Keller, and Warnecke, 2003). However, because of its wide range of application, the concept of entropy may be interpreted in a variety of ways. Therefore, it is difficult to understand its essence precisely.

The concept of entropy, originally introduced in the context of irreversibility of the second law of thermodynamics, is defined as quantity representing the states of matter such like heat, pressure, or content. Heat, pressure, or content are quantity which we can perceive, therefore those are assumed to be easy to understand. On the other hand, although entropy is defined as quantity representing the sates of matter as well, it is not well known whether entropy itself could be "perceived" or not. Therefore, we assume that this is one of the causes which make the concept of entropy to be difficult to understand. Being interested in whether entropy may be felt by our kansei or not, authors has been investigating the efficient way of expressing the concept of entropy, especially in verbal expression.

In our previous study (Sato and Suganuma, 2013b), we conducted an experiment in which we showed our participants several animations, simulating molecular motion. We made eight animations varying the range of molecular motion (content), and/or speed of molecular motion (heat), resulting in different entropy. Our participants were asked to view two animations presented simultaneously, along with several verbal expressions (in Japanese). They chose which animation suits better to the presented verbal expressions. As a result, we observed relatively high correlation between the actual entropy value of the animation and three verbal expressions. Those three verbal expressions were "degree of diffusion", "degree of randomness", and "degree of elusiveness" in Japanese. The term "degree of diffusion," which the term used in the experiment was "kakusanno-doai" in Japanese, may include the meaning of diffusion, spreading, or scatter. The term "degree of randomness", which the term used in the experiment was "ranzatsusa" in Japanese, may include the mening of, random, disorder, or mess. The term "degree of elusiveness," which the term used in the experiment was "tsukamaenikusa" in Japanese, may include the meaning of elusive, or "to be hard to catch/touch".

The concept of entropy is applied to information science as well as thermodynamics. As entropy in thermodynamics is based on molecular motion, we may consider that it represents the states of matter in dynamic situation. On the other hand, entropy in information science which is based on variation of symbols may be considered as entropy in static situation. In previous reports (Sato and Suganuma, 2013b; Sato, 2013), from thermodynamics point of view, we investigated for more appropriate verbal expression corresponding to the variation of entropy in dynamic situation based on kinetic theory of molecules. We considered that investigation of the relation between our kansei quantity and entropy in static situation is important as well as those in dynamic situation, to explore the nature of human understanding of entropy irrespective of dynamic or static entropy. Thus, in this study we examined the relation between kansei quantity raised by verbal expression and entropy of static binary image (example shown in figure 1).

Method of calculation based on information theory is common in calculation of entropy for binary images (Kamata, 2003). However, we could not find calculation method considering the kansei quantity. Therefore, we investigated the adequateness of calculation method in means of human kansei quantity on verbal expressions, as well.

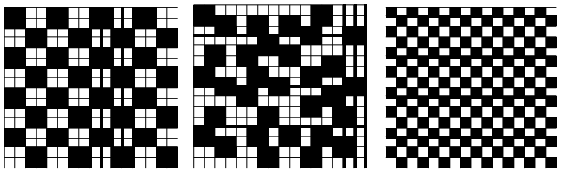

Figure 1: Binary image example of black and white (number of white and black pixels are the same)

2. CALCULATION METHOD OF ENTROPY VALUE OF BINARY FORMAT IMAGES

There are numbers of method of entropy calculation on binary images. Calculation method based on amount of information has been established in context of information science and image processing. However, when taking the correspondence relation between kansei quantity on verbal expressions and actual entropy value of binary images, there are little arguments on how to calculate the entropy value based on kansei quantity caused by verbal expression, or, to say, amount of entropy interpreted by our kansei. In the following, we discussed on the calculation methods of entropy value on binary images.

2.1. Calculation method of entropy value based on Mean Information Content

In the field of information science, entropy has been commonly used to evaluate the efficiency of information compression or information transfer rate of digital images. However, we assume that applying this calculation method in following experiment is questionable.

In general, amount of information entropy S may be calculated by formula (1) defined by Shannon.

$$S = \sum p_i \cdot \log_2(1/p_i) \qquad (1),$$

where, p_i is occurrence probability of every event, and Σp_i is limited to 1. Assuming that every symbol which transmit information having equal occurrence probability, $p = 1/M$ stands, where M is total number of the symbols. Therefore,

$$S = M \cdot 1/M \cdot \log_2(M) = \log_2 M \qquad (2),$$

stands.

However, as formula (2) depends on occurrence probability of the symbols, entropy value found by formula (2) varies according to the difference of symbol itself or its size. Moreover, in field of information science, calculation algorithm of entropy may vary depending on the information compression method.

In case of image entropy calculation, when the size of the image is $I \times J$ and each pixel has Z bit of luminance (color) depth and taking the luminance value as a symbol, entropy S may be found by following formula

$$S = -\sum_{i=0}^{2^Z-1} N_i / N_{pic} \log_2(N_i / N_{pic}) \qquad (3).$$

Here, N_i is number of pixels having luminance value of Z_i, and N_{pic} is number of pixels in the image.

Based on formulas (1)~(3) and variation of how we set the symbols, following three types of entropy may be considered.

(a) information entropy of the binary image 1: taking one bit (whether a pixel is white or black) as a symbol.

(b) information entropy of the binary image 2: taking two bit (area of 2×2) as a symbol

(c) information entropy of the binary image 3: taking the length of the sequence of black pixel

2.2. Calculation method of entropy value of image based on the probability of a thermodynamic phenomena

In previous section, we have proposed calculation methods of entropy on binary images based on the concept of information theory. However, in thermodynamics, the concept of entropy is often explained in stochastic aspects with the number of possible microscopic states in text books or study guide of entropy. Here, we applied the concept of entropy in thermodynamics on entropy calculation of binary images.

One of the most important formulas in the field of statistical thermodynamics is the entropy formula defined by Boltzmann. The entropy S may be found by

$$S = k \cdot \ln W \qquad (4),$$

where k is Boltzmann constant (gas constant of single molecule), and W is a microscopic probability of a molecule's thermodynamic phenomenon (the number of possible microscopic states). Alternating the probability of thermodynamic phenomenon into number of cases of black pixel to appear, we considered two calculation methods of entropy of binary images.

(d) entropy value based on the probability of black pixels to appear in succession.

In case that the probability of black pixel to appear is 1/2, p_i the probability of black pixels to appear in succession would be as shown in Figure 2. When the probability that all of 16 pixels will become black is set to 1, entropy is calculated in quest of the ratio of the occurrence probability of each pattern as probability of a thermodynamic phenomenon.

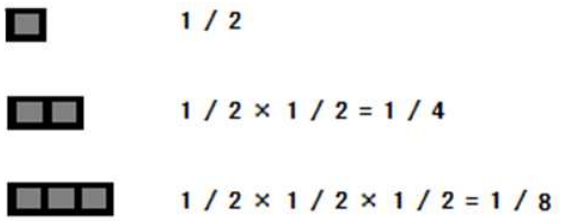

Figure 2: Probability of black pixel(s) to appear consequently

(e) Entropy on the basis of the distance between the black pixels in every pair

When people look at a binary image, it is thought that it feels as a two-dimensional spread. Therefore, it is thought that the method of calculating entropy for each line or each sequence one-dimensionally does not fully reflect the feeling of the two-dimensional spread. Therefore, we considered a method of computing the entropy value radially by means of measuring the distances of all pixels. Here, it assumes that the probability that a black pixel may appear is equally given to the whole picture, and we pay its attention to the distance between the two black pixels A and B as

shown in Figure 3. In this case, the occurrence probability of B to A is proportional to length l of the circumference which is calculated by measuring the radius r.

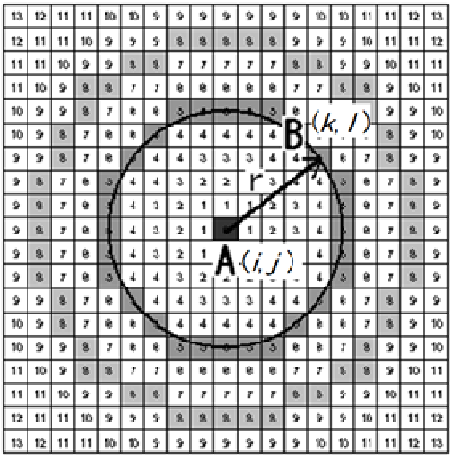

Figure 3: Existence probability which increases with the increase in the distance r from the pixel A to B

Fig. 3 shows how many pixels B can exist in the same distance from the pixel A located at the center, if a length of 1 pixel is defined as 1. In this figure, numbers written on the each pixel show the distance from the central pixel A. For example, pixels at a distance of 5 from pixel A are 28 pixels shown shaded dark in Fig. 3. Similarly, there are 48 pixels at a distance of 8 from the pixel A (lightly shaded in Figure 3.). Thus, the longer the distance between one pixel to pixel A is, the higher the probability of existence of the pixel is. If this probability is made into the probability of a thermodynamic phenomenon, the probability of a thermodynamic phenomenon is proportional to the circumference length which is calculated from the length between two pixels. Therefore, the entropy S_{AB} between two pixels can be calculated by the following formula as $W=r$.

$$S_{AB} = \ln r \tag{5}.$$

Furthermore, in an actual program the following formula (6) will be applied.

$$S = \sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{n}\sum_{l=1}^{n} Z_{i,j} \cdot Z_{k,l} \cdot \ln\left(\sqrt{(k-i)^2 + (l-j)^2}\right) \tag{6}.$$

Here, i, j, k, and l are the coordinate values of two pixels A (i, j) and B (k, l), respectively, as shown in Figure 3. Moreover, at the time the pixel is white, Z bcomes 0 and at the time the pixel is black, Z becomes 1. The value computed with this algorithm shows a spatial spread of a black pixel directly.

3. EXPERIMENTS WHICH EXAMINE THE CORRELATION BETWEEN CALCULATING VALUE OF ENTROPY AND PSYCHOLOGICAL QUANTITY FROM VERBAL EXPRESSION

In chapter 2, we discussed about the calculation methods of entropy values on binary images. We have proposed calculation methods based on the average amount of information and number of possible microscopic states. Our interest is in the relation between the difference of entropy (caused

by the difference of calculation method) and kansei quantity caused by verbal expressions. Hence, we conducted an experiment testing the relationship between the entropy value and kansei quantity caused by the verbal expressions. To minimize the task load of participants, verbal expressions used in this experiment was limited to three. Those were Japanese terms which mean "degree of diffusion", "degree of disorder", and "degree of elusiveness". These verbal expressions were chosen from our previous studies (Sato and Suganuma, 2013a, b; Sato, 2013), which we found the kansei quantity caused by verbal expressions to have relatively higher correlation to the actual entropy value in dynamic situation.

3.1. Experiment method

Participants. Seventy-seven students of Kanagawa Institute of Technology participated the experiment as a course credit. They were all sophomores at department of mechanical engineering, faculty of engineering. At the time the experiment was conducted, they were not taught about entropy yet. Therefore, we assumed that most of participants were not familiar with the concept of entropy at that point.

Stimuli. We made nine binary images as shown in Figure 4 (images A ~ I). Three verbal expressions on which participants made evaluation of binary images were Japanese phrases which mean "degree of diffusion", "degree of disorder", and "degree of elusiveness."

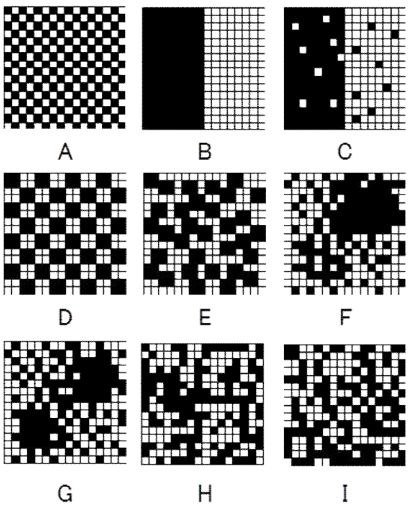

Figure 4: Binary image patterns used in the experiment

Procedure. The experiment was conducted in pair comparison method manner. In each trial, we simultaneously presented two binary images chosen from nine images shown in Figure 4. Three verbal expressions were shown as well. Participants were asked to choose which binary image seems to be more suitable for each verbal expression. The combination of binary images resulted in 36 pairs. Thus we collected 108 responses (36 image presentations x 3 verbal expressions) from one participant.

3.2. Experimental result

Entropy values of binary images for calculation methods (a) ~ (e) are shown in Figure 5. According to Figure 5, we can see that entropy values and the rank order of binary images largely differ due to the difference of calculation methods. Especially, images A and D showed large difference as it was ranked higher in calculation method (a), (e), and (d), but ranked lower in the other calculation methods.

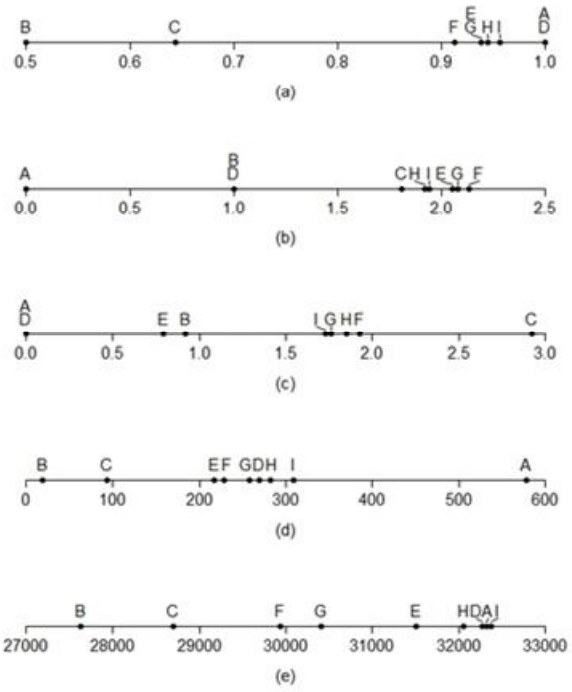

Figure 5: Comparison of the calculated value of the entropy S by five calculation methods. Charts (a), (b), (c), (d), and (e) show the result of three entropy values by means of different calculation methods of information content, entropy value based on the probability of black pixels to appear in succession, and entropy value based on the probability of black pixels to appear in succession, respectively

According to Thurstone's paired comparison method, we ranked and scored nine images for three verbal expressions separately. For each verbal expression, participants' choice was tabulated as win-loss matrix (chosen to be suitable as winning). Then, the win-loss numbers were converted into win-loss ratio, and then converted into z-scores. The average of the z-scores for each image was calculated as the score of the image. These scores are assumed to reflect the kansei quantity caused by verbal expressions (we would refer this score as f). Figure 6 shows the difference of kansei quantity f of binary images for three verbal expressions. Here, image A, which showed a swing in entropy value rank, showed a similar tendency in f value as well. Participants considered image A to be suitable for "degree of diffusion" and "degree of elusiveness," however, not for "degree of disorder."

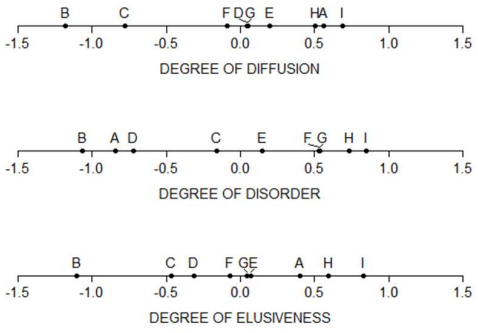

Figure 6: Comparison of the amount f of psychological quantity by three verbal expressions.

In table 1, we assessed the correlation (Pearson's correlation) between the entropy values for binary images by five calculation methods and kansei quantity f caused by three verbal expressions. The relation between the entropy value and the kansei quantity were verified for all the combinations (5 x 3) beforehand. We assumed that the relation between the entropy value and the kansei quantity is linear, and thus we used Pearson's correlation for evaluating their relation in this paper. Note that it was not monotonic increase for combinations of the calculation method and the verbal expression which has relatively low correlation in Table 1.

Table 1: The correlation coefficients (Pearson's r) for verbal expression and calculation methods (left half), along with cross correlations between verbal expressions (right half)

Verbal Expressions	Calculation Method of Entropy Value					Verbal Expressions		
	(a)	(b)	(c)	(d)	(e)	Degree of Diffusion	Degree of Disorder	Degree of Elusiveness
Degree of Diffusion	0.92	0.02	−0.24	0.82	0.95		0.51	0.95
Degree of Disorder	0.41	0.83	0.61	0.05	0.30	0.51		0.67
Degree of Elusiveness	0.78	0.17	0.04	0.72	0.83	0.95	0.67	

3.3. Discussion of the experimental result

As we pointed out earlier, result for binary images A and D showed a characteristic tendency for both the entropy value S and kansei quantity f. Their rank/score differed largely in both S and f, according to the calculation method or verbal expression.

3.3.1. Consideration about the effect of geometric regularity of the image on participants' response

In comparison of kansei quantity f caused by verbal expressions (Figure 6), image A had relatively high *f* for "degree of diffusion", but low *f* for "degree of disorder." In our previous study (Sato and Suganuma, 2013b; Sato, 2013) these two verbal expressions had relatively high correlation with actual entropy value of molecular animation. Therefore, we assume that these two verbal expressions are efficient in describing the concept of entropy. From that point of view, tendency which image A showed is apparently contradicted and thus the characteristic of kansei quantity f for image A seemed interesting.

However, it seems plausible for image A to have seemingly contradictory results. In case of kansei quantity for "degree of diffusion", because image A had black pixels spread entirely for the image, it may be seen as "diffused" to the participants. On the other hand, as image A had uniform and geometrical pattern, it may as well seen as "ordered" image, and resulted in low kansei quantity for "degree of disorder." In both the cases above, we assume that participant made their decision by their thought rather than through their instinct. This may be caused by their interpretation of the verbal expressions and the geometric regularity of the images we presented. The "kansei" quantity in this case may not reflect participants' intuition, but it may be a result of their logical thinking. In that sense, some of our images in the experiment may not be suitable for investigating the relation between the entropy and kansei quantity cased by verbal expressions.

Thus, to eliminate the effect of geometric regulation on kansei quantity we would exclude some of the images from the following discussion. Eliminated images were image A, B, C, D, and E. Image D had similar pattern to image A, and may be considered as geometrically regulated pattern as well. Image B had distinct regions in its both sides. Therefore we considered that it had geometrically regulated pattern. Image C was basically the same to image B, besides few "particles". Image E was relatively "natural," however it was consisted of four pixels in a block, which was relatively

unnatural, compared to the remaining images.

3.3.2. Binary image to be ranking by common sensibility amount in words of three

The remaining images were F, G, H and I (Figure 7). They all had random (unregulated) pattern of black and white pixels. These images, in contrast to the eliminated images, looked relatively natural. They had patterns which may be seen in part of actual photographs. Interestingly, the kansei quantity *f* for these images ranked in the same manner for three verbal expressions (Table 3).

Table 2 shows the calculated entropy values, kansei quantity caused by verbal expressions, and, cross correlation of kansei quantity for images F, G, H, and I. We found high correlation between every combination of verbal expressions which was close to 1. It is interesting that even for the verbal expression “degree of elusiveness” had high correlation to other verbal expressions. The terms “disordered” or “diffusion” are adverb/adjective which indicates the state of the object directly. On the other hand, “elusiveness” is to some extent a reflection of our capability. Therefore, the process of decision may differ between “disordered”, “diffusion” and “elusiveness”.

Although there may be a difference of decision, the tendency of three verbal expressions for four images was alike. Therefore, we assume that feeling, intuition, or kansei in this situation is strongly related to the nature of entropy.

Table 2: The correlation coefficients from the comparisons only using binary format image F, G, H, and I

Verbal Expressions	Calculation Method of Entropy Value					Verbal Expressions		
	(a)	(b)	(c)	(d)	(e)	Degree of Diffusion	Degree of Disorder	Degree of Elusiveness
Degree of Diffusion	0.92	−0.96	−0.59	0.97	1.00		0.99	1.00
Degree of Disorder	0.87	−0.91	−0.54	0.94	0.97	0.99		0.99
Degree of Elusiveness	0.91	−0.95	−0.57	0.96	0.99	1.00	0.99	

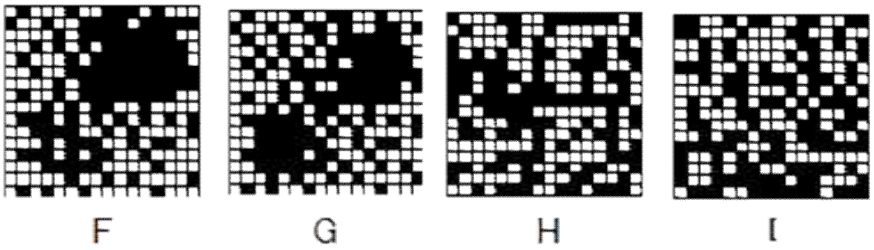

Figure 7: The binary images used on comparisons by natural expression

3.3.3. Consideration about the calculation method of entropy value of the binary format image based on the amount of sensitivities

Here, based on kansei quantity *f* for images F, G, H, and I, we will discuss about the relation of kansei quantity and calculation methods.

The correlation coefficient between the calculation methods and kansei quantity is shown in table 2. We found negative correlation for calculation methods (b) and (c). Possible reason for calculation method (b) was its lack of spatial resolution. That is, in images F~I, brightness of the pixels (black or white) altered in relatively higher frequency. However, the symbol in calculation method (b) was defined as 2x2 block of pixels, which turned out as lower frequency of brightness alteration. Therefore, calculation method (b) might have been inadequate for calculating entropy for image F~I.

Calculation methods (b) and (c) are algorithms which measure the diverseness of the symbols. For instance, calculation method (c) may be assumed as measuring the diverseness of length of the

symbols. If we take a look on images F and G, image F has single large chunk and image G has two chunks. When measuring the diverseness along horizontal axis, because image F has larger chunks, it would result in containing variations of series, compared to image G. Therefore, image F would result in larger entropy with calculation method (c). However, taking a look on both images, image F seems to be more coherent than image G, and does not match the calculation result from methods (b) and (c). We assume that such contradiction was caused by the characteristic of calculation methods (b) and (c), which the diverseness in these methods refer to those in one dimensional array of pixel data. On the other hand, when we see an image, we see it as two-dimensional space. Thus we assume that image information entropy may have less correlation with entropy which our kansei receive.

For calculation methods (a), (d), and (e), we observed higher correlation for all of them in table 2 in comparison to those shown in table1. The difference between table 1 and 2 was that whether images A~E were included (table 1) or excluded (table 2) when assessing the correlation between entropy value and kansei quantity caused by verbal expression. In table 1, when all the binary images were included, correlation coefficient for calculation methods (a), (d), and (e) were 0.92, 0.82, and 0.95, respectively for verbal expression "degree of diffusion". Correlation between verbal expression "degree of disorder" were 0.41, 0.05, and 0.30 for calculation methods (a), (d), and (e) respectively. However, when images A~E were excluded (table 2), correlation between verbal expression "degree of disorder" were above 0.9 for calculation methods (a), (d), and (e).

As we discussed earlier, images A~E seemed not suitable for our objective. Therefore, when assessing the correlation between entropy values and kansei quantity caused by verbal expressions, results obtained from images A~E might have behaved as a noise. The fact that we observed higher correlation between calculated entropy values [calculated by methods (a), (d), and (e)] and kansei quantity caused by verbal expression when images A~E were excluded, suggests that those calculation methods reflects the attribute of entropy of binary image which our kansei receives. Especially, correlations for calculation method (e) were relatively high and close to 1 for all the verbal expressions. Those were 1, 0.97, and 0.99 respectively for "degree of diffusion", "degree of disorder", and "degree of elusiveness". Calculation method (e) is taking the distance between pixels on its basis irrespectively to horizontal or vertical direction. Differently from calculation methods (b) or (c), which take the one-dimensional distance between the pixels, calculation method (e) quantifies two-dimensional spread. We assume that this characteristics of calculation method (e) matched to the "entropy" we feel, and thus we assume that this calculation method was relatively suitable for calculating the entropy which participants felt.

4. CONCLUSION

In this study, we conducted an experiment investigating the relation between the entropy values for binary images and kansei quantity caused by verbal expressions describing the entropy. We asked participants to select a image which seemed to suit to verbal expressions in a pair comparison manner. Verbal expressions we presented to our participants were "degree of diffusion", "degree of disorder", and "degree of elusiveness". Furthermore, we applied variety of calculation methods for entropy calculation, and investigated for efficient calculation reflecting the human intuition or kansei on recognition of entropy. The results we obtained were as follows.

(1) From the comparison of kansei quantity caused by three verbal expressions ["degree of diffusion", "degree of disorder", and "degree of elusiveness"] for images which may exist in nature, we observed relatively high correlations between them. This result suggests that kansei which

functioned when evaluating the impression on binary images with relatively natural pattern was based on innate aspect of entropy.

(2) From the result of images selected in (1), it was suggested that entropy value based on information theory, which was used for index of amount of information, may differ from the "entropy" which human perceive from two-dimensional diversity. Furthermore, it was suggested that calculation method based on distance between two pixels to be relatively adequate to calculate or to measure the "entropy" which human perceive.

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KEER2014, LINKÖPING I JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Product development based on Bernd H. Schmitt's 'Experience value'

Research case on the IGNIS Nature series

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Abstract: We research into a variety of successful-selling products has clarified that offering appeals to customers' sensibility values is the key to higher value-added products, rather than merely offering functionality and benefit. Thus, this quantification acts as a tool for analysis of difficult sensibility values. The analyses based on the concepts referred to as "experience value" by Bernd H. Schmitt have indicated, through a large number of examples, that they are perfect for communicating the superiority of the products. With the analysis of the competitive advantage held especially in the high-class goods market, notions regarding this experience value demonstrated a certain power and influence, and made it possible to clearly recognize the brand's superiority and more easily compare the differences between brands.

While the experience value concept was utilized as a tool for analyses of existing successful products, it is also thought crucial for creating successful products by theoretically conferring sensibility value upon them. Therefore, we investigated methods by which products' success rates could be raised by incorporating this concept of experience value into the IGNIS Nature series manufactured and sold by the ALBION Co., Ltd. Here, ALBION' Shirakami Laboratory adopted a value-added approach towards products by forming a framework for the same with plant extract compounds from various species of privately cultivated herbs. The result was an increase in sales volume.

Keywords: Experience value, Cosmetic

1. INTRODUCTION

Nagasawa et al. (2005, 2006, 2007, 2009) researched a large number of product studies based on the value experience concepts proposed by Schmitt (1999, 2003), the father of value experience marketing.

Advocating new marketing concepts, these investigations were conducted with the goal of injecting vitality into a sluggish Japanese economy. The aim is to break away from the model of so-called industrial society—that of low price, quick delivery and mass production—that supported Japan's post-World War II economic boom; we feel that it is the high value-added luxury brand products found in the US and European markets that embody Japan's goal of escaping the industrial society.

In order for a brand to be worthy of the label *luxury brand*, it has to do more than merely offer customers function and benefit. This is the accomplishment of a product family that has improved upon its level of quality from what might be called an "expected quality" to an "alluring quality." The way in which this alluring quality is theoretically analyzed, as well as its incorporation into the product, is important and here, sensibility engineering or affective science plays a crucial role.

With extremely laborious affective value analysis tools, the authors used the experience value concepts proposed by Bernd H. Schmitt to analyze many top-selling products and luxury brands.

For this research, tests based on those proposed concepts, especially those of Bernd H. Schmitt's experience value, were carried out to maximize the value added by the theoretical incorporation of affective value—considered indispensable in high-price goods—into cosmetics products manufactured by the Albion, and were put into practice in the IGNIS series. The resulting consistently positive market evaluations are reported here in this product development research case study.

To this end, Nagasawa and Someya (2007) used a case study of a Japanese luxury brand in a traditional and well-established industry, the brand Toraya, positioned in the traditional confectionary industry. Rather than using the case study to simply analyze the value added of Toraya products in the framework of experience value, based on the stable growth of technology-based manufacturing, we proposed two new concepts of management, to add to the existing management notions:

(1)Management of core technology that is the essence of technology operations, and

(2)Product-centered experience value, which also provides added value.

With these concepts in practice, we also asserted that this could be a crucial success factor even for ordinary, relatively new businesses.

In this study, we report on case studies of product development using the concepts proposed above, and Bernd H. Schmitt's notion of experience value in particular, putting them into practice with the IGNIS series of cosmetics, manufactured and sold by the ALBION.

2. ALBION AND IGNIS PRODUCT LINES

2.1. The Cosmetics Market in Japan

As shown in Figure 1, over the past few years, the total domestic shipment of Japanese cosmetics has plateaued, a characteristic typical of a saturated market. Specifically, while shipment

revenues have stagnated, the number of shipments has tended to rise, and hence, the unit price of each item can be said to be trending downward.

Since the start of the so-called bubble burst in 1990, the conceptual equating of cosmetics with high-end items ceased to be the prevailing mode of thought. Distribution channels centered on specialized boutiques and department stores have also undergone dramatic changes, diversifying to include drugstores, convenience stores, and even mail order and internet sales. In this changing environment, Japanese cosmetics manufacturers have brought about a diversification of distribution channels and are making the shift from conventional large-scale frameworks of distribution (price-maintained product manufacturers, door-to-door sales, and wholesale distribution manufacturing) to crossover-type markets through multiple distribution policies within each sector and industry and multiple branding policies that respond better to each cosmetic brand's market conditions. Interestingly, in recent years, rather than adopting a stance of merely adjusting domestic sales to match the declining Japanese population, they have entered into other Asian markets. We are seeing an active expansion into overseas markets, and in particular, into the emerging markets of China.

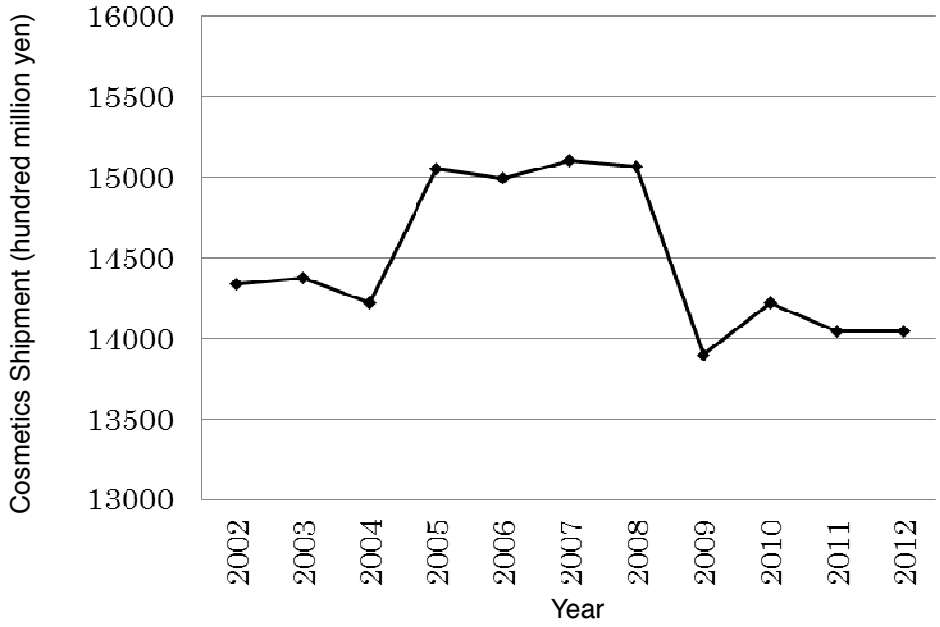

Figure 1: Cosmetics Shipment Revenue
(Source: Ministry of Economy, Trade and Industry, cosmetics shipment statistics)

2.2. Overview of ALBION

ALBION is a medium-sized cosmetics manufacturer that saw sales of 44.2 billion yen in the fiscal year 2012. Since the firm's inception in 1956, the management philosophy has been 'ALBION: Spreading the circle of reliability and integrity around the world by continuing to provide customers with authenticity as the leading name in high quality cosmetics'. It, as a rule, relies upon what is called consultative selling, in the form of a price-maintained product manufacturer, which is limited to specialty cosmetics shops and department stores on a foundation of face-to-face sales. In the sales environment of foreign markets, ALBION is entering certain high-fashion, licensed cosmetics niches with a focus on makeup products but for its domestic policy, centered on skin care (beauty creams), the emphasis is on selling such products instead.

This has its basis in the thought of ALBION President Kobayashi, quoted as saying, ‘There are still many points to tackle in the domestic market. There is no hope for us overseas as long as we have not acquired an overwhelming positioning in the Japanese home market (Otsuka, 2010).

2.3. IGNIS Nature Series

IGNIS is one of ALBION’s lines of skin care cosmetics. Within ALBION, there is the ‘ALBION line’, which deals in all the distribution channels the company utilizes, and the IGNIS line, which targets only specialty boutiques with limited distribution. While the ALBION line is representative of the company as a whole, in order to avoid competition between the IGNIS and ALBION lines, the IGNIS line aims to appeal to peoples’ inner sensitivities by promoting an image of nature and environmental friendliness.

Hence, while the ALBION line can be explained in terms of the long-held functions and results of the cosmetics industry, basing its philosophy on the beauty in science, the IGNIS line prioritizes not only a philosophy of beauty but also the pleasure in its use and the sense of satisfaction in real results. This family of products communicates these ideas directly and immediately to the customer to gain their understanding. According to this definition, one could say that even compared to the rest of the ALBION family, this product series stands out the most for its valuation of aesthetics and sensibilities. Figure 2 is a representative sampling of the IGNIS nature series.

Within the IGNIS line, the Nature series, which went on sale in 2009, comprises a product line that includes compounds made with the essential ingredients of the traditional Japanese medicinal herb mugwort. It is not an exaggeration to say that the communication of the properties of mugwort as the active ingredients utilized is crucial to the product profile. Figure 3 shows mugwort (yomogi).

With the debut of new products in the market, we introduced the idea of experience value marketing and conducted product research and development accordingly.



Figure 2: IGNIS nature series



Figure 3: Mugwoot (yomogi)

3. EXPERIENCE VALUE MARKETING IN COSMETICS

Originally, the price of cosmetic products was determined by function and usefulness. Departing from traditional marketing, which is dependent upon supply and demand, this product appeals to the senses and emotions. In short, this merchandise embodies ‘Kansei products’—emotional or affective products that consider the user’s psychology and emotions for product design (Nagasawa et al, 2002)

In this context, the factors contributing to making a hit product include obvious results for the skin,

a comfortable usability that will make one want to use it on a daily basis (the starting point of habitual use), and an addictive fragrance. These are the elements that give a product affective or emotional value, with package design and marketing, advertising, and the atmosphere of the point-of-sales environment itself also being essential factors. It is truly important to provide value from the point of consideration of the purchase to the actual purchase and throughout the product's useful life until its disposal. Accordingly, it is not that the customer is paying for function and convenience; rather it is more appropriate to think that the customer pays for all the experiences with the product, beginning with first coming across the product up to finally discarding it, and up until the next purchase.

According to this definition as well, analyses of value-added products that are based on Bernd H. Schmitt's experience value marketing can be said to illustrate effective product development methods. As a result, when new products were rolled out in 2011, in addition to performing analyses of existing products from 2009 and new ones under the paradigm of experience value marketing, similar investigations into the creation of new values in terms of experience value concepts were conducted. The value addition achieved was proactive and thorough.

4. ANALYSIS OF EXPERIENCE VALUE IN EXISTING PRODUCTS

Table 1 shows the results of analyses on the experience value already acquired by the IGNIS Nature series upon the sale of its existing products in 2011.

In 2009, this product family's development preceded the introduction of experience value marketing, and the experience values shown here have always been recognized as valid results.

Table 1: Experience Values of IGNIS Nature series (sales of existing products in 2009) based on Bernd H. Schmitt's Strategic Experiential Module

Category	Customer Experience of IGNIS Nature series (sales of existing products in 2009)
SENSE	・Unmistakably feeling results upon use. ・Unique fragrance reminiscent of nature. ・Colour, shape, and materials of packaging.
FEEL	・The view of nature/reproduction employed on the sales floor. ・The sense of special worth that comes from limited distribution.
THINK	・An advertising message that appeals to the 'blessings of nature' and towards a common understanding and acceptance.
ACT	・Conversion to a lifestyle that is in balance with nature.
RELATE	・Acting in concert with and making exchanges with others who are knowledgeable about an environmentally friendly existence.

4.1. SENSE(Sensory-Based Experience Value)

SENSE (Sensory-based experience value) elements of marketing are seen in the usability, fragrance, and packaging of the IGNIS Nature series.

4.1.1. Usability

The end-purpose of using cosmetics is to maintain the skin's health. Hence, unlike with pharmaceutical products, the smoothness and even spread at the time of application along with the gentle and moist feeling afterwards have been called the 'primary sensations' and are crucial

elements in its continued use. In short, it can be said that these makeup products are already positioned around the idea of providing SENSE.

It is understood that the high quality of primary sensations in the IGNIS Nature series can be fully felt beginning not just immediately after application, but continuing to the next morning, and even more so over continued use, leading to skin improvement at higher and higher levels.

4.1.2. Fragrance

This series appeals to living in harmony with nature, and fragrance is an important factor in its pursuit. Nevertheless, the mere scent of generic nature is not enough to deliver impact to consumers; hence, the venture into creating individualized scents in the IGNIS Nature series, giving birth to a more personalized world that distances itself from stereotypical ideas about makeup and creates a unique view of nature.

4.1.3. Packaging

Views of nature are manipulated through a basic theme of light green coloring for packaging, materials, and patterns, bottles of minimalist design, and a similarly colored box with a more natural paper surface texture.

4.2. FEEL (Affective Experience Value)

The FEEL (affective experience value) of the IGNIS Nature series confers a feeling of the exceptional through the reproduction of nature at the point of sale and through its limited distribution.

4.2.1. Point of Sale Environment Production

Not just the products but the production and design of the sales space itself communicate IGNIS's philosophy by evoking the imagery of its coexistence with nature.

4.2.2. A Sense of Uniqueness Owing to Limited Distribution

ALBION limits its distribution to specialty boutiques and department stores, but a further whittling down to only specialty boutique transactions results in an even more limited distribution. Hence, an aura of the extraordinary and hard-to-obtain is created—this product cannot be picked up just anywhere.

4.3. THINK (Intellectual Experience Value)

A sense of common understanding and approval of 'the blessings of the plant' that are appealed to in its advertisements is promoted with the IGNIS Nature series THINK (intellectual experience value) marketing.

Appeals to visuals of plant life are the centerpiece here, with advertising efforts taking great pains to not rely on detailed scientific accounts regarding the product's efficacy. These efforts have led to positive feelings of empathy and approval of consumers regarding the benefits of plants.

4.4. ACT (Action-Oriented Experience Value)

ACT (action-oriented experience value) marketing in the IGNIS Nature series is seen in the sense of change towards a way of living that is in balance with the natural environment.

Various proposals and advertising campaigns with keywords recalling nature and balanced lifestyles are being conducted, along with customer proposals for a shift towards lifestyles that are more in tune with nature.

4.5. RELATE (Relational Experience Value)

The RELATE (relational experience value) marketing element of the IGNIS Nature series can be seen in the examples of people who engage in balanced, natural living and are active in interpersonal exchange and solidarity actions. In order to see a future in which this is possible, the essential factor is to focus solely on face-to-face sales in specialty boutiques.

ALBION originally restricted distribution to specialty boutiques and department stores; IGNIS is available in boutiques only and has been further narrowed down to directly managed stores. This is because in this environment, adequate consultation that results from guaranteed face-to-face sales is a guiding principle. Consequently, each store's sales staff thoroughly introduces and explains the product so that a relationship between the consumer and sales staff can be firmly formed.

5. TAKING ON EXPERIENCE VALUE MARKETING IN NEW PRODUCTS

As indicated earlier, analyses of experience value held by existing products were performed, but upon the release of new products, we investigated the additional products of the IGNIS Nature series individually with the five modules proposed by experience value marketing.

Specifically, ALBION established facilities in Fujisato, Akita Prefecture as part of an expansion of its research capacity. At Shirakami Laboratory, also part of ALBION, and the attached pilot farm, mugwort is cultivated. This is the central and essential ingredient in the IGNIS Nature series, greatly contributing to the products' added value. Following this, investigations into each of the following modules were conducted from this standpoint of private cultivation of essential components. Figure 4 shows ALBION Shirakami Laboratory, and Figure 5 is of their associated pilot farm.



Figure 4: Shirakami Laboratory



Figure 5: Shirakami Pilot Farm

5.1. Investigations into SENSE Marketing

As regards SENSE marketing, from the start it appeared that these cosmetics were of good quality and were highly refined. This is why it was thought that there would be no need to make large-scale changes. However, when it came to packaging, because the focus was on mugwort as the essential component (as described later), in order to further and palpably bring out the greenness of the mugwort, its light-green shade was changed to bluish green instead, although the basic design was retained. This had the effect of differentiating it from other IGNIS products while simultaneously driving home a sense of its debut onto the market.

5.2. Investigations into FEEL Marketing

For FEEL marketing, appeals are made to the Shirakami Laboratory as an entity in itself. Shirakami Laboratory rented a public preschool that had fallen into disuse and renovated its interior for their current facilities. By leaving the exterior unchanged from its days as a preschool, it made possible the expression of a characteristic of gentleness with the cosmetics company, even while being run as a laboratory. Efforts were made at every opportunity to communicate this to the customer.

5.3. Investigations into THINK Marketing

Focusing on THINK, appeals were made to the peace of mind and sense of safety that comes from home-grown essential ingredients. The communication of ideas recalling safety and peace of mind with customers was performed in a way that was easy to understand due to longstanding quality guarantees and the direct explanation of the company's organic farming. Trends regarding food safety and peace of mind can be seen in the cosmetics industry as well; we are entering an age in which the ingredients used in cosmetics are assumed from the start to be safe and healthy and are subject to the same standards as food products in terms of their traceability. Although in the current situation, the various ingredients are subject to strict testing upon production with structures that do allow for safety and peace of mind, we think the easiest way to communicate this information permanently to customers is through a concise message such as 'Grown Organically in our Own Fields'.

Moreover, Shirakami Laboratory is located at the foothills of the Shirakami Mountains, an area registered as a natural world heritage site. These factors immediately communicate a natural grandeur and the importance of nature conservation to customers.

5.4. Investigations into ACT Marketing

For ACT marketing, Shirakami Laboratory strived to transmit season-related information to customers. In particular, during winter in the Shirakami region, dramatic changes in the natural environment are visible in the period in which snow falls. Even during the time that snow covers the fields, plant observation is carried out to see how the plants are surviving the winter, and once again upon the melting of the snow, in the springtime budding period. This type of information was carefully communicated to the customer, conveying a sense of the changing seasons. Out of this came sincere efforts to lend a sense of seasonality to customer lifestyles through the products.

5.5. Investigations into RELATE Marketing

For RELATE marketing, the challenge was to shrink the distance between the product and consumer by communicating to them, through all available media, the efforts being made in ALBION Shirakami Laboratory.

At ALBION especially, the consultation performed during face-to-face sales of all products is essential. It is the approach taken not only with customers, but also with developers in R&D. Active study and training programs were conducted for the staff termed as beauty advisors (BAs), who make the face-to-face sales at the counter, and for the management staff, responsible for business operations, at Shirakami Laboratory and the attached pilot farm; they later communicated the highlights of these operations and activities to customers. As a further step, Shirakami Laboratory also held expanded study sessions and on-site observation programs for client businesses. Figure 5 shows staff study and training at Shirakami Laboratory.



Figure 6: Staff Study and Training at Shirakami Laboratory

6. RESULTS

Figure 7 presents the changes in the sales volume of the IGNIS Nature line from its inception in fiscal year 2009 up to the fiscal year 2012, during which new products based on additional investigations into Bernd H. Schmitt's experience marketing were introduced. It should be noted that on this graph, the total series sales revenue for the 2009 fiscal year was set at 100 for use as an indexation criteria.

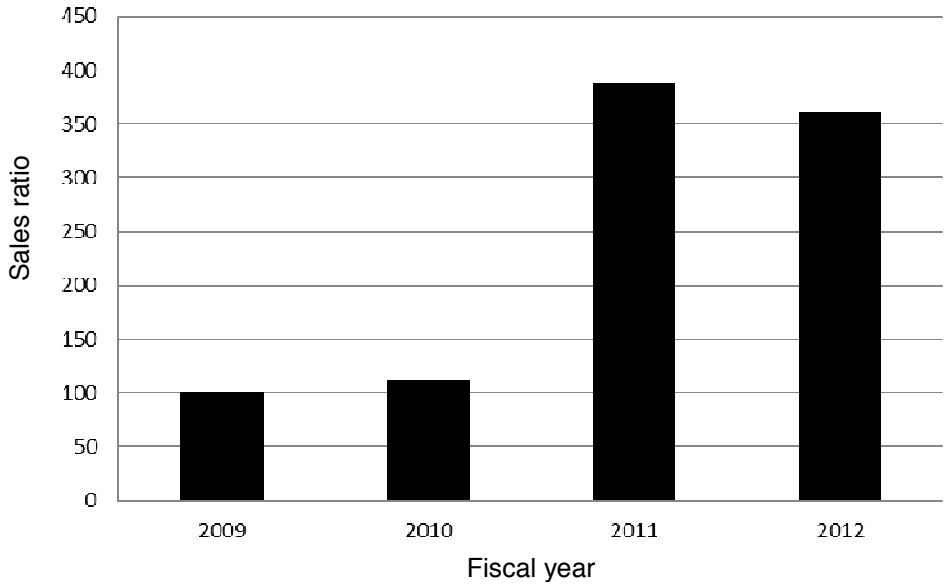

Figure 7: Trends in IGNIS Sales (2009 benchmarked at 100)

We see from the results that since fiscal year 2011, when new products based on Bernd H. Schmitt's experience value marketing were researched and introduced, sales almost quadrupled and definite product revitalisation was achieved. Ups and downs are to be expected, and it cannot be positively asserted that the contribution was solely due to experience value marketing in the strictest sense, but it is thought that as an applied example, there is an obvious contribution to sales improvement here, which proves the efficacy of this concept.

The GNIS Nature line provides the customer with the experience value outlined above, and the customer has responded by appreciating and supporting that experience value.

In this case study, we investigate the points of success in the creation of experience value. It can be said that for many cosmetics, especially in the field of high-quality cosmetics, many products already possess ① SENSE (sensory-based experience value), ② FEEL (affective/emotional experience value), and ③ THINK (intellectual experience value). This means that the primary quality is expected to be present, and even the secondary quality is in the process of becoming an expected factor. The GNIS Nature line of cosmetics is not assumed to be one of “alluring quality” but through the company’s offering of peace of mind and safety, by growing their own cosmetics ingredients, the expectation of “a quality that moves you” is achieved, which increases its value considerably.

Nevertheless, the more that experience value is cantered around maximizing sensibility value, the more complicated the customer behaviour, business, and product networks become, and the harder it is to communicate the product’s sensibility or affective quality to the end users. One advantage that can be highlighted is the fact that the IIGNIS Nature line operates in a unique distribution system that offers the following points of customer contact: ④ ACT (action-based experience value) and ⑤ RELATE (relational experience value). The developers use these elements to communicate to the customer the amount of thought put into the product, through company and customer points of contact, instead of stopping at merely providing high performance as experience value at a level that sends the message "you'll notice the difference when you use it." In short, the message, "hear about it and be convinced" is thought to be added to the message, "use it and be convinced."

Following these concepts, sensibility and affective product values have increased in the field of high-quality cosmetics (a field in which it was previously difficult to use experience value to incorporate theoretical values of sensibility into products), and it can be said that a product that appeals to the emotions of the consumer has been fully realized. As a result, these products are considered to have undergone a successful revitalization.

7. CONCLUSION

We harboured doubts about the mass production, low price, quick turnaround, and industrial manufacturing-type elements of the so-called traditional marketing, and hence, conducted research studies centred on the luxury brand models of the United States and Europe. It was in this milieu that we came across Bernd H. Schmitt’s experience value marketing. We have now arrived at the present situation in which this excellent theory is well researched and supported by Japanese examples. We also restructured this theory to fit the specific circumstances of this research.

This study adds to the body of existing case studies. We have undertaken methods for actual product development and have put theory into practice, obtaining results of remarkable significance. In the future as well, we would like to introduce product development and theory of this type, continuing to bring to light the efficacy of experience value marketing.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Educational Experience in Kansei

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Abstract: Since the earliest *Kansei* works saw the light now more than 30 years ago, the *Kansei* has boomed exponentially. Because of many and various achieved business successes by different working groups as well as the methodology geographical dispersion throughout the world. Multi-faceted *Kansei* has been developed for the last 20 years in a very wide and varied way.

The *Kansei* has experienced as if talking of a tree, a branching experience still going on nowadays. Today we can speak from *Kansei in theory, Kansei emotion measurement, Kansei engineering, Kansei information, Kansei education, Kansei design* to *Kansei in practice* and many other disciplines.

Three years ago our team started the experience to introduce *Kansei* in the educational atmosphere, applying it to the finals degree projects. In the School of Building Engineering at the Universitat Politècnica de València and inside its final degree project proposal, a workshop on Kansei Engineering was offered. During these years at the eighth semester of the building engineer degree, students have been working for almost 5 months under the supervision of a team of teachers on their final project till the final public oral defense was made infront of a committee.

During these years we have worked with an average of 10 students per year. Some have successfully completed their final projects, others have not achieved the minimum required. The article aims to explain the experience during the last 3 years the team has accumulated in Kansei Education, and can be of interest for every teacher.

Keywords: Academic Kansei, Kansei final project, educational experience.

1. INTRODUCTION

Kansei has been spreading around the world for over these last 30 years. As a result of many and various achieved business successes by different working groups, and because of its inner interest and the worldwide spread of its methodology nowadays we can find a huge range of different ways of using kansei and its extension itself.

The orderliness covered are numerous and diverse increasing since 1878, when Amane Nishi characterized the *Kansei* term in an academic context for the first time. Following Shimizu et al. (2004) and Lévy (2013) we can find differences between Kansei Enginnering, Kansei Science (Harada 2003) and Kansei Design or Kansei sociology (Takeda 2006), we can find aswell the term Kansei associated with marketing (Dentsu, 1985 and Fujioka, 1984).

As a reflection of this we only have to take a look into KEER itself where we can find a various set of disciplines. One of the KEER scopes is to attempt to represent most facets of the areas in wich Kansei research is carried out. The conference will therefore include different kansei aspects such as kansei theory, kansei emotion measurement, kansei information, kansei education, kansei engineering till kansei in practice.

In our day by day routine we have been including and living with kansei in various facets. Kansei has become an important part of our lives, started reading and assimilating after we tried to discover and experience ending with new investigations and publications. We started with the earlier kansei stages and nowadays we are working with kansei and the new ICT (information communication and technologies). All this involves expending great time with different kansei areas. Most of us are university teachers and one of our higher ambitions is to unify teaching and research in order to keep both at the top possible level.

This objective, easy to understand, helps us to focus on one knowledge and scientific area so that all our efforts have a unique target helping us to be more efficient at teaching and scientific level. Within this context our working group tried to join both our teaching and our scientific objectives, and we found the clue due to the Bologna process of adaptation to the new draft European Higher Education Area (EHEA).

This paper objective is to describe a kansei educational experience. We aim to describe the processes followed to involve and motivate building engineers students non indoctrinate with kanseis methodologies. Showing the results obtained not only in a quantitative way but also from the different surveys and interviews with the pupils.

The paper maybe of interest to every single teacher with kansei feelings. And research groups in order to know the viability of such methodologies.

2. EDUCATIONAL ENVIRONMENT

The process of adaptation to the EHEA has brought significant changes in the methodology of university education through the new European Credit Transfer System (ECTS). However, the implementation by universities is not limited to adapt program content to a new structure, but also implies a deeper transformation requiring a methodological renewal that includes changes in teaching methods and procedures to be used in the development of the teaching-learning process. With this opportunity of paradigm change the need to implement kansei education was reachable.

This scenario also includes the Final Project (FP) development as main part of our experience. The FP is developed differently to all the other subjects of the university curriculum as Caro et al. (2005) say, and is mandatory at the end of university studies as it should reflect all the knowledge and skills acquired during the degree.

At Spanish universities and according to the Libro blanco (2004) (Building Engineering White Book) final degree project is developed during the eighth semester, and has a teaching order of 12 ECTS where they should develop the competencies, skills and following abilities:

- Integrate training content received in a construction project and its management.
- Research in one of the lines established by the departments.
- Exchange with other schools in the framework of national and international relations.
- Conducting educational cooperation agreements signed by the university and the administration or public and private undertaking

The School of Building Engineering (ETSIE) of the Universitat Politècnica de València (UPV), in order to adapt to the new EHEA implemented a new system through scientific-technical workshops initiated in 2010-2011 academic year in order to prepare the Final Project Degree in Building Engineer by UPV. These workshops had to be carried out during 4 ½ months and attended between 4 and 15 students per group supervised by a team of teachers till they reached their final public defense. The pedagogical methodology used in the Final Project workshops is based on project-based learning (PBL) activities. This active teaching methodology has a holistic approach to education and is designed to engage students in authentic research problems Blumenfeld et al. (1991) so it obviously differs from traditional teaching processes Kubiatki et al. (2011).

This paper aims to show how kansei methodology has been used in an educational environment and has been applied to such an interesting, immersive and important subject such as the Final Project.

3. TEACHING METHODOLOGIES

3.1. WORKSHOP DESCRIPTION

Within this entire environment our group formed by the four authors found the key to develop a Kansei educational experience. The main aim was to experience the possibility of developing a Kansei study with non indoctrinated persons in a bit more than 4 months, and that this work had the entity a university final project demands.

The workshop has been offered for the last 3 years since 2011. The workshop has been tendered to the students as “New Techniques for designing user-oriented architectural spaces”. The ETSIE workshop complete offer was about 40 different areas all of them related to architecture, building technologies, building management, building rehabilitation, energy efficiency among others. The amount of pupils demanding final project workshops has been about 400 students per year, having each workshop between 4 to 15 students. All students were completely free to choose the workshop they wanted to attend until it was full. Once one workshop was full it was closed for new applicants.

The overall objective of the workshop had as said before two main objectives, on one side to practice educational Kansei experience and on the other hand to develop a Final Project (FP) at university level. All this using Kansei Engineering (KE) methodology to architectural spaces. As is

weel known from Nagamachi (1989), the methodology consist in finding the relationship between the perception that a product has according to its own user language, the various designing parameters that define such product and product assessment as a whole.

Students have to realize that in order to design a product is essential to involve every single participant on the project within the designing process, the end user, sales men, production technicians, designers, quality controllers and so on. This way of project management is used in many industrialized sectors. However, related to architecture and the building sector this is not so common, the end user and even all the intermediate stakeholders, suppliers or partners involved in the construction process are not usually part of the designing and architectural process. With this aim, students must analyze the perceptions and identify the designing elements and parameters that cause those perceptions through different architectural spaces of the Universitat Politècnica de València. In particular students should be able to:

- Assimilate the concepts of "Kansei methodology" research and apply it to the design of an architectural space.
- Develop "KE" research methodology (affinity diagram, fieldwork and statistical data processing).
- Analyze research data.
- Discuss the results and research methodology.
- Being able to attend and guide an oral public defense of his work.

Pupils haveto deliver by the end of the semester 3 main things. One essay describing their whole work, an oral defense infront of a committee and a poster as a synthesis of the whole work and in order to disseminate workshop results.

In order to show the workshop structure the FP essay structure is as follows:

COVER

INDEX

1. INTRODUCTION. Defining the essay aim, and project description.

   1.1. Background

   1.2. Essay Structure

2. LITERATURE REVIEW.

   2.1. Design Techniques of user-oriented products.

   2.2. Studies of perception and semantic differential.

   2.3. Studies of architectural space.

3. OBJECTIVES AND HY POTHESIS

   3.1. Objectives

   3.2. Hypothesis

4. MATERIALS AND METHODS. Identify key design elements of architectural spaces causing a positive overall rating in the user.

4.1. Identifying perceptions resulting from the architectural space.

4.2. Getting the design elements associated with the architectural space.

4.3. Development of questionnaires.

4.4. Selection and sample size.

4.5. Development of the fieldwork.

4.6. Data processing and statistical analyzes by using SPSS.

5. RESULTS.

6. CONCLUSIONS.

7. References.

3.2. WORKSHOP STRUCTURE AND METHODOLOGY

The methodology used in the FP workshops is based on the PBL technique, which is an active learning-teaching procedure. This methodology was chosen to allow students an independently way of learning with mentoring and supervision by the workshop supervisors in order to acquire research skills. In order to keep a correct supervision and to establish some milestones a number of presently and group sessions were established. The total compulsory minimum classroom hours were 20, and they were divided into 10 sessions of two hours per session (spare).

The classroom activities were organized according to the objectives to be achieved in each of the different session. These activities were reflected in:

- Theoretical sessions (30%) to provide students with a guide or basic guidelines for learning the methodology and other needs they may have.
- Development, analysis and discussion of data and methodology (57.5%) contrasting impressions with students and analyzing all their collected data.
- Individual work guided by the teacher at class (12.5%)

At the end of each of the different sessions, the student got a stunt of activities they must develop for the next one. These tasks were a part of the final essay to be develop as well as the implementation and drafting of research. Another important aspect is that the FP development is completely individual. However, there are tasks that require cooperative character as data collection and fieldwork for the survey collection, where students worked together and developed teamwork skills.

Table 1 shows the activities that are taking place, both in the classroom and independent work of the student according to the objectives for each session.

Table 1: Workshop Structure

WEEK	Objective	Classroom activity (2 hours/week)	Outdoor activity	Assessment
01	Students must assimilate the concepts of KE methodology in order to apply it to the design of an architectural space	Workshop Introduction: objectives, methodology, evaluation, structure (1 hour). Explanation and introduction to the methodology of KE. Information is provided. (0.5 hours) Explanation of how perceptions and design elements of an architectural space are collected. (0.5 hours)	Pickup perceptions or expressions that generate the architectural spaces and design elements by visiting buildings and spaces of the university, journal and book review ... Bring pictures of different spaces Provided reading literature.	Workshop attendance
02	Students must be able to perform the affinity diagram perceptions or expressions that generate the offices and develop the literature review chapter.	Affinity diagrams or expressions that generate perceptions cabinets (2 hours). 	Bibliographic research information of the concept of KE as well as research methodology. Writing chapter of the literature review.	Workshop attendance Evaluation of the information provided by the student in the collected perceptions and participation in the activity
03	Students must be able to perform the affinity diagram design elements that make up the architectural spaces and to develop the methodology chapter done so far.	Affinity diagrams of the design elements that make up the offices (2 hours). 	Writing the literature review chapter. Writing the methodology development up to now.	Workshop attendance Evaluation of the information provided by the student design elements contained and participation in the activity
04	Students must be able to carry out the field study and develop the methodology chapter done so far	Preparation of the survey (1 hour). Presentation of the process through surveys and data collection (1 hour). Collection of essays: a literature review	Fieldwork. Write the methodology developed to this point.	Workshop attendance Evaluation of the literature review

WEEK	Objective	Classroom activity (2 hours/week)	Outdoor activity	Assessment
05	Students must be able to prepare the data in order to analyze them	Session data processing. Coding in Excel to treat in SPSS (1.5 hours). Review papers: literature review (0.5 hours).	Fieldwork. Write the methodology used up to this point.	Workshop attendance. Evaluation of the methodology to this point.
06	Students must be able to analyze objective data.	Session data statistical processing objective parameters (1 hour). Comment results (1 hour).	Analize results and draw up to this point. (Methodology and results)	Workshop attendance. Evaluation of the methodology and results to this point.
07	Students must be able to analyze the subjective data (perceptions)	Statistical data processing perceptions (1 hour). Comment results (1 hour).	Interpret results and draw up to this point. (Methodology and results)	Workshop attendance Evaluation of the methodology and results to this point.
08	Students must be able to analyze the subjective data (perceptions and design elements)	Statistical data treatment and design elements relating to perceptions. (1 hour). Comment results (1 hour).	Interpret results and draw up to this point. (Methodology and results)	Workshop attendance. Evaluation of the methodology and results to this point.
09	Students should be able to write conclusions	Individual working session. (1 hour). Review papers: methodology and results (1 hour).	Correction of mistakes Write conclusions	Workshop attendance. Evaluation of the FP
10	Students should be able to develop oral communication and presentation and FP panel	FP final presentation session (1 hour). Review of complete essays. (1 hour).	Mistakes corrections and final doubts	Workshop attendance. Exposure assessment and Poster

3.3. WORKSHOP ASSESSMENT

The whole evaluation is a continuous and formative task, thought pupils have been personel guided right since the beginning. The pupil advance and the essay is assessed in every milestone having had more than 4 reviews before the final one. Every evaluation is formative and is discussed with each of the students personally face to face. Before their final oral defense they need to be assessed by the FP supervisors who are the workshop teachers. This final supervision determines who can attend the final oral defense and who has not reached the minimum level required for a FP. Every student gets a final inform from its supervisor that allows them to go into the last step which is the final oral defense. This final inform by the FP workshop responsible will be issued if the student has developed the FP working properly and therefore developed all outdoor activities and attended all FP sessions

The final FP assessment is conducted by a committee appointed for this purpose. The committee is made up by three teachers two selected by lot and the third one invited by the workshop supervisors. The minimum requirements for the oral defense are:

- The student must have passed the total credits of the degree except the FP.
- Students must have been authorized by their academic director or person in charge of the FP workshop.

The final qualification obtained in the FP has been changing during these three years. The two first ones 2011-2012 the 70% of the final qualification was assessed by the pupil supervisor and the 30% by the committee. This has change on 2013 were the whole assessment correspond to the committee.

3.4. WORKSHOP DISSEMINATION

In order to make the workshop result visual and to spread the knowledge every single student attending the oral defense is asked to prepare a poster of his individual work (figure 1). These posters are exposed in two different exhibitions centers, the first one is the ETSIE exhibition room and the second one is “Salon Tecnológico Internacional de la Construcción” EXCO (International Building Technology Exhibition).

This task prepares them to synthesize the whole work developed during the last 4 months and to prepare their oral defense.

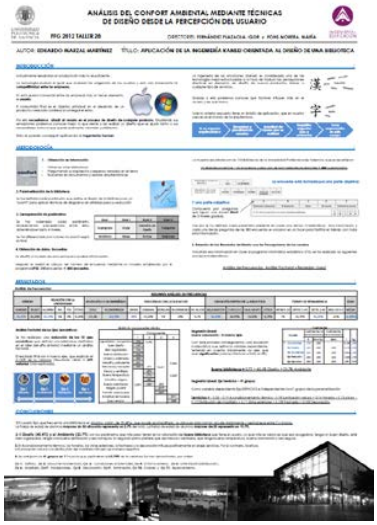

Figure 1: Sample student panel

4. RESULTS AND CONCLUSIONS

There are two types of results, the quantitative ones obtained from the enrolled students, its assistance, final qualifications and so on and the qualitative ones obtained from different surveys and interviews with the pupils that end to be almost colleagues at the very end of the workshop.

According to the results shown in Table 2 the percentage of projects oral defended has been increasing throughout the years. Although not shown, the percentage of the first year non defended (because they do not met the minimum) students was 55.56%. Despite this we can highlight that 60% of those non defended repeated the same workshop the following year, Table 3.

This is due to two reasons: the student has not passed the entire total credits of the degree except the FP and student interest in the FP development.

Table 2: Enrolled, submitted and not submitted students to the workshop during the 3 academic years.

	Course 2010/2011		Course 2011/2012		Course 2012/2013	
	Number	**%**	**Number**	**%**	**Number**	**%**
Enrolled	18		16		13	
Approved	8	44.44 %	10	62.50%	10	76.92%
Suspended	10	55.56%	6	37.50%	3	23.07%

Table 3: Repetition ratios of the suspended students.

	Course 2010/2011		Course 2011/2012		Course 2012/2013	
	Number	**%**	**Number**	**%**	**Number**	**%**
Suspended	10		6		4	
Registered for the following year	6	60.00 %	3	50.00%	2	50%
Not enrolled for the following course	4	40.00%	3	50.00%	2	50%

Moreover, to assess the results of the implementation of scientific and technical workshop in-depth interviews were conducted with randomly selected students to extract certain relevant data. As a result the students improve their affinity to an area of research prior unknown. However, they expressed the difficulty of developing a research in which subjective impressions of users assessing architectural spaces makes them assume a conflict from the technical point of view. Another aspect to the fore of qualitative research is student satisfaction about the FP when finalized, when in principle, it seemed to take on a difficult challenge.

In the qualitative side the first result is that pupils chose our workshop among others even though ours was the furthest in content regarding to their studies. This was a surprise because at the beginning, with the previous workshop information they had, almost none of them really knew what was it about. The beginnings were very difficult because they could hardly understand the methodology and the final objective. Speaking about relations between perceptions and design

parameters sound magic to them. This image was completely changed in the 100% of the cases once they were able to analyze the statistical data.

For our team the kansei educational experience has been successful during these 3 academic years. But also has to be said that the workshop instructors consider that a huge effort is required by both the student and the teacher to develop the PBL methodologies within the kansei area at ETSIE. In fact, according to the results shown in Table 3 it can be seen that the enrollment exceeds the limit of 15 planned on the scientific-technical ETSIE workshops because of an accepted demand. So, after the experience of the first workshop course, the decision was not to increase the number of students for next editions, despite this it was proposed for next courses, to develop FP work in pairs to reduce the total effort.

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Can we categorize moviegoers on their emotions?

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Abstract: The choice of a product is based on the performances but also on the emotions it caused, particularly in cultural products. We hypothesize that customer preferences are partly dependent on the emotions aroused by the use. For each pair user/product type there exists a function linking emotions and preference. The design of online recommendation systems, such as those used in e-commerce, is a real challenge. This requires understanding the customer's need in order to recommend the right products for them, i.e. those that are likely to be appreciated. The current recommendation systems rely on similarities between customers based on products purchased (or assessed). The best way to advise an amateur is then to determine its emotional neighborhood, and recommend the products liked by its neighbors. To validate this hypothesis a full-scale study was conducted on a given product: movie. After determination of a list of emotions adapted to movies; data were collected through an online survey. The data processing (more than 6500 evaluations) has several objectives: 1 . Identify, for each client, relationships between emotions and overall assessment; 2 . Identify groups of customers with similar overall assessments; 3 . Identify groups of customers with similar relationships.

Keywords: User, Emotions, Preference, Neighborhood

1. INTRODUCTION

Electronic commerce websites offer a huge number of products and services for sale, therefore choosing the right product is sometimes not an easy task for a website visitor. These websites often use recommender systems. Recommender systems have emerged in order to help people to choose products or services that best meet their needs and preferences. To recommend products to an active customer, most of recommendation algorithms focus on finding customers who have purchased and/or rated products in common (collaborative filtering).

The challenge addressed in this paper concerns the understanding of why customers gave those evaluations. To explain why a product is liked or not, emotions could be used.

Since the sixties, many disciplines such as marketing, economics and engineering have taken into account users' emotions, as their emotions influence their decision to purchase products.

Emotions can be viewed as mechanisms that return signals in response to favorable or harmful events (Desmet and Hekkert, 2007). Research in customer behavior has discovered then confirmed the importance and the dominance of emotions and affective states in decision making (Richins, 1997; Camerer et al., 2005). Several studies have shown that taking into account the preference of a customer begins with an understanding of the product emotional perception (Norman, 2004). Differences between customer preferences may be due to the fact that they perceive differently the same product (Nakada, 1997; Shang et al, 2000).

The objective of the paper is to show that the integration of information concerning the emotions elicited by products in a recommender system may improve the quality of the recommendations. The proposed approach enables finding customers having the same ratings of products but also getting those who have similar perceptions of products, from an emotional point of view.

The product chosen to illustrate our approach is a movie, product for which preferences are mostly guided by emotions. After a determination of a list of emotions adapted to movies, data were collected through an online survey. The data processing (more than 6500 evaluations) has several objectives: 1 . Identify, for each client, relationships between emotions and overall assessment; 2 . Identify groups of customers with similar overall assessments; 3 . Identify groups of customers with similar relationships.

2. DATA COLLECTION

2.1. The Web Survey

An online survey was designed to allow participants to rate a set of 100 movies, chosen among the most popular in the last decade. For each film, the subject can either pass (if he/she hasn't seen it) or rate. In this second case, the evaluation had to be complete i.e. the subject rated a global appreciation (on a 10-point scale) and different emotions. For emotion, we choose to relies on DES adaptation to films' evaluation (McHugo et al., 1982). 8 adjectives were defined: (1) amused; (2) sad; (3) angry; (4) scared; (5) attentive; (6) anxious; (7) surprised; (8) joyful. Ratings of feelings within each category were made on a 7-point scale from "not at all" to "very strongly."

Hundred films were selected for this study. The list was built using 9 film experts (4 men and 5 women), films should be recent (released in the 3 last years) and cover a broad diversity of genre (action, comedy, horror, etc.). To collect the data, a survey was conducted using the application Survey Monkey ™, invitations were sent using the university mailing list. The target population was then expected to have a good understanding of French (the language of evaluation). The list of hundred films was presented for all users in the same order.

Subjects had the choice to leave the questionnaire at any time (in case of fatigue), this is indicated by the button "Exit". Survey Subjects were also asked to indicate (if they agree) their gender and age.

Over June 2013, 854 subjects responded:

526 subjects rated more than 4 films, 169 subjects rated less than 4 films, and 159 subjects rated no film at all.

The quantity of ratings was considered as important enough to allow us to make a statistical study of these results.

Firstly, the homogeneity of the group has to be tested. This statistical study will focus on the 695 subjects who have seen at least one film of the list.

2.2. Data Description

The data collected are formatted in a 3D table: subject (695)*movies(100)*global and emotional evaluations (1+8). Figure 1 represents the density matrix of subject/film. We can see on this figure the areas of high density. On a line, it means that the subject saw a lot of films. On a column, it means that the film has been seen by a lot of people. For example, the 25th film (Intouchables by Nakache&Toledano, a blockbuster French movie of 2011) has been seen by almost all subjects. The data are more scattered when we approach the end of the list. This shows a potential limit of the test. Indeed, the length of the questionnaire seems to be superior to the patience of the testers who had no possibility to continue the test in another session.

To have a representation of the population, a principal component analysis (PCA) of the data of the global appreciation was performed. This PCA considers the movies as the individuals and the subjects as the variables, and allows a visualization of the diversity of the judgments in the panel of subjects (consonance analysis, (Dijksterhuis, 1995)). Since the input matrix is sparse, the PCA is not trivial (Ilin, A., Raiko, T., 2010). Here we use pairwise exclusion.

Figure 2: presents the results (map of the variables). The first component accounts for 27% of inertia, and all the subjects of the population is oriented in the same direction on this first component. This figure stresses the variability of the group regarding global movie evaluation.

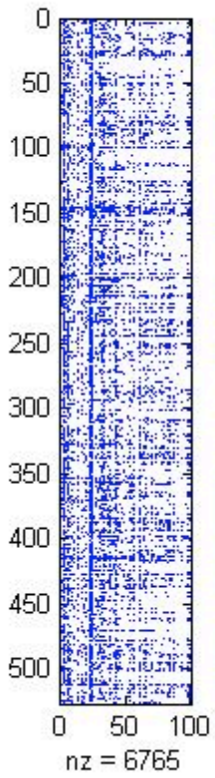

Figure 1: Collected evaluation of films

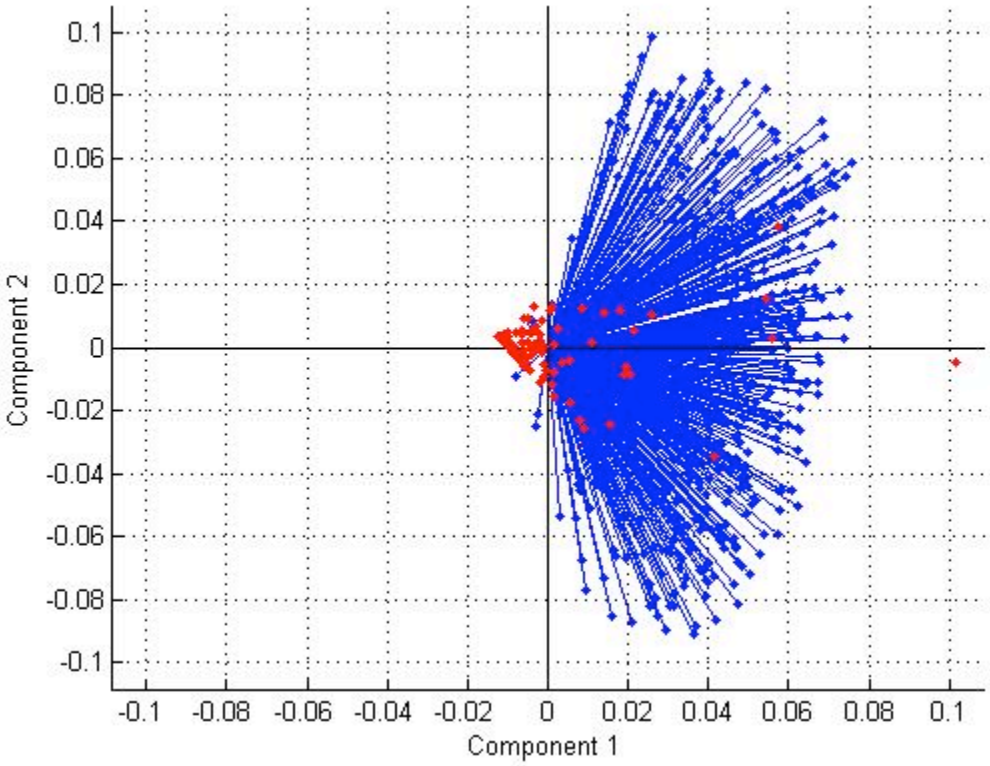

Figure 2: Couple customer/film for the sparse matrix

3. DATA TREATMENT

A strong assessment of this study is that the preference of a subject is guided by subject's emotions. The first idea to test with the data is: are there one or more preference functions based on emotions? In other words, can we classify people by "type" of preferences function? For example, a preference function of a subject who appreciates comic films would give a high preference score when the rating “amused” is high and the rating “anxious” is low.

3.1. Relationship between emotion and overall preference

To verify the existence of this relationship and identify the function f such as overall preference=f(emotions), we apply a multiple linear regression. For each subject i who saw films from 1 to J, we assume there exists a function F such as:

$F(i,j) = \text{overall preference} = C^t + a_{i,1}*S_{Amused}(j) + a_{i,2}*S_{Sad}(j) + a_{i,3}*S_{Angry}(j) + a_{i,4}*S_{Scared}(j) + a_{i,5}*S_{Attentive}(j) + a_{i,6}*S_{Anxious}(j) + a_{i,7}*S_{Surprised}(j) + a_{i,8}*S_{Joyful}(j)$

Given that 9 parameters must be estimated in this model, this regression is only meaningful for subjects who evaluated more than 9 films, 325 subjects in our study.

To illustrate the results, Figure 3 represents the regression coefficients obtained for 4 subjects, randomly chosen. For example, customer 4 is waiting for films that provoke scaring. On the opposite, customer 8 wants surprising and anxious films but not scared at all. We distinguish different profiles of moviegoers. Each user is represented by his/her function. The aim of the study is to find if profiles can be determined, that is to say some groups of users that share the same functions.

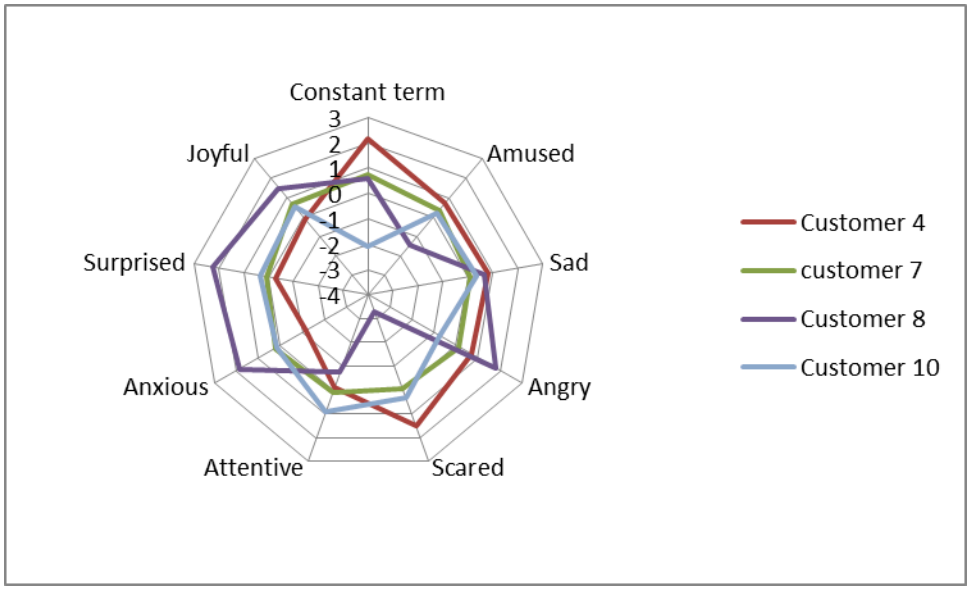

Figure 3: Coefficients of the regression for 4 selected subjects

To verify the predictive quality of function f, we determined its statistical confidence. The functions are reversed to predict the "preference" evaluation of each subject. A scale of half points materializes the difference between the real score and the predictive score. Figure 4 presents the absolute mean of the prediction for each subject. The column finds its legend on the left side of the graph. The squared linked line is linked to the right legend. For 86% of the 325 subjects the projected evaluation stands in a 1-point interval around the actual evaluation. Only for one subject did the error exceed 2-points.

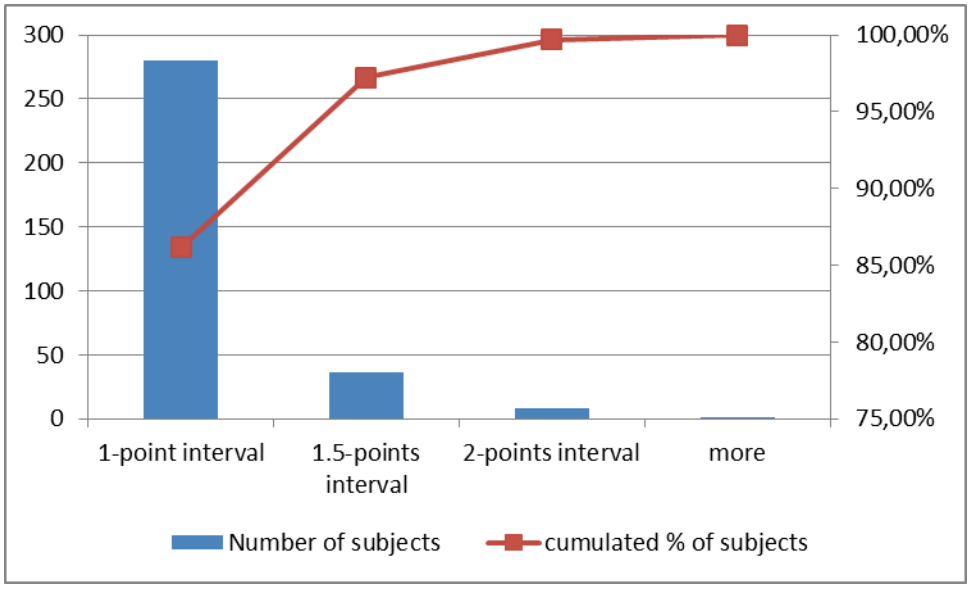

Figure 4: Histogram of the error of the preference prevision (given by functions f)

These results emphasize the veracity of our hypothesis: functions linking preferences to emotions can be determined. For films, customer preferences are partly dependent on the emotions aroused during the use.

3.2. Variant or non variant emotions

The descriptors used to describe emotions are taken from a previous study of McHugo et al. (1982). They are supposed to be relevant, descriptive and not redundant. We study the distribution of the regression coefficients for each emotion. If an emotion is not suited for movies, users should evaluate in a haphazard way this descriptor (and thus have an homogeneous distribution on the full scale) or everybody the same assessment (product has not been distinguished on this scale). If this is the case in a general situation, it may be that some descriptors are not suited for movies.

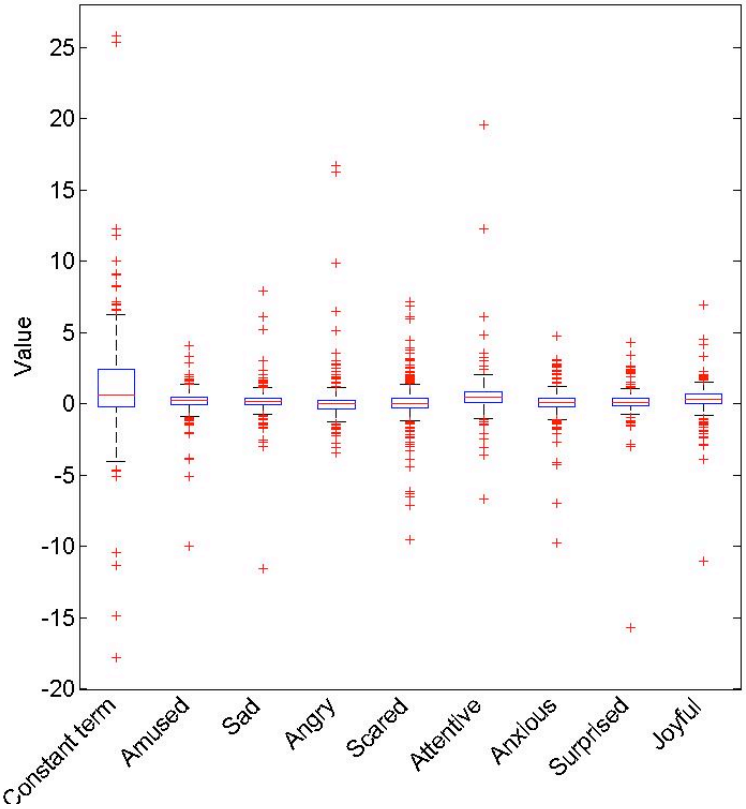

Figure 5: Box-plot of the coefficients of the models f for all the panel of subjects

Figure 5 describes the coefficients of the 325 "f" functions. On each box, the central mark is the median; the edges of the box are the 25th and 75th percentiles. The spacings between the different parts of the box help indicate the degree of dispersion. For all the emotions, we see a dispersion of all the coefficients. For example, the sadness is an emotion researched by people while others rejected it. Anxious seems to be the more consensual. We choose to keep all the descriptors for the following of the study, meaning that McHugo et al.'s list seems to be generic.

We can notice that for some subjects the Constant term is predominant which means that emotions are not the main driver of global evaluation.

3.3. Preference and Perception neighborhood

To generate the preference and perceptual data, we have assumed that customers obey certain "profiles" of preferences. This assumption is quite consistent with marketing studies showing that customer preferences obey to behaviors that can be typed by groups, segments. The interest of stressing the existence of dependence between preference and emotions is to use either or both of these input data to create neighborhood. Those neighborhoods could then be used to recommend products to potential customers.

To create neighborhoods we use 2 matrixes:

1. Subjects/overall preferences
2. Subjects/weights of emotions (coefficients of f).

The first clustering will group the subjects according to the films they like or dislike while the second one will group subjects considering the reasons why they like or dislike films. To make the groups, we use iterative k-mean clustering with squared Euclidean distance. This iterative partitioning minimizes the sum, over all clusters, of the within-cluster sums of point-to-cluster-centroid distances (Seber 1984; Spath, 1985). We face the problem of matrix Subjects/overall preferences sparsity. For a given pair of subjects, distance is then computed based only on the films in common.

Both of the iterative clusterings achieve a best repartition for 5 clusters. Figure 6 represents the repartition of the subjects regarding these 2 clusterings. The x-axis represents the preference clusters and in the y-axis the emotional cluster. The size of the dots is proportional to the number of subjects.

All subjects in a given abscise belong to the same preference cluster. For instance there are 129 subjects in the fifth preference cluster. All subjects in a given ordinate belong to the same emotional cluster. For instance there are 117 subjects in the first emotional cluster.

The larger intersection is obtained for the fifth emotional clustering and the first preference clustering with 50 subjects.

A Chi-square test was conducted on the correspondent contingency table. The observed Chi-square value is 19.9 while the maximum value for a 16 degrees of freedom is 26.3 (for a significance level of 5%). We can conclude on the independency of emotional and preference clusterings.

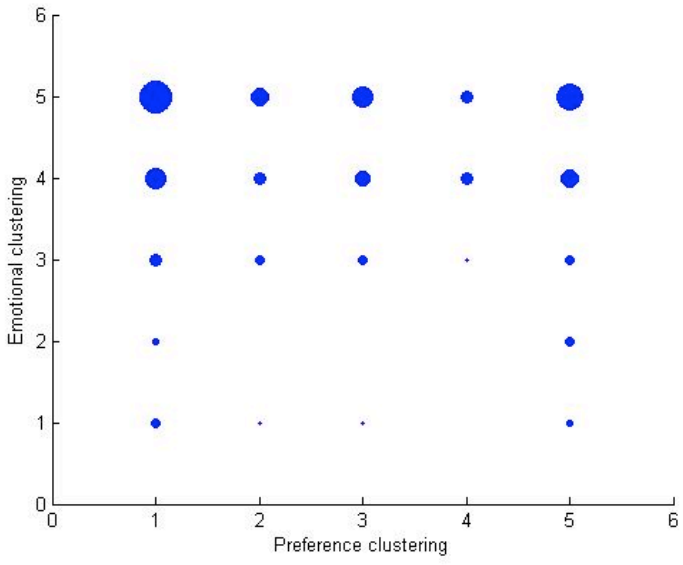

Figure 6: Cross clusters

4. DISCUSSION AND CONCLUSION

The proposed approach enables finding customers having the same ratings of products but also getting those who have the same perceptive reasons of ratings.

In this study, we determined a list of emotions adapted to movies and collected data through an online survey. We identify for each client, relationships between emotions and overall assessment. We grouped subjects with similar overall assessments and subjects with reasons for these assessments. Overall assessments are currently used by e-commerce websites as base for the recommendation system. Yet our results stress the existence of other possible relevant informations that could be of great interest to find customer with the same product expectation.

We can then predict a product based on films that other users have liked (overall score of preference) but also in terms of perceptual reasons that guided the note. This can become very useful cause emotions often guide the choice of a product, whether technological, cultural or edible. Further work will explore the use of the emotional information to improve product recommendation.

One of the next steps is to study the adaptability of DES emotions. Can we use the same words to speak about emotions involve by a film, by a telephone or by a yogurt? Is there a common list of vocabulary or the process of selection is to redo for each application?

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6B - Writing

Adjective-Based Estimation of Short Sentence's Impression

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Abstract: This paper proposes a new method to estimate impression of short sentences considering adjectives. In the proposed system, first, an input sentence is analyzed and preprocessed to obtain keywords. Next, adjectives are taken out from the data which is queried from Google N-gram corpus using keywords-based templates. The semantic similarity scores between the keywords and adjectives are then computed by combining several computational measurements such as Jaccard coefficient, Dice coefficient, Overlap coefficient, and Pointwise mutual information. In the next step, the library sentiment of patterns.en - natural language processing toolkit is utilized to check the sentiment polarity (positive or negative) of adjectives and sentences. Finally, adjectives are ranked and top na adjectives (in this paper na is 5) are chosen according to the estimated values. We carried out subjective experiments and obtained fairly good results. For example, when the input sentence is "It is snowy", selected adjectives and their scores are: white (0.70), light (0.49), cold (0.43), solid (0.38) and scenic (0.37).

Keywords: Impression, polarity, relatedness, semantic similarity.

1. INTRODUCTION

Estimation of semantic similarity between words or some entities is important. It is one of the essential and fundamental technologies for information retrieval and natural language processing. It has a large range of applications, such as word sense disambiguation (Linlin Li, Benjamin Roth, and Caroline, 2010), information retrieval (Saini, & Sharma, & Gupta, 2011), paraphrase recognition (Prodromos, 2009), text summarization and annotation (Ramiz, 2009), and lexical selection (Jian, Lujun, Yang, Hua-Jun, Hua, Qiang & Zheng, 2008). Several measures have been proposed to compute the relatedness scores. These scores can show the similarity between words, a word and its relation. There are semantic relatedness measurements: Ref. (Alexander & Graeme, 2006) introduced the second order co-occurrence pointwise mutual information as a measure of

semantic similarity using the British National Corpus (BNC). Ref. (Mehran Sahami & Timothy, 2006) evaluated knowledge-based measures of word relatedness using *WordNet* as their central resource. Some of the other researchers define the semantic relatedness between the words using Web (Huirong, Pengbin, Baocai, Mengduo & Yanyan, 2011), (Danushka, Yutaka, and Mitsuru, 2011), (Michael & Simone, 2006), (Lun, Yong and Hsin, 2007). Most of the researches, however, just focused on the relatedness between words (noun), a word (a noun) and concepts or entities, which seems not sufficient if we consider realistic applications. For examples: *"summer comes"* associates that the temperature is high, whereas *"summer passes"* means the temperature is not high. Therefore, the estimation of the relatedness between sentence and adjective is one of the most important researches for new trend of *Kansei* research.

In many languages, adjectives are one of the most important elements. They are the best indicator of subjectivity. Usage of adjectives is a popular way to express our feeling, and our impression about something or the quality of any facts or events. They make the content of what speakers tell become more visual and vivid. Also, they are used for descriptive talk or writing.

Sentiment analysis and opinion mining refer to applications and researches related to usage of adjectives. Their objective is to identify and to extract the subjective information in source materials. It has received considerable attention in the research community. The task of polarity and emotion identification may contribute to a broad variety of possible applications such as recommender systems, the collection of opinions in product reviews, in financial news and also in the domain of human computer interaction. The semantic orientation can be analyzed from various levels such as words, sentences, phrases or on entire documents (Subrahmanian & Reforgiato, 2008), (Samaneh & Fred, 2010), (Tim, 2011). These methods extract adjectives and their frequencies from the given reviews, and then it is able to predict the polarity of each adjective using the learned classifier, and classify the review based on the polarity of the adjectives. Current researches have obtained many achievements, however, they are just limited in such areas: judgment or evaluation, whereas they are able to apply and extend to the others, impression estimation in particular.

In this paper, we propose a new method that adopts the association measurement and the sentiment analysis as the main tasks. One of the advantages to compute the relatedness strength between words is that system can express the impression of a given sentence using adjective. The main contribution of this method is to propose a new concept of semantic association - adjective and sentence, and to propose an impression estimation system.

2. PROPOSED SYSTEM

Before detailed explanation, we give a brief about the process of the proposed system. Fig.1 illustrates flow of the process. There are 3 main steps: keywords extraction, adjectives collection, and their ranking. First, preprocessing is carried out to extract keywords from the input sentence. In this step, we group the words by each part of speech and select one word as a keyword of each group. Selected keyword candidates are then used to query the *N*-gram utterances (*N* = 5 in this paper) which are used in the next step - adjective candidate extraction. The dataset for the proposed system is a collection of keywords and the candidate adjectives queries based on Google *N*-gram. Then, we apply association measures to compute the correlation between adjective and keywords. We check the polarity orientation of the adjectives and the input using `Sentiwordnet` (Kerstin, 2008), and `Patterns.en` library. Finally, the top n_a adjectives having the highest similarity scores and the same orientation with the input sentence are displayed.

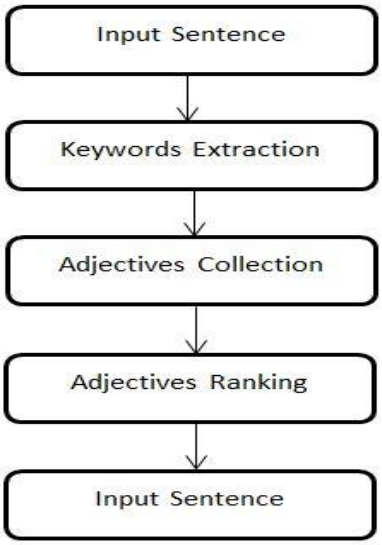

Figure 1: Overview of the proposed system

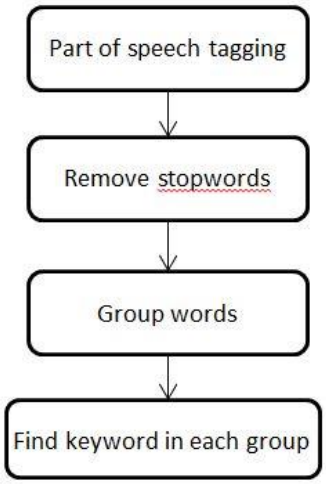

Figure 2: Overview of Keyword Extraction

To compute the similarity between each collected adjective and keywords, there are two cases we need to deal with. In the first case - only a single keyword, the relatedness score between keyword and adjective is computed using corpus-based association measures: Jaccard, Dice, Overlap and PMI. In the second case when there are plural number of keywords, the multivariate association measures (Tim, 2011) and Dice for multivariate are used to compute the relatedness score between the keywords and the adjectives.

The sentiment checking module of `Patterns.en` and `Sentiwordnet` (Kerstin, 2008) are used to check the polarity of adjective and input. The following sections give a step-by-step explanation of the proposed system using the following examples to easy understanding.

2.1. Keywords Extraction

Keywords extraction is detailed in Fig.2. A sentence is preprocessed based on part of speech (POS) tagging and stopwords removal. For the task of stopwords removal, *Wordnet* corpus of

stopwords is used to filter words, little lexical content, out of the given sentence. Then, the rest of the words are grouped by POS tagging. Each word in each category queries unigram frequency based on Google *N*-gram corpus. For the case when these words have higher frequencies, it can be considered as common and not important ones. Therefore, we regard the word in each category with minimum frequency as a keyword of the group.

Here, we explain the above keywords extraction steps using an example when the input is *"A lot of trees were blown down in the storms"*.

- Step1: Part of speech tagging:
  "A" and "*the"* appear as determines of sentence; "*lot, trees, storms* are nouns; *blown*, *were* are verbs; *of*, *in* are prepositions; *down* is adverb.

  Words after removing stopwords: *trees, blown, storms*.

- Step 2: Frequencies of group and words are queried:
  - Nouns:
  - Verbs: *blown*
    - *trees:* 54,000,000.
    - *storms:* 12,530,000.
  - Verbs: *blown*
- Step 3: Keywords decision:
  - Key noun: *storms*
  - Key verb: *blown*

  Result: Keywords are *storms, blown*.

In our research, inputs are short sentences, so obtaining keywords belongs to one of the following two cases:

- Case 1: A word playing the role of keyword. That word might be a noun, a verb or an adjective.
- Case 2: A pair of words playing a role of keyword. These two words are noun and verb.

2.2. Adjective Collection

This step aims to have a dataset of *N*-adjectives (N_a) which are related most to the obtained keywords. The keywords are then used to create templates to query Google *N*-gram. The resulting queries are continually processed. Finally, all of the adjectives are collected. Fig. 3 shows the overview of adjective collection.

Later tables show some examples of the templates created from keywords. The order of the words in the query is free. The result is a list of *N*-gram chunks. To have an effective retrieval, keywords are changed to many forms as what we mentioned - form of noun, verb and adjective. The following explanations give the templates for each situation.

In the case keyword is a noun, templates are illustrated in Table 1.

Input: *sunrise*

Keyword: *sunrise*

After using these templates to query, the *N*-gram chunks are preprocessed (tokenizing, Part of speech tagging), and then adjectives are extracted and saved in a list as shown in Table 2.

Similarly, for the case of verb and the case of adjective playing the keyword role, the created templates are shown respectively in Table 3, and Table 4.

The most important and also the most difficult case is Case 2, which we explained in section 2.1.

In this case, we use strings having 2 words of keyword to query. The following is the example.

Input: *A lot of trees were blown down in the recent storms.*

Keywords: *storm, blown.*

Table 5 shows the templates.

In this example, if there are less than n_l extracted adjectives, we have to use templates for only noun and only verb to query Google *N*-gram separately. We limited the number of list of adjectives because of the computational efficiency of adjective selection. In the proposed system, we set n_l = 20 based on the preliminary experiment. The result of this case will be the intersection of 2 queried adjectives lists.

2.3. Dataset

After having a list of adjectives, the problem is how to compute the similarity score between each adjective in the list and the keyword. To address this task, we need to create a group of words to query frequency based on Google *N*-gram. The method to create strings to query for keywords and each adjective is almost the same as in section 2.2. However, each adjective of created resulting list in section 2.2 is added to the template to query. The result is the frequency for each keyword and adjective. To illustrate this step, we use the case - sunrise is the keyword. The templates to retrieve the frequency of key noun sunrise and adjective in this case are presented in Table 6.

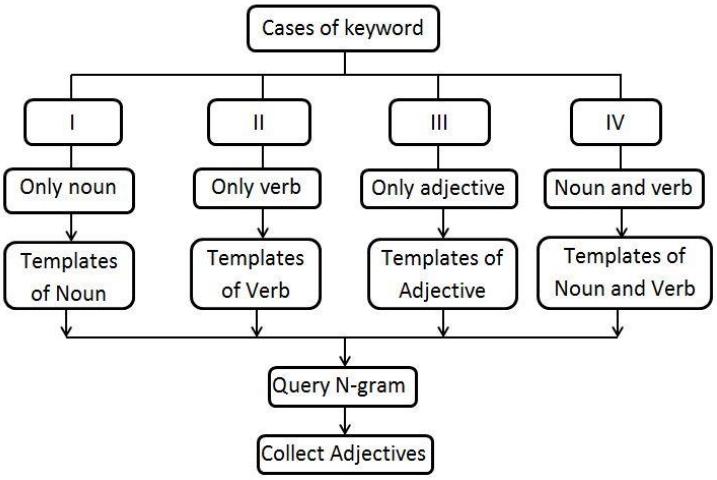

Figure 3: Overview of Adjective Collection

Table 1: Templates to query adjectives in the case there is only one noun

Templates	**Examples**
as + noun	*as sunrise*
Singular noun + to be	*sunrise is*
Capitalized singular noun + to be	*Sunrise is*
Plural noun + to be	*sunrises are*
Capitalized plural noun + to be	*Sunrises are*

2.4. Similarity measure

According to the analysis in section 2.1, we have cases of keywords: Case 1 - a single word and Case 2 - a pair of words. Therefore, we need 2 cases of measurements. There are:

- Two variants association measures are used for Case 1.
- Multi variants association measures are used for Case 2.

Table 2: Adjective list of *"sunrise"* query

Input	*Sunrise*
Output	*'beautiful', 'drier', 'certain', 'sharp', 'geological',...*

Table 3: Templates to query adjectives in the case there is only one verb

Templates of tenses of verb	Examples
Present	*Rain*
Present and 3rd singular	*Rains*
Past	*Rained*
Present continuous	*Raining*
Present perfect	*Rained*
Capitalize	*Raining*

Table 4: Templates to query adjectives in the case there is only one adjective

Templates	Examples
Adjective + as	*rainy as*
Adjective + and	*rainy and*
Query as the case that verb keeps the role of the keyword	(showed in table 1)
Query as the case that noun keeps the role of the keyword	(showed in table 3)

Table 5: Templates to query adjectives in the case keyword is a pair of noun and verb

Templates	Examples
Singular noun + present tense of verb	*storm blows*
Singular noun + past tense of verb	*storm blew*
Singular noun + past perfect tense of verb	*storm blown*
Singular noun + V-ing	*storm blowing*
Plural noun + present tense of verb	*storms blow*
Plural noun + past tense of verb	*storms blew*
Plural noun + past perfect tense of verb	*storms blown*
Plural noun + V-ing	*storms blowing*
Capitalized plural noun + present tense of verb	*Storms blow*
Capitalized plural noun + past tense of verb	*Storms blew*
Capitalized plural noun + past perfect tense of verb	*Storms blown*
Capitalized plural noun + V-ing	*Storms blowing*
Use verb and noun to query separately in the case there are not enough n_l adjectives	Showed in Table 1 and Table 3

Table 6: Templates to query dataset in the case there is only one noun

Templates	Examples
Singular noun + adjective	*sunrise beautiful*
Plural noun + adjective	*sunrises beautiful*
Capitalized plural noun + adjective	*Sunrises beautiful*

2.4.1. Two variants association measures for Case 1

Here, we propose a new concept of association, so we modify four popular co-occurrence measures: Jaccard, Overlap, Dice, and Pointwise mutual information (PMI) to compute semantic similarity using Google *N*-gram. Before introducing association measures, notations are presented in the following Table 7. In this paper, parameters are noun, verb and adjective.

- Jaccard Coefficient: It is often used in information retrieval. The measure was originally designed for binary vectors. It divides the number of equal features with the number of features in general. The Jaccard coefficient measure for two words is computed as

$$Jaccard(w_1, w_2) = \frac{F(w_1, w_2)}{F(w_1) + F(w_2) - F(w_1, w_2)} \quad . \quad (1)$$

- Dice Coefficient: It is very similar to the Jaccard measure and is also often used in information retrieval. The definition is as follows:

$$Dice_1 = \frac{2F(w_1,\ w_2)}{F(w_1) + F(w_2)} \quad . \quad (2)$$

- Overlap Coefficient: The measure is defined:

$$Overlap(w_1, w_2) = \frac{F(w_1, w_2)}{\min(F(w_1), F(w_2))} \, . \quad (3)$$

- Pointwise mutual information (PMI): It computes how often a lexeme and a feature co-occurrence, compared with what would be expected if they were independent. This measure is computed as

$$\mathrm{PMI}(w_1,\ w_2) = \log_2 \frac{P(w_1, w_2)}{P(w_1)(w_2)} \quad . \quad (4)$$

The occurrence score is calculated using two variation association measures between keyword and each adjective in the adjectives list. The result of the example whose keyword is *sunrise* is illustrated in the Table 8.

2.4.2. Multi variants association measures

The association will be the association between noun, verb and adjective. (Tim, 2011) explored two possible generalizations of pointwise mutual information (PMI) for multi-way co-occurrences and Dice for 3 parameters.

- Interaction information: Interaction information is based on the notion of conditional mutual information. Conditional mutual information is the mutual information of two random variables conditioned on the third one. Interaction information can be equally be defined for nv > 2 variables.

$$SI_1(w_1, w_2, w_3) = \log_2 \frac{P(w_1, w_2)P(w_2, w_3)P(w_1, w_3)}{P(w_1)P(w_2)P(w_3)P(w_1, w_2, w_3)} \quad . \quad (5)$$

- Total correlation: Total correlation quantifies the amount of information that is shared among the different random variables, and thus expresses how related a particular group of random variables are

$$SI_2(w_1, w_2, w_3) = \log_2 \frac{P(w_1, w_2, w_3)}{P(w_1)P(w_2)P(w_3)} \quad . \quad (6)$$

- Dice 2: The extension of original Dice measure.

$$Dice_2(w_1, w_2, w_3) = \frac{F(w_1, w_2, w_3)}{F(w_1) + F(w_2) + F(w_3)} \quad . (7)$$

For our experiments, these measures are applied into the proposed system to compute the association between pair of words (noun and verb) and adjective. We use Table 9 to show the result of the example that *storm*, and *blown* are keywords.

However, one important point needs to notice in this case. As we especially mentioned in the section 2.2, if there are less than n_l extracted adjectives, we need to query adjective for noun and verb separately and intersect 2 resulted lists to have the final result. Therefore, the method to calculate the similarity scores is the similarity measurement between each adjective and each word of keywords independently using method as section 2.4.1.

Table 7: Notation

Notations	Description
F(w1)	Frequency of word 1 in corpus
F(w2)	Frequency of word 2 in corpus
F(w3)	Frequency of word 3 in corpus
Nw	Total number of words in corpus
F(w1,w2)	$\sum co-occurrence\ frequency\ of\ word\ 1 and\ word\ 2$
F(w1,w3)	$\sum co-occurrence\ frequency\ of\ word\ 1 and\ word\ 3$
F(w2,w3)	$\sum co-occurrence\ frequency\ of\ word\ 2 and\ word\ 3$
F(w1,w2,w3)	$\sum co-occurrence\ frequency\ of\ word\ 1 and\ word\ 2\ ,\ and\ word\ 3$
P(w1)	$F(w_1) / N_w$
P(w2)	$F(w_2) / N_w$
P(w3)	$F(w_3) / N_w$
P(w1,w2)	$F(w_1, w_2) / N_w$
P(w1,w3)	$F(w_1, w_3) / N_w$
P(w2,w3)	$F(w_2, w_3) / N_w$
P(w1,w2,w3)	$F(w_1, w_2, w_3) / N_w$

Table 8: Adjectives list of *"sunrise"* query

Adjective	PMI	Jaccard	Overlap	$Dice_1$
beautiful	15.964	0.001	0.003	0.002
Drier	14.266	0.0002	0.0003	0.001
Certain	8.207	0.0001	0.0002	0.0001
Best	6.964	0.00002	0.0005	0.0037
…..	…...	……	……	……

Table 9: Adjectives list of *"storm blown"* query

Adjective	SI_1	SI_2	$Dice_2$
Cute	1.0079	0.0003	0.0001
Atmosphere	9.0889	8.2228	0.0006
Evolutionary	4.2076	4.4170	0.0001
ceramic	3.1546	4.4365	0.0002
…..	…...	……	……

2.5. Sentiment:

In our research, we use *patterns.en* library to calculate and check the polarity orientation of the input and output.

For example:

Input: *A lot of trees were blown down in the recent storms.*

- Sentiment of input:
  sentiment("A lot of trees were blown down in the recent storms") = (-0.0556, 0.2639)
- Sentiment of its list of adjective after extracting:
  sentiment (*cute*) = (0.5, 1.0)

  sentiment(*atmosphere*) = (0, 0)

  sentiment (*severe*) = (-0.25, 0.25)

At this step, the sentiment of all adjectives is checked. All adjectives have the same polarity as input are kept and ordered for the next step ranking.

2.6. Adjectives Ranking

We again need to consider separate ranking procedure for the cases: single keyword and pair of words keyword.

2.6.1. Ranking method using for Case 1 (Section 2.1)

The method we use to rank is the average ranking. Depending on the situation, the vector of each adjective has 3 or 4 elements corresponding with the association measures (SI1, SI2, Dice) or (PMI, Jaccard, Overlap, Dice).

However, since association measures have different ranges, normalization scheme is thus necessary. In this application, the scale from 0 to 1 is used. It helps parameters have the same scale for a fair comparison between them. The normalized value is computed as following:

Table 10: Normalization Notation

Notation	Explanation
E	A column needs to normalize
$E_{\max}$	Maximum value of column E
$E_{\min}$	Minimum value of column E
e_i	Value for variable E in the ith row
v_n	Normalized value

Table 11: After normalization

Adjective	SI1	SI2	Dice2
Cute	0.007	0.008	0.007
Atmosphere	0.046	0.050	0.050
Evolutionary	0.017	0.014	0.010
Ceramic	0.003	0.004	0.003
…..	…...	……	……

$$If\ (E_{\max} = E_{\min})\ \ then\ v_n = 0.5$$

$$else\ \ v_n = \frac{e_i - E_{\min}}{E_{\max} - E_{\min}} \quad (8)$$

where the notations for normalization computation are shown in Table 10.

- Apply into our application:

List N_a adjectives, each column is value of each association measure. Scores will be normalized to let elements of each adjective have a fair role in ranking. Table 11 shows the result after normalization.

- Ranking

The way to rank is the usage of the averaged rank. It means we compute the average score of semantic association score of each adjective.

We calculate the average score for each adjective i of list: $r_i = \frac{\sum_j^m r_{ij}}{m}$, where m is the number of the association measures we used (in this case m = 4). The final ranking is obtained by ordering the average ranks.

The output of this task is the top n_a words having the highest average score and the same orientation with the input polarity orientation.

2.6.2. Ranking method in Case 2 (section 2.1)

We use the same way as section 2.6.1 to order adjectives. However, this case has special exception which is noticed in the section 2.4.2. The similarity score of noun, verb and adjectives are calculated separately noun - adjectives and verb - adjectives. Therefore, to rank adjectives, we apply the method in section 2.6.1 to each word of keyword and get two rankings, r_1 and r_2. Then, results need to be merged. The computation of ranking combination is proposed

$$r(x) = \frac{1/r_1(x) + 1/r_2(x)}{1 + |r_1(x) - r_{12}(x)|} \quad , \quad (9)$$

where: $r(x)$: rank of item *x* in list after combination two lists.

$r_1(x)$: rank of item *x* in list when list is affected by factor 1.

$r_2(x)$: rank of item *x* in list when list is affected by factor 2.

This proposed ranking method is used in the case we have a list of items and 2 factors affecting the order of list. The list will be ordered based on the factor in which the list interacts with. The goal of our method is combine two lists order together to optimize the order list. Finally, we select the top N_a adjectives in the ordered list whose polarity orientation is similar to the input polarity orientation.

3. EXPERIMENT AND EVALUATION

3.1. Experiment

In order to evaluate the effectiveness of the proposed system, we conducted an experiment. With each input, the results are lists of 3 adjectives, their order and their scores. Table 12 shows the results of the experiment.

Table 12: Experimental Result

N	Sentence	Adj1	S	Adj2	S	Adj3	S	Adj4	S	Adj5	S
1	It is snowy	White	0.72	Light	0.49	Cold	0.43	Solid	0.38	Scenic	0.37
2	It is windy	Vigorous	0.29	Breeze	0.27	Various	0.27	Accidental	0.27	Medical	0.27
3	It is cloudy	Momentary	0.62	White	0.52	Light	0.52	Black	0.50	Tag	0.45
4	It is rainy	Light	0.54	Sky	0.40	Heavy	0.34	Patriotic	0.32	Raindall	0.31
5	It will be sunny	Early	0.70	Real	0.63	Good	0.42	Competitive	0.37	Second	0.36
6	It is raining outside	Light	0.55	Sky	0.40	Heavy	0.38	Patriotic	0.32	Raindall	0.31
7	It is snowing outside	Light	0.62	White	0.56	Heavy	0.46	Solid	0.3	Regional	0.28
8	Sunrise	East	0.50	Sky	0.30	Bright	0.32	Beautiful	0.28	Geological	0.27
9	Sunset	Red	0.43	Ocean	0.42	Western	0.38	Super	0.36	Beautiful	0.30
10	Some people are going under the snow	Slow	0.53	First	0.49	White	0.46	Heavy	0.45	Central	0.43
11	An earthquake destroyed	Massive	0.43	Recent	0.43	Emergency	0.39	Powerful	0.32	Huge	0.31

	much of San Francisco.										
12	A lot of trees were blown down in the recent storms	Magical	0.31	Winter	0.27	Terrible	0.25	Noxious	0.25	Severe	0.25
13	Storm hits Oklahoma	Early	0.38	Real	0.35	Good	0.33	Competitive	0.32	Second	0.29
14	Summer comes	Early	0.63	Hard	0.56	Hot	0.54	Full	0.50	Expensive	0.49
15	Winter comes	Harsh	0.38	New	0.31	Beautiful	0.30	Long	0.29	Cold	0.27
16	Autumn comes	Alive	0.14	Love	0.14	Brown	0.11	Accessible	0.11	Cold	0.10
17	Spring comes	Hot	0.59	Important	0.57	New	0.56	Critical	0.53	Great	0.51
18	Rainbow appears	Beautiful	0.56	Southeast	0.47	Remarkable	0.46	Global	0.43	Yellow	0.34
19	Ice is melting	Arctic	0.61	Faster	0.48	Global	0.46	Antarctic	0.45	Northern	0.43
20	Outside the snow began to fall	Heavy	0.51	Fresh	0.42	White	0.40	Light	0.39	More	0.38

3.2. Evaluation Method

3.2.1. Method

Subjective experiment for the evaluation was carried out using 60 subjects (39 males and 21 females, 44 non-native speakers and 16 native speakers). The ages of subjects are older than 10 years old. We created and distributed the survey to let people judge output of the proposed system corresponding with the given input.

3.2.2. Materials

This survey consists of 20 concept sets, each set consisted of a sentence such as *"Storm hits Oklahoma"* and 5 adjectives that system conducted to express impression of the given sentence. To evaluate the proposed system imple-mentation is, we tried 4 types of different sentences:

- Sentences whose keyword is only one noun.
- Sentences whose keyword is an adjective.
- Sentences whose keyword is a noun.
- Sentences whose keywords are a noun and a verb.

The topic the proposed system treated is related to the weather, or the natural phenomena. We choose these topics be-cause they are commonly used, can be representative topics as given examples and are able to help us evaluate system easily and more accurately.

The grade scale is from 1 to 5. In each concept, grades are given for individual evaluation. The majority of work for subjects is that they would give the grade that best matches with how agreeable they thought about the outputs for the given input sentences. Table 13 summarizes the number of sentences in each group.

3.2.3. Procedure

After accessing the consent forms, the sub-jects read instructions from the computer screen. There are two parts of the survey that the users need to finish. The first part asks personal information such as gender, age, nationality, and level of English language. The main part is the second part. In this part, the subjects need to indicate their level of agreement with generated

adjective corresponding with the given input in each concept on scale from 1 to 5.

3.3. Evaluation Result

Table 14 shows summary statistics for the 4 samples of data. As the table shows the score participants marked stretch from 1 to 5. The common evaluation is agreement which we can see from the average grade, at 3.1. To compare the difference grading between groups of sentences, Fig.4 shows the frequency of subjects for each type of sentence in each grade. Overall, it is clear that noun-group has higher score than the other groups and satisfied with the majority of people (more than 40 people graded 4 and 5). For other groups, the popular grade is 3.0. To be clearer, Fig.5 shows how different is it in the grades between groups. Obviously, the efficiency of noun group compared to other group is much higher.

Table.15 and Table.16 show which means of groups are significantly different from which others. Most of the pairs are significant difference, but just only one pair adjective and verb is not and the grades for these pairs are not that high. It means that adjective-group and verb-group are considered as two non-effective working groups.

4. CONCLUSION

A new system of the impression estimation of a short sentence has been presented in this paper. In order to obtain keywords, we analyze and pre-processed the input. They are then used to make up templates to collect adjectives from queried data using Google *N*-gram. The co-occurrence scores between keywords and adjectives are computed based on semantic similarity computational measurements: Jaccard coefficient, Dice coefficient, Overlap coefficient, and Pointwise mutual information. After that, polarities between input and adjectives are checked using the sentiment library *patterns.en*. Finally, the adjectives are ranked and top n_a adjectives are considered as an output of system. For example, the experiments were carried out and got fairly good result. With the input "*it is snowy"*, the results are *white* (0.70), *light* (0.49), *cold* (0.43), *solid* (0.38), and *scenic* (0.37)

In our future work, we will improve more in the tasks of keyword extraction and semantic similarity methods to make the proposed system working well with complex inputs.

Table 13: Number of sentences

Type	Number
Adjective	5
Verb	2
Noun	2
Verb and noun	11

Table 14: Experiment average result

Max	Min	Mean	Median	Stdev
5	1	3.1	3	1.2

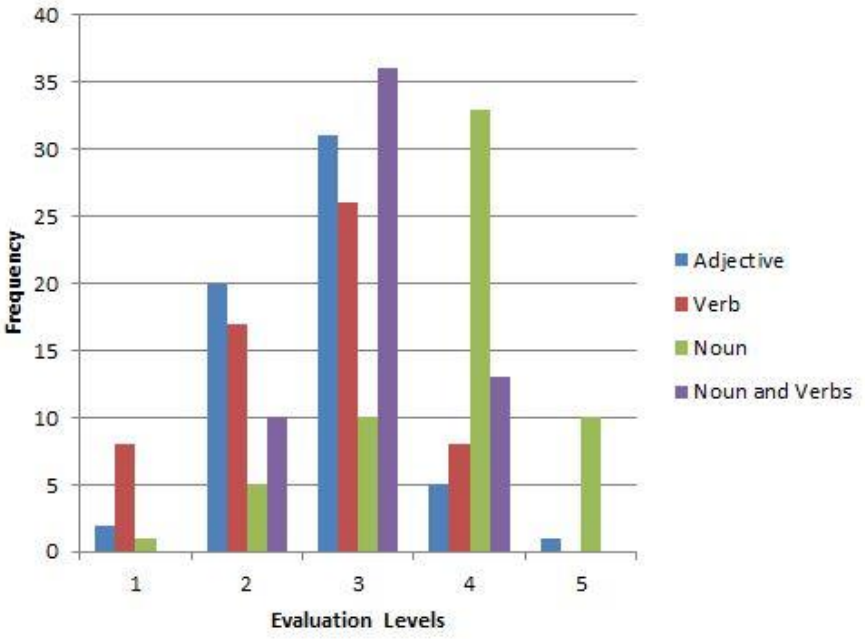

Figure 4: Evaluation levels

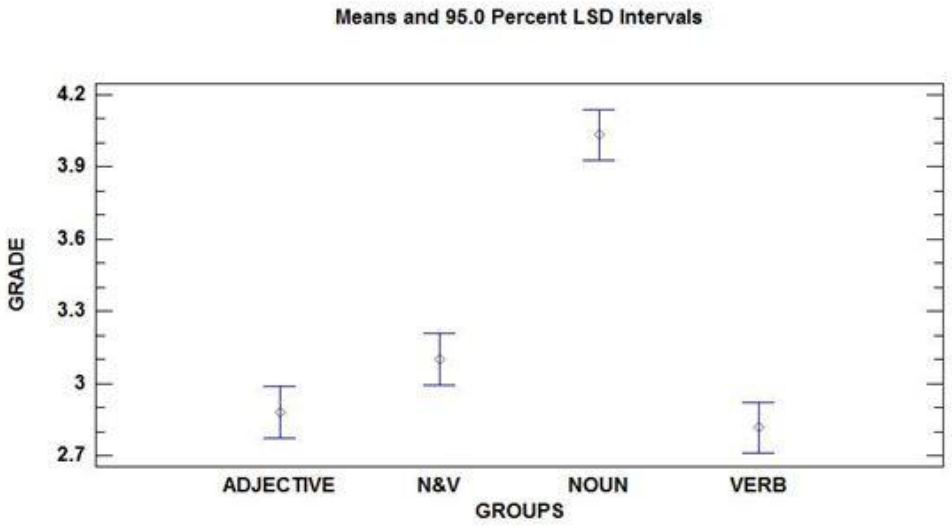

Figure 5: Group Comparison

Table 15: Comparison result

Groups	**Count**	**LS Mean**
Verb	60	2.82
Adjective	60	2.88
Noun and verb	60	3.10
Noun	60	4.03

Table 16: Difference between groups

Contrast	Sig.	Difference	+/- Limits
Adjective – Noun and Verb	*	-0.223	0.213808
Adjective – Noun	*	-1.15417	0.213808
Adjective - Verb		0.0625	0.213808
Noun and verb – Noun	*	-0.931167	0.213808
Noun and verb – Verb	*	0.2855	0.213808
Noun – Verb	*	1.21667	0.213808

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Understanding Customers' Affective Needs with Linguistic Summarization

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Abstract: To increase the chance of launching a successful product into market, it is essential to satisfy customers' affective needs during the product design stage. However, understanding customers' affective needs is very difficult task and product designers might misunderstand the customers' affective needs. In this study, linguistic summarization with fuzzy set is used to present customers' affective needs with natural language statements which could be easily understood by human beings. The relations between customers' affective needs and product design elements are represented by type-I and type-II fuzzy quantified sentences. To illustrate the applicability of the linguistic summarization with fuzzy set in translating customers' affective needs to natural language statements, a case study is conducted on mobile phone design. The results indicate that the linguistic summarization with fuzzy set can be a useful tool to assist designers to create products satisfying affective needs of customers.

Keywords: Affective Design, Linguistic Summarization, Fuzzy Sets.

1. INTRODUCTION

With the fierce competition in market environment, satisfying the customer needs on product has become one of the most important factors in product development for almost all companies. Considering the fact that the mass customization and personalization have been recognized as a key factor for companies to gain competitive advantages (Jiao, Zhang, & Helander, 2006). The functional and affective needs have been undoubtedly accepted as the primary importance for satisfying the customer needs. Since there are many similar products which are functionally equivalent with the progress in product design technologies, it is very difficult to differentiate them based only on their functional attributes (Khalid & Helander, 2004; Shi, Sun, & Xu, 2012). Furthermore, design in terms of usability and performance has not been seen as competitive advantage because nearly all companies have same technologies. Thus, it is necessary to design products considering the customers' affective needs so that differentiating among them is possible.

The affect is defined as customer's psychological response to the perceptual design details of the product (Demirbilek & Sener, 2003). Affective design is the inclusion or representation of affect (e.g.

emotions, subjective impressions, visual perceptions, etc.) in the design processes (Khalid & Helander, 2004). The main challenge for affective design is to accurately grasp the customer's affective needs and subsequently to design products to meet those needs (Bahn, Lee, Nam, & Yun, 2009). Many studies have worked on how to measure and analyze human reactions to affective design and how to assess the corresponding affective design features. However, capturing the customers' affective needs is sometimes very hard owing to their linguistic origins. Affective needs are imprecise as they include subjective impressions, very hard to transform into verbal descriptions. In some cases, to express their affective needs on product, customers and designers might use different sets of context. These differences in semantics and terminology could lead to the inconsistency in transferring affective needs effectively from customers to designers (Jiao et al., 2006).

There have been reported a plenty number of studies to analyze relations between affective needs of customers and product design elements. Especially, Kansei Engineering (KE) has been introduced as a methodology for translating the customer's affective needs on a product into the design elements of the product (Nagamachi, 1995). KE has been successfully implemented in affective design so as to express the relationship between the affective needs of the customers and the design elements of the product. The relationship between affective needs of customers and product design elements has also been dealt with in a wide range of approaches. Han et al. (2000; 2004; 2001) identified most important design elements along with the predicted effect on usability by employing empirical models, e.g., multivariate linear regression techniques. Methods such as linear regression could only handle linear relations; and they are therefore not capable of effectively dealing with nonlinear relations. To deal with the nonlinearity between affective needs of customers and product design elements, the soft computing techniques such as fuzzy set (FS), artificial neural networks (ANN) and so on have been used. The relationships between the affective user needs and product design variables were examined by FS and fuzzy rule based models by Hsiao (1994), Kwon (1999) and Akay and Kurt (2009). In addition to above works, a few studies have implemented ANN with other soft computing techniques in product design. Hsiao and Huang (2002) used an ANN model to analyze the relationship between product form parameters of a chair and image perception of the product using several adjective pairs. Hsiao and Tsai (2005) developed a hybrid modeling approach based on fuzzy ANN and genetic algorithm (GA) for automatic design of product forms. By considering color parameter as well as design form parameters, ANN and grey theory (GT) were used to predict the image sensation of a product based on a given input set of form and color parameters, respectively (Tsai, Hsiao, & Hung, 2006). Lai et al. (2005) used Grey Prediction and ANN models to find optimal design combinations of product form parameters of mobile phones satisfying a desired product image represented by semantic word pairs. Lai et al. (2006) extended their previous product image study on product form by incorporating product color factor using Quantitative Theory Type I and ANNs. Yanagisawa and Fukuda (2005) proposed an interactive reduct evolutional computation system for aesthetic design of products. Poirson et al. (2007) employed a GA to explore the best design parameters enhancing perceived quality of brass musical instruments measured with a sensory attribute intonation. Chang et al. (2007) developed a comprehensive model of form attractiveness for exploring the attractiveness of passenger car forms aimed at young customers. Lin et al. (2007) developed a fuzzy logic approach to determine the best combination of mobile phone form elements for matching a given product image. Hong et al. (2008) presented an approach for optimally balancing various affective satisfaction dimensions based on the multiple response surfaces methodology with a case study on mobile phone designs. Shieh and Yang (2008) used fuzzy support vector machines to help product designers in a case study on

mobile phone design. Yang and Shieh (2010) recommended a machine learning approach known as support vector regression (SVR) to develop a model that predicts customers' affective responses for product form design. Yang (2011a) presented a classification based on KE for modeling customers' affective responses and analyzing product form features in a systematic situation. Chan et al. (2011) proposed an intelligent fuzzy regression method generating models which represent fuzzy relationship between affective responses and design variables. Yang (2011b) integrated the methodologies of SVR and multi-objective GA into the scheme of hybrid kansei engineering system (KES). A case study of mobile phone design was given to demonstrate the analysis results. Wang (2011) proposed a hybrid KES, combining grey system theory and SVR, for effectively and accurately predicting the relationship between product form elements and product images. Oztekin et al. (2013) suggested a Taguchi based method in KE with a case study on mobile phones. From the literature, it is seen that there are many works on the affective design of mobile phones since it is accepted as a status symbol and fashion icon by customers.

The key factor in affective engineering is to transform customers' emotions on products into the design features which should be easily understood by designers. One of the efficient ways to present affective responses of customers is "if-then" rules. However, "if-then" rules might fail to represent affective responses of customers in some situations where more complex natural language based sentences are required. In this paper, we propose linguistic summarization with FS for representing customer's emotions on products using more complex statements instead of "if-then" rules. The rest of the paper is organized as follows. In section 2, basic definitions of linguistic summarization with FS are introduced. Section 3 presents the application of linguistic summarization with FS to a case study on mobile phone design. Finally, the conclusion remarks and future directions are discussed in section 4.

2. LINGUISTIC SUMMARIZATION

One of the descriptive techniques in data mining is summarization intending to discover patterns that cover overall aspect of data in a concise manner. Although the simplest form of summarization is based on the statistical methods, understanding the results obtained by them are sometimes beyond the capacities of human beings, and usually providing a limited knowledge to use. Hence, linguistic summarization with FS that generates natural language statements from data has received a great attention in the literature. The first studies on linguistic summarization using FS was proposed by Yager (1982; 1991, 1995; 1996). After that, the studies on linguistic summarization with FS have been reported under the different names such as fuzzy quantification (Barro, Bugarin, Carinena, & Diaz-Hermida, 2003; Miguel Delgado, Sánchez, & Miranda, 1999; M. Delgado, Sanchez, & Vila, 2000; Zadeh, 1983), semi-fuzzy quantifiers (Félix Diaz-Hermida & Bugarín, 2011; F. Diaz-Hermida, Bugarin, & Barro, 2003; F. Diaz-Hermida, Bugarin, Carinena, & Barro, 2004; F. Diaz-Hermida, Losada, Bugarin, & Barro, 2005), fuzzy association rules (Dubois, Hullermeier, & Prade, 2006; Dubois, Prade, & Sudkamp, 2005; Martin & Shen, 2009; Martin, Shen, & Majidian, 2010), fuzzy rules (Dubois & Prade, 1996; Serrurier, Dubois, Prade, & Sudkamp, 2007) and so on.

Before representing the idea of linguistic summarization, the related definitions on FSs are given. A FS on X, denoted by A, is defined as $A=\left\{\left\langle x,\mu_A(x)\right\rangle \middle| x\in X\right\}$ where $\mu_A(x)$ is the membership grade of x. The α-cut of A is the crisp set $A_\alpha=\left\{x\in X\middle|\mu_A(x)\geq\alpha\right\}$.

Let Y be defined as a set of objects $\mathrm{Y}=\{y_1,y_2,y_3,\ldots,y_M\}$, V be defined as a set of attributes $\mathrm{V}=\{v_1,v_2,v_3,\ldots,v_K\}$ and X_k $(k=1,2,\ldots,K)$ be the domain of v_k. Then $v_k^m \equiv v_k(y_m) \in \mathrm{X}_k$ is the value of the kth attribute for the mth objects. Most of the linguistic summarization studies have employed two summary forms based on the fuzzy quantifiers, proposed by Zadeh (1983). The first summary form called as type-I fuzzy quantified sentence is in the form of "*Q* Y*'s are / have S* [*T*]". Here, Q is the linguistic quantifier labelled with FS (e.g. about half, most, etc.), Y is the set of objects, S is the summarizer labelled with FS, and T is the degree of truth describing how much data support the summary. The second summary form called as type-II fuzzy quantified sentence is in the form of "*Q* Y *being* w_g *are / have S* [*T*]". w_g is a qualifier (pre-defined summarizer) labelled with FS. "Most tall people are blonde" can be given as an example for type-II fuzzy quantified sentences. Here, "most" is the linguistic quantifier (Q), "people" is the set of objects (Y), "tall" is the qualifier (S_g), and "blonde" is the summarizer (S). Since a type-II fuzzy quantified sentence is a general case of the type-I fuzzy quantified sentence, in this paper, we hereafter only concentrate on type-II fuzzy quantified sentences.

The degree of truth defined by Delgado et al. (2000) is used for evaluating type-II fuzzy linguistic summaries as follows:

$$T=\sum_{\alpha_i\in\Gamma(S|w_g)}(\alpha_i-\alpha_{i+1})\times\mu_Q\left(\frac{|\,S(v_S^m)_{\alpha_i}\cap w_g(v_g^m)_{\alpha_i}\,|}{|\,w_g(v_g^m)_{\alpha_i}\,|}\right) \tag{1}$$

In Eq.(1) $\Gamma(S\,|\,w_g)=\{\alpha_1,\alpha_2,\ldots,\alpha_n\}$ is a set of union of α levels of $\Gamma(S\cap w_g)\cup\Gamma(w_g)$ and it holds $0=\alpha_{n+1}<\alpha_n<\ldots<\alpha_2<\alpha_1=1$. w_g should be normal FS. If it is not normal FS, it should be normalized. $S\cap w_g$ should also be normalized by the same factor used in the normalization.

The linguistic summaries are usually evaluated by the degree of truth. But, some authors advocate that the degree of truth is solely insufficient to evaluate the quality of a linguistic summary. Therefore, we have used some additional quality measures proposed by Wu and Mendel (2011). One of these quality measures is the degree of sufficient coverage T_c, presenting generality and describing whether a linguistic summary is supported by enough data. In order to compute T_c the coverage ratio should be first calculated as:

$$r=\frac{\sum_{m=1}^{M}t_m}{M} \tag{2}$$

where t_m is defined as:

$$t_m = \begin{cases} 1, & \mu_S(v_S^m) > 0 \text{ and } \mu_{w_g}(v_g^m) > 0 \\ 0, & \text{otherwise} \end{cases}$$

r is the percentage of data which fits both the qualifier and the summarizers of a linguistic summary at nonzero degrees. r can not be used directly in the evaluation since it is usually very small. Therefore, the function determined by r_1 and r_2 (r_1 and r_2 with $0 \leqslant r_1 < r_2$ are real numbers such as $r_1 = 0.02$ and $r_2 = 0.15$), maps the coverage ratio into the appropriate T_c as follows:

$$T_c = f(r) = \begin{cases} 0, & r \le r_1 \\ \dfrac{2(r - r_1)}{(r_2 - r_1)^2}, & r_1 < r < \dfrac{r_1 + r_2}{2} \\ 1 - \dfrac{2(r - r_1)}{(r_2 - r_1)^2}, & \dfrac{r_1 + r_2}{2} \le r < r_2 \\ 1, & r \ge r_2 \end{cases} \tag{3}$$

The degree of reliability (T_r) determines whether a linguistic summary provides reliable knowledge or not. It can be stated that a summary is reliable if it has high degree of truth and a sufficient coverage. T_r is defined as:

$$T_r = \min(T, T_c) \tag{4}$$

3. APPLICATION OF LINGUISTIC SUMMARIZATION TO AFFECTIVE PRODUCT DESIGN

The mobile phones are seen as a status symbol and fashion icon according to most of young and middle aged users who give more importance to the affective dimensions of a phone (Katz & Sugiyama, 2005). Therefore, it is important to grasp what the target young users really want for designers in such a competitive market. In this section, we use linguistic summarization for extracting knowledge related to customers' affective needs on mobile phones which are very popular products, especially to the young generation. For the sake of clarity, each stage of the methodology is presented in detail on this particular example.

Step 1. Identification of semantic space: An initial semantic space was formed by interviewing users, surveying magazines related to mobile phones, scanning web pages of main mobile phone trademarks, and gathering words used from marketing personnel of a phone company. In this way, a total of 113 adjectives were obtained. Following this, using a group of four experts in mobile phone design, a reduced adjective set was established. The reason for this is that a larger set decreases the reliability due to fatigue during the semantic evaluation. Finally, eleven adjective image words are specified for describing the image of a mobile phone (Table 1).

Table 1: The Image/Impression adjectives

adj_1	New fashioned	adj_7	Attractiveness
adj_2	Sportive	adj_8	Harmoniousness
adj_3	Cheap	adj_9	Contentedness
adj_4	Simple	adj_{10}	Rigidity
adj_5	Elegance	adj_{11}	Granularity
adj_6	Luxuriousness		

Stage 2: Morphological analysis: Form elements were extracted from 73 mobile phones. As a result of morphological analysis and by referring to previous studies (Akay & Kurt, 2009; Lai et al., 2005) seven design parameters are determined from phones samples, together with their associated types (Table 2).

Table 2: Form elements

DP_1- Body shape	Parallel Line- PL	 Convex- RC	 Concave- CC
DP_2- Phone color	Plain- D	Complex- K	Patterned- DL
DP_3- Length			
DP_4- Width			
DP_5 - Thickness			
DP_6- Display dimension			
DP_7- Weight			

Stage 3: Evaluating product image of phones samples: 73 mobile phones were evaluated by 132 volunteer university students (76 male and 56 female, average age of 22). The existing literature (Dahan & Srinivasan, 2000) indicates that high-resolution photos can be used to elicit responses about products and yield results comparable to those using physical products. Therefore, semantic evaluation was performed using the pictures of phones. Images of mobile phone samples having equal sizes were presented to subjects in full-scale front and side views. Next, each subject was requested to evaluate each mobile phone presented in random order according to each adjective word on a 7-point semantic scale. There was no time limitation for the evaluation because assessment was carried out online in a web based system. Later on, aggregation on subjects' scores was realized by taking the mean value of each adjective word for each phone (Table 3).

Stage 4: Fuzzy rule extraction by Linguistic Summarization with Fuzzy Sets: A data set was formed by taking seven design parameters as the inputs in Table 4 and adjectives as in Table 3 outputs. The first and the second design parameters have categorical values, while other design parameters have continuous values. The relationships between design parameters and adjectives are represented by type-II fuzzy quantified sentences which provide richer knowledge comparing to “if-then” rules. FS used for labelling design parameters have been illustrated in Fig 2(a-f).

Table 3: Results of Semantic Differential Evaluation

Phone No.	Image/Impression adjectives						
	adj_1	adj_2	adj_3	…	adj_9	adj_{10}	adj_{11}
1	4.01	3.49	4.99	…	4.82	4.82	4.70
2	3.46	3.14	4.41	…	4.49	4.78	4.11
3	5.31	5.03	6.07	…	5.33	5.33	5.45
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
72	5.92	5.39	5.46	3.67	4.74	4.76	5.18
73	5.31	5.06	5.73	3.60	4.80	5.22	5.43

Table 4: Design parameters of mobile phones

Phone No.	INPUT						
	DP_1	DP_2	DP_3	DP_4	DP_5	DP_6	DP_7
1	PL	D	103	44	17	10.7	85
2	RC	K	106	47	18	7.98	76
3	PL	DL	88	42	23	12	104
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
71	RC	D	102	46	14	11	85
72	PL	DL	105	45	18	13	92
73	PL	K	109	53	20.9	16.3	120

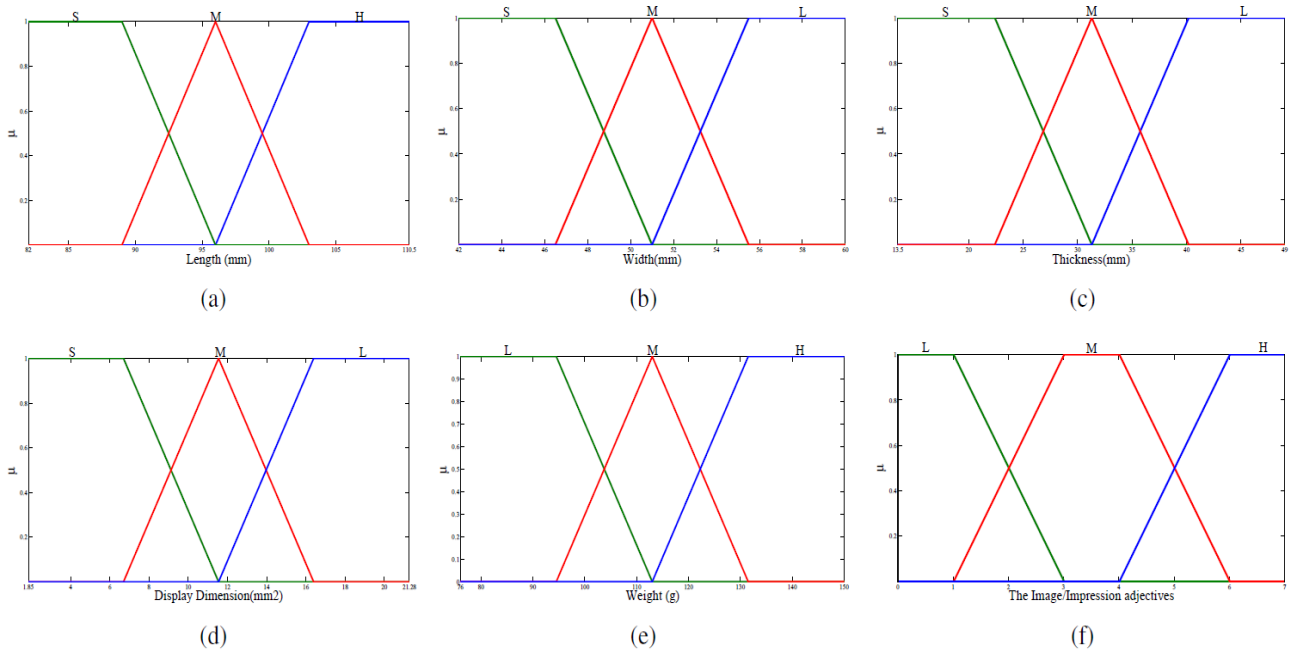

Figure 2: Fuzzy Sets for Design parameters and Adjectives (a) Length (S=Short, M=Middle, H=High), (b) Width (S=Small, M=Medium, L=Large), (c) Thickness (S=Small, M=Medium, L=Large), (d) Dimension (S=Small, M=Medium, L=Large), (e) Weight (L=Light, M=Medium, H=Heavy), (f) Adjectives (L=Low, M=Medium, H=High)

"All", "about half" and "most" have been considered as the linguistic quantifiers. The linguistic quantifiers are defined as follows:

$$Q_{All}(c) = \begin{cases} 1, & c = 1 \\ 0, & \text{otherwise} \end{cases} \tag{5}$$

$$Q_{About\ half}(c) = \begin{cases} 2c, & c < 0.5 \\ 2(1-c), & 1 \geq c \geq 0.5 \end{cases} \tag{6}$$

$$Q_{most}(c) = c \tag{7}$$

To generate, evaluate, and rank linguistic summaries, a MATLAB code has been developed. Totally, 1,621,917 linguistic summaries are evaluated by computing the degree of reliability. The top two linguistic summaries for each of the adjectives are shown in Table 5.

Table 5: The linguistic summaries obtained by computing the degree of reliability (T_r)

Adj	Rules	(T_r)	Adj	Rules	(T_r)
Adj_1	Most of the cell phones with high length, medium width, small thickness and light weight are medium new fashioned	0.893	Adj_6	Most of the cell phones with high length, medium width, small thickness and large display dimension are high luxuriousness	0.936
	Most of the cell phones with parallel line, high length, medium width, small thickness and large display dimension are high new fashioned	0.915	Adj_7	Most of the cell phones with high length, medium width, small thickness and light weight are medium attractiveness	0.857
Adj_2	All cell phones with high length, medium width, small thickness and medium display dimension are medium sportive	1		Most of the cell phones with high length, medium width, small thickness and large display dimension are high attractiveness	0.940
	Most of the cell phones with parallel line, high length, medium width, small thickness and large display dimension are high sportive	0.741	Adj_8	All cell phones with high length, medium width, small thickness and light weight are medium harmoniousness	0.916
Adj_3	Most of the cell phones with high length, medium width, small thickness and light weight are medium cheap	0.866		Most of the cell phones with high length, medium width, small thickness and large display dimension are high harmoniousness	0.893
	Most of the cell phones with high length, medium width, small thickness and large display dimension are high cheap	0.979	Adj_9	All cell phones with high length, medium width, small thickness and light weight are medium contentedness	0.915
Adj_4	All cell phones with high length, medium width, small thickness and light weight are medium simple	0.915		Most of the cell phones with medium length, medium width and small thickness are high contentedness	0.880
	About half of the cell phones with high length, medium width, small thickness and light weight are high simple	0.420	Adj_{10}	All cell phones with high length, medium width, small thickness and light weight are medium rigidity	0.916
Adj_5	All cell phones with high length, medium width, small thickness and medium display dimension are medium elegance	1		Most of the cell phones with high length, medium width, small thickness and large display dimension are high rigidity	0.943
	Most of the cell phones with middle length, medium width and small thickness are high elegance	0.807	Adj_{11}	All cell phones with high length, medium width, small thickness and light weight are medium granularity	0.915
Adj_6	Most of the cell phones with high length, medium width, small thickness and light weight are medium luxuriousness	0.915		Most of the cell phones with high length, medium width, small thickness and large display dimension are high granularity	0.946

4. CONCLUSION AND FUTURE WORKS

In this paper, we have illustrated the applicability of linguistic summarization with FS to affective design for mobile phones. In the proposed approach, first, eleven adjectives have been identified to describe the image of a mobile phone. Next, 73 mobile phones have been evaluated to extract form

elements, and seven design parameters have been determined from mobile phone samples. FS have been constructed for eleven adjective words and some of the design parameters. “Most”, “About half” and “All” has been considered as linguistic quantifier. The relationship between design parameters and adjective words has been presented by type-II fuzzy quantified sentences. The extracted simple and interpretable linguistic summaries have the characteristics of presenting novel ideas for successful product design. The significance of affective design is increasing more and more as the market becomes more competitive. Therefore, it is possible to use the proposed approach for other customer products such as home appliances, automobiles, furniture and so on.

ACKNOWLEDGMENTS

This research is supported by The Scientific and Technological Research Council of Turkey (TUBITAK: 112M030)

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Differences between Kansei evaluations caused by the awareness of differences in background information

Through the study about titles, Wa-Gashi and illustrations

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Abstract: This research is based on the outcome of a previous study on Wa-Gashi (a traditional Japanese sweet), its title explanation and evaluation. In this research, we focused on ‘Haru-no-yume’. From the result, in five-sixth patterns, we found that the evaluations varied as we gave more information. Furthermore, we conducted another experiment. Through an evaluation of six painting illustrations which were created by two students, we investigated on the relationship between the evaluation process and title. Similarly to the result of the previous study about Wa-Gashi, it was revealed that the evaluations were certainly affected by the titles in several cases. Moreover, we saw that the evaluations were not only affected by direct elements but also indirect elements, such as something with which it is associated with, or resemble.
Keywords: familiarity, knowledge, evaluation, background information, impression.

1. PREVIOUS STUDY

Since we evaluate things by processing them through our Kansei, there can be difference whether someone previously knew 'the meaning of name or concept' behind the things being evaluated. In the previous research, we focused on the Japanese traditional sweet ‘Wa-Gashi’ as stimuli because of their unique names (Mei in Japanese)' and the 'background story based on tradition' which serves to inspires more than their taste or beauty of shape. We set the objectives of this research to reveal the differences and the tendencies of the inspiring ability by the combination of Wa-Gashi and its title in the presentation process for Kansei evaluation.

1.1. Result of previous study

The shapes of Wa-Gashi are often associated with their name. Then, we considered the shape characteristics “realistic – abstract” as a shape factor. Secondly, we observed the way of titling as ‘directly following the shape’ and ‘indirectly named with a rich background’. Therefore, we also considered “direct – indirect” as a naming factor. Moreover, we observed that the Wa-Gashi under the category of ‘abstract and indirect’, were difficult to understand in relation to their meaning and background. Hence, we selected Wa-Gashi with middle realistic and indirect naming. As a result, we could select three kinds of typical Wa-Gashi: ‘Himawari’, ‘Haru-no-yume’ and ‘Mizu-yamabuki’, as appropriate varieties. We showed the subjects three types of information about Wa-Gashi, such as the title, the shape, and explanation containing the background story. There were six order patterns of showing information (Table 1). At each step, subjects evaluated with SD questionnaire.

Table 1: The order patterns of showing information

	Pattern 1	**Pattern 2**	**Pattern 3**	**Pattern 4**	**Pattern 5**	**Pattern 6**
The first	Wa-Gashi	Wa-Gashi	Title	Title	Explanation	Explanation
The second	Wa-Gashi + Title	Wa-Gashi + Explanation	Title + Wa-Gashi	Title + Explanation	Explanation + Wa-Gashi	Explanation + Title
The third	Wa-Gashi + Title + Explanation	Wa-Gashi + Explanation + Title	Wa-Gashi + Wa-Gashi + Explanation	Wa-Gashi + Explanation + Wa-Gashi	Explanation + Wa-Gashi + Title	Explanation + Title + Wa-Gashi

In the result, we found three commonly affected evaluation adjective sets throughout three Wa-Gashi samples: cool, premium and beautiful. These adjective sets may work as major impression for Wa-Gashi. Also, for the effectiveness of evoking good impression, there we found correlation between the reality of shape and the order of showing information. For the middle abstract shaped Wa-Gashi, the most effective order was 'show Wa-Gashi -> show explanation -> show title', and 'show title -> show explanation -> show Wa-Gashi' for the realistic shaped Wa-Gashi. For the very abstract shaped Wa-Gashi, the order of showing story first scored best. This result was totally different from other case. Also, in the ‘very abstract’ case, the evaluation for ‘like’ tends to correlate with that of ‘difficulty’.

From the annotation made during evaluation, we could estimate the different imagining process according to the realistic characters of shape and shape-name association.

1.2. Additional Consideration

Additionally, we focused on ‘Haru-no-yume’ and on the evaluation of ‘like-dislike’ in this research. We focused on ‘Haru-no-yume’ because its shape is semi-realistic and explanation was effective in changing evaluation. According to the comments from the subjects, ‘Himawari’, the most realistic one, was too easy to understand, and ‘Mizu-yamabuki’ was too difficult to understand. The detail about ‘Haru-no-yume’ is below.

- Photograph: Figure 1.
- Title: ‘Haru-no-yume’. ‘Haru’ means a spring, and ‘Yume’ means a dream. Altogether, it may mean ‘Dream in the spring’.
- Explanation: ‘Haru-no-yume’ is a ‘joyo bun’, and represents a white butterfly. This is named after the Chinese historical story ‘Kocho-no-yume’. In the survey, 6% of the subjects answered that this Wa-Gashi represents a ‘butterfly’, and 30% has known the story of ‘Kocho-no-yume’, Chinese historical story.

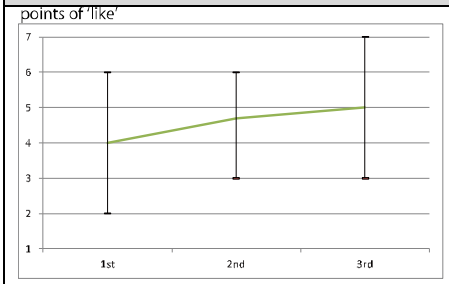


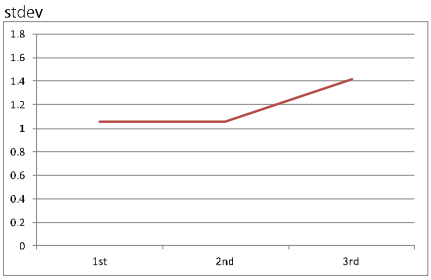
Figure 1: ‘Haru-no-yume’

As a result of previous study, pattern 1, 2, and 4 increased on the points of ‘like’ higher than the first step. On the other hand, pattern 3, 5, 6 decreased on the points.

Table 2: The results of pattern 1, 2 and 4

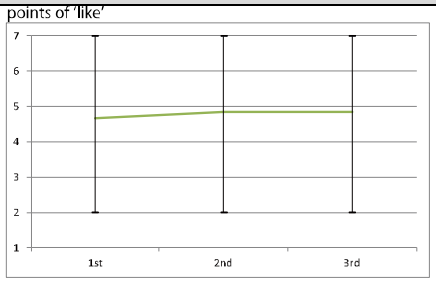
Pattern 1

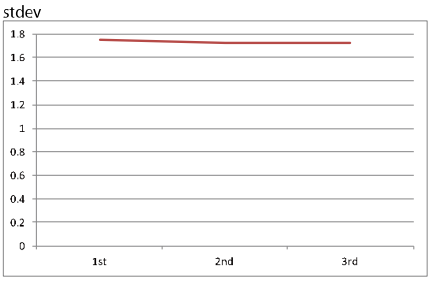




	maximum	minimum	average	stdev
1st	6	2	4	1.054093
2nd	6	3	4.7	1.05935
3rd	7	3	5	1.414214

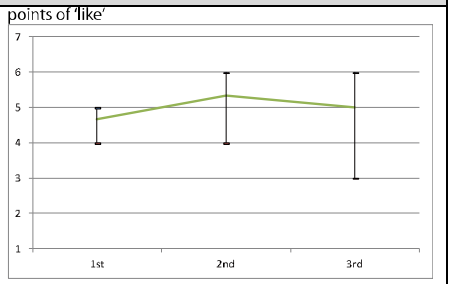
Pattern 2

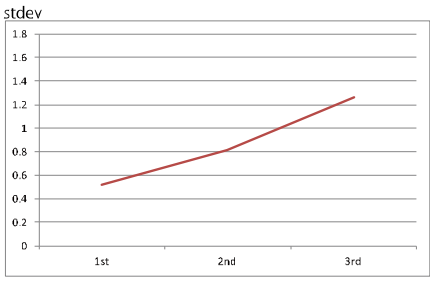




	maximum	minimum	average	stdev
1st	7	2	4.666667	1.75119
2nd	7	2	4.833333	1.722401
3rd	7	2	4.833333	1.722401

Pattern 4



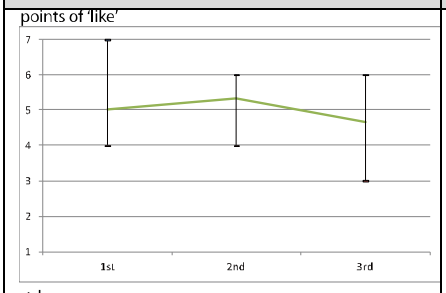


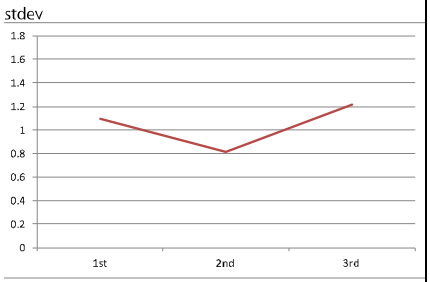
	maximum	minimum	average	stdev
1st	5	4	4.666667	0.516398
2nd	6	4	5.333333	0.816497
3rd	6	3	5	1.264911

In the pattern 1 and 3, the points, which were in the third step, were more dispersed than the first step. In the pattern 2, the points were consistently dispersed. The individual point was virtually changeless. Therefore, showing information like pattern 2, the order of 'show Wa-Gashi -> show explanation -> show title', was not effective on changing evaluations.

Table 3: The results of pattern 3, 5 and 6

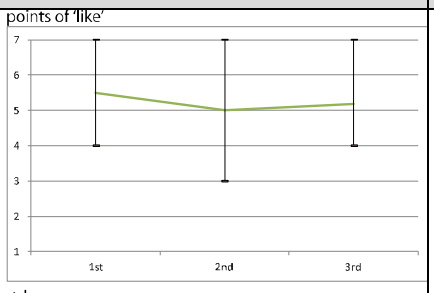
Pattern 3

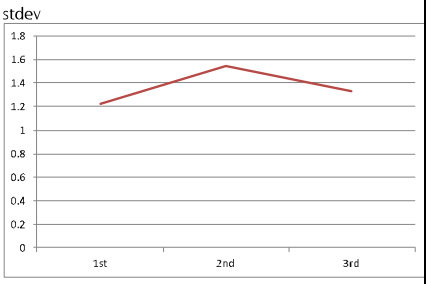




	maximum	minimum	average	stdev
1st	7	4	5	1.095445
2nd	6	4	5.333333	0.816497
3rd	6	3	4.666667	1.21106

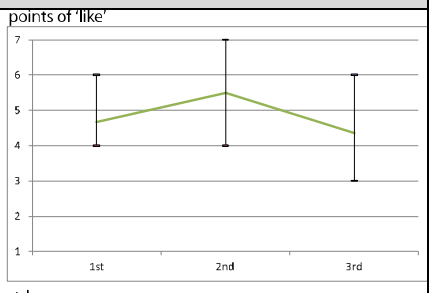
Pattern 5

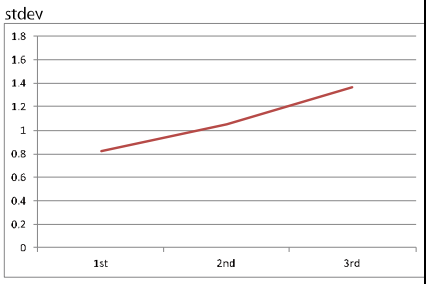




	maximum	minimum	average	stdev
1st	7	4	5.5	1.224745
2nd	7	3	5	1.549193
3rd	7	4	5.166667	1.32916

Pattern 6





	maximum	minimum	average	stdev
1st	6	4	4.666667	0.816497
2nd	7	4	5.5	1.048809
3rd	6	3	4.333333	1.36626

Showing explanation first is common to pattern 5 and 6. We considered that 'Haru-no-yume' should not be revealed by its story first. In both pattern 3 and 4, we show the title first. However, pattern 3 effectively decreased the points, on the other hand, pattern 4 widely increased. Therefore, we considered that the timing of 'understanding' was important. In other words, in pattern 3, subjects were satisfied with the information when they saw Wa-Gashi in the second step, and explanation was too much.

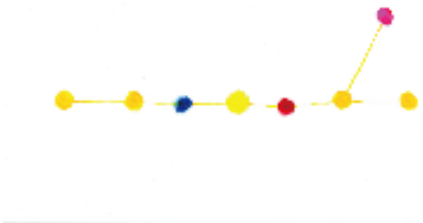
However, almost all Wa-Gashi are intentionally designed to enjoy thinking about a title of Wa-Gashi, form of Wa-Gashi, the season, historical events, and so on. In the next experiment, we investigated the relationship of another object and its title.

2. EVALUATION EXPERIMENT OF ILLUSTRATIONS

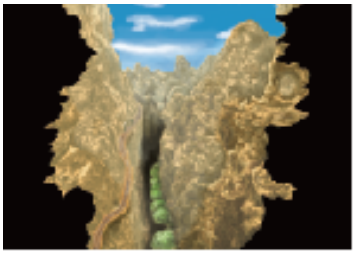
On November 2013, two students held an exhibition of their art works at the University of Tsukuba Festival. Then, some visitors look on thoughtfully, or commented on the meaning of exhibit title and painting. Through the evaluations of illustrations and titles, we investigated on the relationship between the evaluation process and title.

2.1. Evaluation experiment

In an evaluation experiment, we randomly selected six illustrations from the art works of the two students. (Figure 2)



my rule (2001/10/22~2013/10/23)



Canyon



パン屋：bakery



崖わたり

*Gake-watari: crossing precipice



←18:50→



朝の通学風景

*scene of attending school in the morning

Figure 2: Six illustrations

We interviewed six Japanese subjects using an evaluation-grid method. The subjects consisted of four females and two subjects were males, and all had never seen the illustrations before. We instructed the subjects to see the illustrations in the orientation at which titles can be read, and to tilt the composition, so as to ensure they read the title properly. (Figure 3)

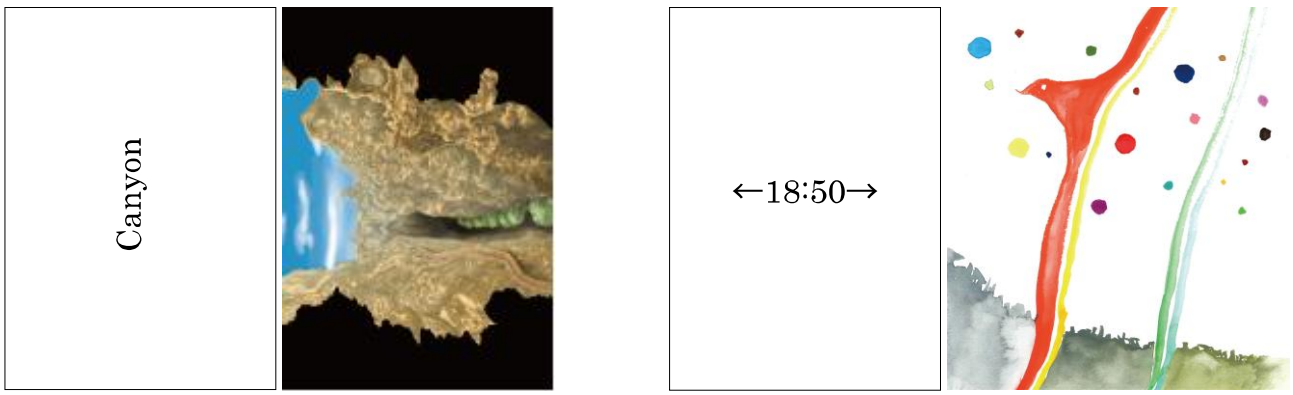


Figure 3: Samples of title and illustration

Firstly, subjects ranked six illustrations. In the second place, we asked subjects the reason and more detailed elements as possible by using laddering method. There are upper construct, which shows conceptual element, and lower construct, which shows concrete element.

The result of this study is presented in the Figure 4. The left part shows the upper construct, and the right part shows lower.

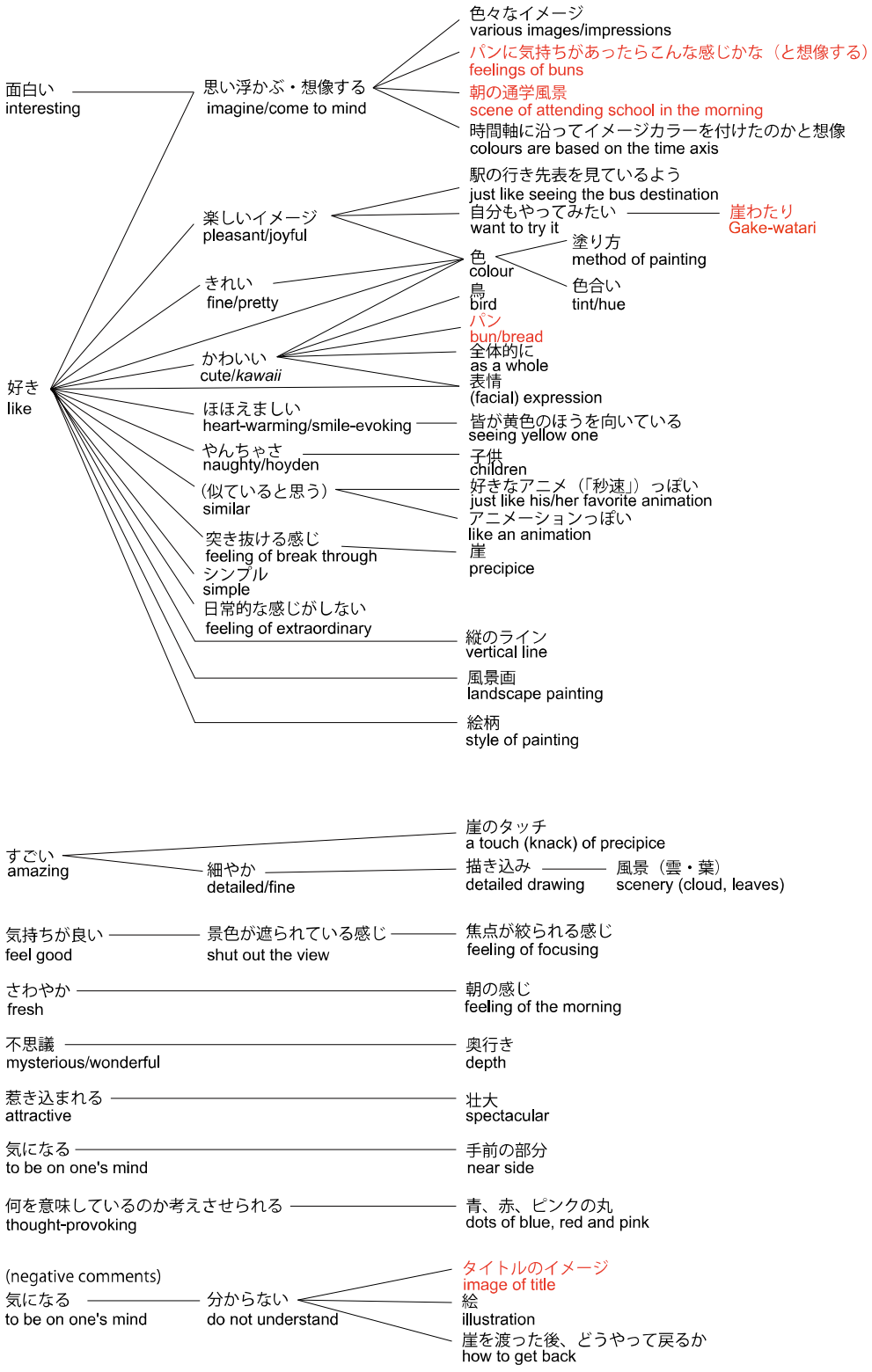


Figure 4: Result of e-grid interview

2.2. Discussion

The elements, which are shown in red, are concerned with titles or the title itself. Some subjects answered that they did not understand the concept of title, and so as a result did not like the illustration. One example of such comment is ‘too difficult and dislike’. On the other hand, subjects who imagined something, pleasant or cute image, answered that they like the illustration, or it is interesting. After the experiment, we asked subjects a question about ‘buns’. Then subjects answered that they did not think the characters are buns without the title: ‘bakery’. Moreover, we confirmed that evaluations are affected by indirect elements, something with which they were associated with, or resemble.

2.3. Conclusion

Following the result of this study, similar to that of the previous study about Wa-Gashi, we revealed that evaluations are certainly affected by titles in the several cases. Through the interview, we confirmed some examples of evaluation process. Moreover, we confirmed that evaluations are affected by various elements, not only direct elements, such as colors and shapes, but also indirect elements, something relating to association or resemblance. We hope to utilize this result in our next study.

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Text Data Mining of English Books on Tourism

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Abstract: Nowadays, approximately sixteen million Japanese travel abroad, and six million foreigners come to Japan for sightseeing. It can be said that it is just the time of sightseeing right now. Therefore, the knowledge of tourism has become more and more important, and reading materials in English that can be said to be a world common language has been indispensable. If we have beforehand enough knowledge of the features of English in this field, reading of the texts will become easier. In this paper, we investigated several English books on tourism, comparing with journalism in terms of metrical linguistics. In short, frequency characteristics of character- and word-appearance were investigated using a program written in C++. These characteristics were approximated by an exponential function. Furthermore, we calculated the percentage of Japanese junior high school required vocabulary and American basic vocabulary to obtain the difficulty-level as well as the *K*-characteristic of each material. As a result, it was clearly shown that English materials for tourism have a similar tendency to literary writings in the characteristics of character-appearance. Besides, the values of the *K*-characteristic for the materials on tourism are high, and the books with older publication and with higher specialty are more difficult than journalism.

Keywords: English style analysis, Metrical linguistics, Statistical analysis, Text data mining, Tourism.

1. INTRODUCTION

Nowadays, approximately sixteen million Japanese travel abroad, and six million foreigners come to Japan for sightseeing. If including the number of domestic tourists, the total number of tourists will be several times higher. However, in spite of the tourism boom, there's a shortage of experts and researchers in tourism industry. Then, the upbringing of skilled professionals in the industry has been strongly called for (Teikyo Univ., 2006).

The goal of “tourism” is to research characteristics of current status of tourism and its impact to the modern society. Studying tourism means to gain deep understanding of changes and systems in society and of business administration that could further develop the tourism industry in the future (Teikyo Univ., 2006).

In order to study tourism, reading materials in English that can be said to be a world common language has been indispensable. If we have beforehand enough knowledge of the features of English in this field, reading of the texts will become easier.

In this paper, we investigated several English books on tourism, comparing with journalism in terms of metrical linguistics. As a result, it was clearly shown that English materials for tourism have some interesting characteristics about character- and word-appearance.

2. METHOD OF ANALYSIS AND MATERIALS

The materials analyzed here are as follows:

Material 1: Douglas G. Pearce, *Tourism Today: A Geographical Analysis*, 2nd ed., 1995

Material 2: Les Lumsdon, *Tourism Marketing*, 1997

Material 3: Dean MacCannell, *The Tourist: A New Theory of the Leisure Class*, 1999

Material 4: Phillip Kotler, John T. Bowen and James C. Makens, *Marketing for Hospitality and Tourism*, 4th ed., 2005

We examined the first three chapters of each material. For comparison, we analyzed the American popular news magazines “TIME” and “Newsweek” published on January 9 in 2006. Because almost no changes are seen in the frequency characteristics of character- and word-appearance for theses magazines for about 60 years, we have used them as a standard of comparison in various ways (Ban *et al.*, 2002). Deleting pictures, headlines, etc., we used only the texts.

The computer program for this analysis is composed of C++. Besides the characteristics of character- and word-appearance for each piece of material, various information such as the “number of sentences,” the “number of paragraphs,” the “mean word length,” the “number of words per sentence,” etc. can be extracted by this program (Ban *et al.*, 2004a) (Ban *et al.*, 2005a).

3. RESULTS

3.1. Characteristics of Character-appearance

First, the most frequently used characters in each material and their frequency were derived. The frequencies of the 50 most frequently used characters including the blanks, capitals, small letters, and punctuations were plotted on a descending scale. The vertical shaft shows the degree of the frequency and the horizontal shaft shows the order of character-appearance. The vertical shaft is scaled with a logarithm. This characteristic curve was approximated by the following exponential function:

$$y = c * \exp(-bx) \quad (1)$$

From this function, we are able to derive coefficients c and b (Ban *et al.*, 2005).

The distribution of coefficients c and b extracted from each material is shown in Figure 1.

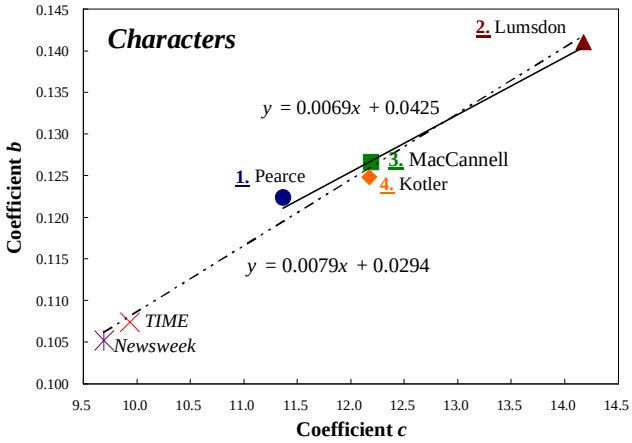

Figure 1: Dispersions of coefficients *c* and *b* for character-appearance.

There is a linear relationship between *c* and *b* for the six materials. These values are approximated by [$y = 0.0079x + 0.0291$]. The values of coefficients *c* and *b* for Materials 1 to 4 are high: the value of *c* ranges from 11.336 (Material 1) to 14.175 (Material 2), and that of *b* is 0.1224 (Material 1) to 0.1410 (Material 2). On the other hand, in the case of the news magazines, *c* is 9.693 and 9.934, and *b* is 0.1052 and 0.1074, both of which are lower than those for the four materials for tourism. Previously, we analyzed various English writings and reported that there is a positive correlation between the coefficients *c* and *b*, and that the more journalistic the material is, the lower the values of *c* and *b* are, and the more literary, the higher the values of *c* and *b* (Ban *et al.*, 2001). Thus, the values of the coefficients for the books on tourism are higher than those for the news magazines, that is, journalism, which means the materials for tourism have a similar tendency to literary writings, as we have expected.

3.2. Characteristics of Word-appearance

Next, the most frequently used words were derived. Just as in the case of characters, the frequencies of the 50 most frequently used words in each material were plotted. Each characteristic curve was approximated by the same exponential function. The distribution of *c* and *b* is shown in Figure 2.

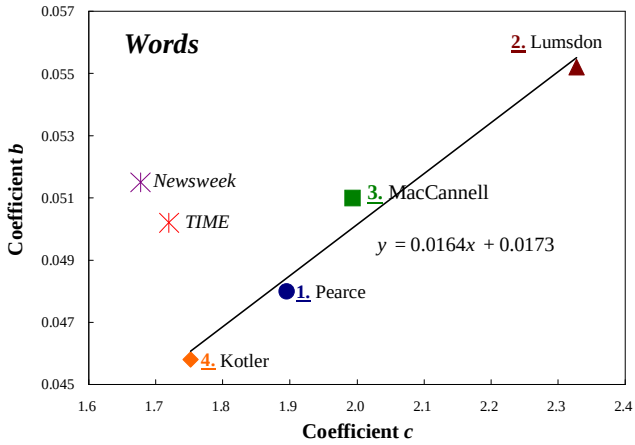

Figure 2: Dispersions of coefficients *c* and *b* for word-appearance.

As of the coefficient *c*, the values for Materials 1 to 4 are high: they range form 1.752 (Material 4) to 2.327 (Material 2), compared with those for news magazines, that is, 1.677 (*Newsweek*) and 1.720 (*TIME*). In the case of word-appearance, we can see a positive correlation between coefficients *c* and *b* for the four materials for tourism, and the values are approximated by [$y = 0.0164x + 0.0173$]. On the other hand, the values for news magazines are relatively similar and we might be able to regard them as a cluster.

As a method of featuring words used in a writing, a statistician named Udny Yule suggested an index called the "*K*-characteristic" in 1944 (Yule, 1944). This can express the richness of vocabulary in writings by measuring the probability of any randomly selected pair of words being identical. He tried to identify the author of *The Imitation of Christ* using this index. This *K*-characteristic is defined as follows:

$$K = 10^4 \left(S_2 / S_1^2 - 1 / S_1 \right) \tag{2}$$

where if there are f_i words used x_i times in a writing, $S_1 = \Sigma x_i f_i$, $S_2 = \Sigma x_i^2 f_i$.

We examined the *K*-characteristic for each material. The results are shown in Figure 3.

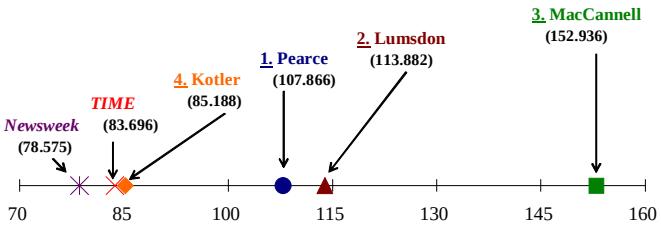

Figure 3: *K*-characteristic for each material.

According to the figure, the values for the four materials for tourism are high: they range form 85.188 (Material 4) to 152.936 (Material 3), compared with those for news magazines, that is, 78.575 (*Newsweek*) and 83.696 (*TIME*). The values for the books on tourism have a wide range as much as about 67.7, and Material 4, which is the lowest among the four tourism books, is almost equal to *TIME* magazine.

Besides, the value of *K*-characteristic gradually increases in the order of *Newsweek*, *TIME*, Material 4 and Material 1. This order corresponds with the coefficient *c* for word-appearance, as well as the intervals of the values in both cases are very similar. In addition, the characteristic of the values of the books on tourism being higher than journalism is the same as the cases of the coefficients *c* and *b* for the frequency characteristics of character-appearance. We would like to investigate the relationship between *K*-characteristic and the coefficients for word- and character-appearance in the future.

3.3. Degree of Difficulty

In order to show how difficult the materials for readers are, we derived the degree of difficulty for each material through the variety of words and their frequency (Ban *et al.*, 2003). That is, we came up with two parameters to measure difficulty; one is for word-type or word-sort (D_{ws}), and the other is for the frequency or the number of words (D_{wn}). The equation for each parameter is as follows:

$$D_{ws} = \left(1 - n_{rs} / n_s \right) \tag{3}$$

$$D_{wn} = \{ 1 - (1 / n_t \ * \ \Sigma n(i)) \} \tag{4}$$

where n_t means the total number of words, n_s means the total number of word-sort, n_{rs} means the required English vocabulary in Japanese junior high schools or American basic vocabulary by *The American Heritage Picture Dictionary* (American Heritage Dictionaries, Houghton Mifflin, 2003), and $n(i)$ means the respective number of each required or basic word. Thus, we can calculate how many required or basic words are not contained in each piece of material in terms of word-sort and frequency.

Thus, we calculated the values of both D_{ws} and D_{wn} to show how difficult the materials are for readers, and to show at which level of English the materials are, compared with other materials. Then, in order to make the judgments of difficulty easier for the general public, we derived one difficulty parameter from D_{ws} and D_{wn} using the following principal component analysis:

$$z = a_1 * D_{ws} + a_2 * D_{wn} \quad (5)$$

where a_1 and a_2 are the weights used to combine D_{ws} and D_{wn}. Using the variance-covariance matrix, the 1st principal component z was extracted: [z = 0.2301 * D_{ws} + 0.9732 * D_{wn}] for the required vocabulary, and [z = 0.1129 * D_{ws} + 0.9936 * D_{wn}] for the basic vocabulary, from which we calculated the principal component scores. The results are shown in Figure 4.

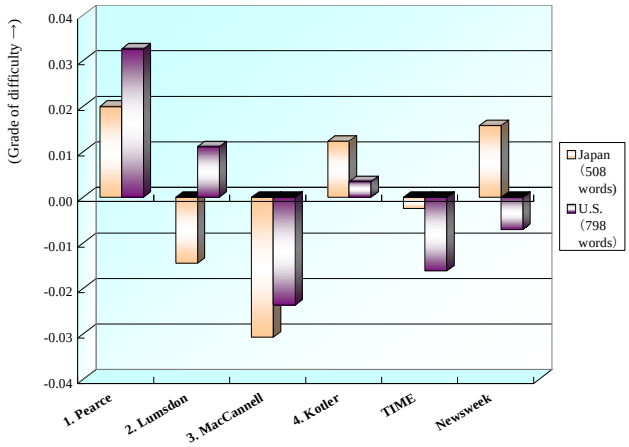

Figure 4: Principal component scores of difficulty shown in one-dimension.

According to Figure 4, in the case of the required vocabulary, Material 1 published in 1995, which is the oldest among the six materials, is the most difficult. The difficulty level decreases in the order of Material 2 and Material 3, as the publication years of the materials are more updated. However, the degree of difficulty of Material 4, whose publication year is the newest among the four tourism materials, is high next to Material 1. It seems that this is because the specialty of Material 4 seems to be considerably high. Besides, *Newsweek* is also difficult as much as Material 1 and Material 4.

On the other hand, in the case of the basic vocabulary, the degree of difficulty of Material 1 is rather high, and Material 2 is a little more difficult than Material 4. Because the difficulty of *Newsweek* is calculated as rather lower in this case, we can judge that the three materials for tourism except Material 3 are more difficult than *TIME* and *Newsweek* magazines.

In addition, we can see that Material 1, 2, and 3 are more difficult in the case of the basic vocabulary than in the required vocabulary.

3.4. Other Characteristics

Other metrical characteristics of each material were compared. The results of the “average of

word length," the "number of words per sentence," etc. are shown together in Table 1. Although we counted the "frequency of prepositions," the "frequency of relatives," etc., some of the words counted might be used as other parts of speech because we didn't check the meaning of each word.

Table 1: Metrical data for each material.

	1. Pearce	2. Lumsdon	3. MacCannell	4. Kotler	*TIME* 2006	*Newsweek* 2006
Total num. of characters	135,628	96,381	133,220	207,028	141,650	155,444
Total num. of character-type	80	71	79	80	82	80
Total num. of words	21,453	15,098	21,705	33,038	23,810	25,792
Total num. of word-type	3,261	2,700	4,562	4,965	5,889	6,342
Total num. of sentences	779	740	861	1,849	1,033	1,281
Total num. of pararaphs	145	133	137	397	218	245
Mean word length	6.322	6.384	6.138	6.266	5.949	6.027
Words/sentence	27.539	20.403	25.209	17.868	23.049	20.134
Sentences/paragraph	5.372	5.564	6.285	4.657	4.739	5.229
Commas/sentence	1.198	0.935	1.702	0.917	1.302	1.171
Coefficient *c* for character-appearance	11.3660	14.1750	12.1900	12.1730	9.9337	9.6932
Coefficient *b* for character-appearance	0.1224	0.1410	0.1266	0.1248	0.1074	0.1052
Coefficient *c* for word-appearance	1.8948	2.3272	1.9929	1.7515	1.7195	1.6770
Coefficient *b* for word-appearance	0.0480	0.0552	0.0510	0.0458	0.0502	0.0515
Difficulty (prin. comp. score) [Japan]	0.0199	-0.0146	-0.0307	0.0122	-0.0025	0.0157
Difficulty (prin. comp. score) [US]	0.0325	0.0110	-0.0237	0.0035	-0.0162	-0.0071

3.4.1. Mean Word Length

As for the "mean word length" for the four materials for tourism, it varies from 6.138 letters for Material 3 to 6.384 letters for Material 2. They are a little longer than *TIME* (5.949 letters) and *Newsweek* (6.027 letters). It seems that this is because the materials for tourism contain many long-length technical terms for tourism such as ATTRACTION, DESTINATION, RESTAURANT, and TRAVELLER.

3.4.2. Number of Words per Sentence

The "number of words per sentence" for Material 1 is 27.539 words, which is the most of the six materials, and approximately 10 words more than Material 4 (17.868 words), which is the fewest. From this point of view, as well as the result of the difficulty derived through the variety of words and their frequency, Material 1 seems to be rather difficult to read. In the case of other three materials for tourism, it is 20.403 (Material 2) to 25.209 (Material 3) words, which are almost equal to *Newsweek* (20.134 words) and *TIME* (23.049 words).

3.4.3. Number of Sentences per Paragraph

The "number of sentences per paragraph" for Materials 1, 2, and 3 is from 5.372 (Material 1) to 6.285 sentences (Material 3), which is a little more than the news magazines (4.739 and 5.229 sentences).

3.4.4. Frequency of Relatives

The "frequency of relatives" for the four tourism materials is 1.944% (Material 1) to 2.710% (Material 2), which is a little fewer than the case of *TIME* magazine (2.944%). Therefore, we can assume that as the materials for tourism tend to contain fewer complex sentences than *TIME* magazine, they are easy to read than *TIME* from this point of view.

3.4.5. Frequency of Auxiliaries

There are two kinds of auxiliaries in a broad sense. One expresses the tense and voice, such as *BE* which makes up the progressive form and the passive form, the perfect tense *HAVE*, and *DO* in interrogative sentences or negative sentences. The other is a modal auxiliary, such as *WILL* or *CAN* which expresses the mood or attitude of the speaker (Ban *et al.*, 2004b). In this

study, we targeted only modal auxiliaries. As a result, while the “frequency of auxiliaries” of Material 4 (1.607%) is highest among the six materials, other three tourism materials contain 0.747% (Material 3) to 0.927% (Material 2) auxiliaries, which are fewer than *TIME* magazine (1.134%). Therefore, it might be said that while the writers of Material 4 and *TIME* tend to communicate their subtle thoughts and feelings with auxiliary verbs, the style of the materials for tourism can be called more assertive.

3.5. Word-length Distribution

We also examined word-length distribution for each material. The results are shown in Figure 5.

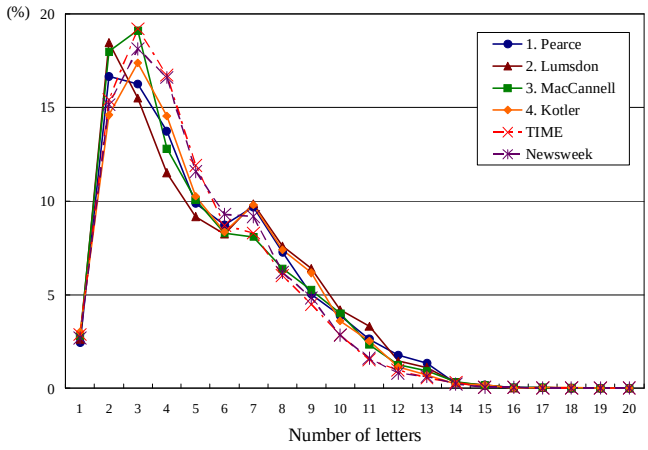

Figure 5: Word-length distribution for each material.

The vertical shaft shows the degree of frequency with the word length as a variable. As for the four materials for tourism, the frequency of 2- or 3-letter words is the highest: the frequency of 2-letter words ranges from 14.595% (Material 4) to 18.479% (Material 2), and that of 3-letter is 15.499% (Material 2) to 19.115% (Material 3). Although the frequency decreases until the 6-letter words, the frequency of 7-letter words such as TOURISM, TOURIST, and TRAFFIC is 0.951% (Material 1) to 1.636% (Material 2) higher than that of 6-letter words in the three tourism materials except Material 3.

Besides, the news magazines have higher frequency than the tourism books in 4-, 5-, and 6-letter words, and the degree of decrease for the news magazines gets a little higher than the tourism materials after the 8-letter words.

3.6. Correlation of the Number of Words with that of Characters, Sentences, and Paragraphs

We checked the correlation of the total number of words with the total number of characters, sentences, and paragraphs for the four materials for tourism. The results are shown in Figure 6. While the principal shaft shows the total number of characters, the secondary vertical shaft shows the total number of sentences and paragraphs with the total number of words as a variable.

According to the figure, we can see a strong positive correlation between the total number of words and that of characters. We can also see a positive correlation between the total number of words and that of sentences, as well as the total number of words, and that of paragraphs, although each correlation is a little weaker than in the case of the characters. For values of four materials, approximations shown in the Figure 6 were provided. Therefore, if we know the total

number of words for a certain material for tourism, we can estimate the total number of characters using the function [$y = 6.1934x + 1710.2$], the total number of sentences by [$y = 0.0666x - 463.75$], and the total number of paragraphs by [$y = 0.016x - 162.36$].

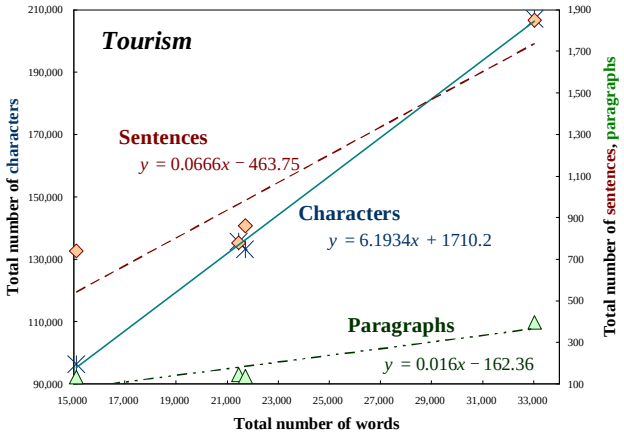

Figure 6: Word-length distribution for each material.

4. CONCLUSIONS

We investigated some characteristics of character- and word-appearance of some famous English books on tourism, comparing these with *TIME* and *Newsweek* magazines. In this analysis, we used an approximate equation of an exponential function to extract the characteristics of each material using coefficients *c* and *b* of the equation. Moreover, we calculated the percentage of Japanese junior high school required vocabulary and American basic vocabulary to obtain the difficulty-level as well as the *K*-characteristic. As a result, it was clearly shown that English materials for tourism have the same tendency as English literature in the character-appearance. The values of the *K*-characteristic for the materials on tourism are high, compared with the journalism. Moreover, the books with older publication and with higher specialty are more difficult than journalism.

In the future, we plan to apply these results to education. For example, we would like to measure the effectiveness of teaching the 100 most frequently used words in a writing beforehand.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Trial-manufactured of paper like washi by reusing wood and plant waste

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Abstract: To make paper from non-wood fiber is important because of protection of forest resources environmentally. Moreover, if paper can be made from familiar plants, it will be useful for both effective utilization of resource and environmental education. In this research, corn shuck and leaf, and half-split chopsticks were soaked into the bleaching agent on market in Japan, with changing concentration of the agent and soaking time, and pulp was manufactured. Relations between the quantity of the agent and the soaking time, or pulp yield were examined. For corn shuck and leaf, the yield decreased linearly with increase of the agent or soaking time, in general. But, for the case of applying much shuck, the relation showed maximum curve. If the agent was very less, paper had yellowish. If the agent was increased, the paper became whiter, but orange tint slightly. Compared with papers on market, created papers had smaller apparent specific gravity and air resistance, and were thicker. The sensory test was conducted using both of created papers and papers on market. Homogeneity impression was associated with many impression factors. Papers which were judged as homogeneous had impressions of high intensity, high artificial degree and not-warmth. Papers with heterogeneous or rough impression brought high ventilation impression for subjects. Individual differences of impression points relevant to visual and tactile were apparently smaller than those which might be regarded as physical properties, in general.

Keywords: Paper-making, Half-split chopsticks, Corn shuck and leaf, Japanese paper, Sensory test.

1. INTRODUCTION

For use as raw material of bioethanol, demand of corn is growing. Corn shuck, leaf and stem are provided in large quantities after crop of corn. The effective utilization of them has big significance.

Production of paper is considered as an example of the effective utilization. Although such researches are not enough, paper may be made from corn waste. Almost of paper is made from wood nowadays. Since non-wood fiber has low quality and is difficult to obtain stably, paper is rarely made from non-wood fiber industrially. For the purpose of effective utilization of familiar plants, papers made from bamboo grass and butterbur are sold only a little quantity as local products, in Japan. The production of industrial paper which used bamboo as raw materials has been carried out for an effective utilization of local resources (Kawata, 2009).

In Japan, paper-making is often conducted in school education for environment. For example, paper was produced experimentally by using shredder wastepaper, used milk pack and half-split chopsticks, for the purpose of learning about reuse of resources and reduction of waste through paper-making. In addition, paper-making from kenaf (Masuo, Tsuchiya & Shimizu, 1990), butterbur (Takada, Han, Nakata & Nakamura, 2007), stem/ leaf of potato and bark of Japanese cypress had also been attempted. In many of these studies, raw materials were boiled with sodium hydroxide and were pulped. In several studies, particular bleaching agent on market was used for pulpifcation, because it was easy to obtain. Components of the bleaching agent are sodium hydroxide and sodium hypochlorite. However, in any studies, relations of pulp production conditions and pulp yield, or paper quality were not examined enough.

To produce pulp from plant and wood waste, corn shuck/ corn leaf/ half-split chopsticks was soaked in the bleaching agent under various conditions in this study. Then, relationships between the yield and pulping conditions were examined. For papers created and those on market, compression properties, air resistance and hue were measured. The sensory test of papers was also made. Relationships between each impression factor were examined.

2. EXPERIMENT

2.1. Pulp production

By soaking raw materials into the mixed-solution of the bleaching agent and water under room temperature, we examined whether these became pulp. Dry shuck of corn/ dry leaf of corn/ half-split chopsticks (White birch) in air-dry condition was used for the material. The bleaching agent concentration in the mixed-solution and time of soaking in the solution were changed. In the exploratory experiment, high concentration of the agent resulted in high pulping efficiency if quantity of the agent was constant. But compared with the influence of quantity of the agent, influence of the agent concentration was small. Pulping conditions in this research are shown in Table 1. Raw materials were soaked in the solution for the time which was shown in Table 1. Then, those were ground by mixer for 20 seconds. Pulp was obtained by filtering suspension with the net for catching goldfishes. Pulp was dried at 70 degrees Centigrade for 6 hours, and weight of pulp in oven-dry condition was measured. In each condition, experiments were conducted three times. Yield was obtained by dividing weight of pulp in oven-dry condition by weight of raw material in oven-dry condition.

2.2. Paper-making

The silk screen (120 meshes) was pasted on the bottom of the wooden frame for paper-making. The internal dimensions of the frame were 10 cm by 15 cm. Air-dried pulp of 1.2 g was used so that basis weight of paper would be set to 80 g/m^2. The pulp were soaked in water for 12 hours or more, and was ground in mixer for 10 seconds to obtain suspension. Suspension was poured into

the frame, and pulp on the silk screen was tried to be uniform distribution. Finally, the layer of pulp was not compressed and was dried at room temperature.

2.3. Measurement of the physical properties of papers

The compression properties and air resistance of 23 papers (13 created papers and 10 commercial papers) were measured. Created papers with large deformation or big variation in thickness were not measured properties. Compression properties were measured with three places for each paper. Air resistance was measured at neighborhood of four corner of each paper. Compression properties were measured by KES-FB3 testing apparatuses (KATO TEKKO CO., LTD.). Load area and maximum stress were 2 cm^2 and 50 gf/cm^2 respectively. Immediately after reaching the maximum stress, load was removed. Those experimental measurements were carried out in the laboratory controlled at the standard condition of 20±2 degrees Centigrade and 65±5 %R.H.. Thicknesses were measured at compression stresses of 0.5 gf/cm^2 and 50 gf/cm^2, and were expressed as T_0 and T_{50} respectively. Total work load (per unit area) until reaching maximum stress (W) was measured. Total work load (per unit area) of process removing load was also measured. The hysteresis (H) was evaluated by the percentage of the latter divided by the former. The reflectance to the light of 400 to 700 nm was measured. At five places, which were the central part and neighborhood of four corners, reflectance of each paper was measured. Reflectance was measured about both sides.

Table 1: Pulping conditions

	Weight (g)	Bleaching agent and water (ml)	Soaking time
Half-split chopsticks	about 12.6 (3 pairs)	150 and 0	7 days
		200 and 0	7 days
		250 and 0	7, 23 days
Corn shuck	5	75 and 225	24 hrs
		100 and 200	24 hrs
		125 and 175	12, 18, 24 hrs
		150 and 150	24 hrs
		200 and 100	12, 18, 24 hrs
Corn leaf	3, 5	100 and 300	24 hrs
		120 and 280	24 hrs
		150 and 250	24 hrs
		180 and 220	24 hrs

Table 2: Papers used for the sensory test

Created paper	Production conditions of pulp		
	Weight (g)	Bleaching agent and water (ml)	Soaking time
Corn shuck	5	125 and 175	18 hrs
Corn shuck	5	200 and 100	12 hrs
Corn leaf	3	180 and 220	24 hrs
Half-split chopsticks	about 12.6	250 and 0	7 days
Commercial paper			
Recycled paper (acid-free paper)			
"Minogami" (A kind of Japanese paper, which made from mulberry)			
Unbleached mulberry paper			

2.4. The sensory test of sample papers

The sensory test was carried out by SD-method in January-February 2014. The questionnaire consisted of 14 impression items: uniformity/ softness/ whiteness/ weight/ yellowness/ warmness/ porosity/ roughness/ degree of shiny/ weakness/ degree of ventilation/ thickness/ newness/ artificial level. Subjects judged each paper's impression by visual and tactile, and selected corresponding grid from 7 grids between symmetric adjectives. Subjects were 29 college students, 19 female and 10 male. Average age was 21 years old. The papers applied in the test are shown in Table 2. Recycled paper has 70 % mixing rate of used paper, 72 % degree of whiteness and 65 g/m^2 basis weight. At first, every subjects evaluated the recycled paper with unaware that it was the recycled. Subjects evaluated other papers by random turn. Finally, subjects considered all the questionnaire items. If subjects felt the item as to be unsuitable for evaluation of paper, subjects reported. Validity of questionnaire items was inspected.

3. RESULTS AND DISCUSSION

3.1. Relations of the bleaching agent quantity and the yield

Pulp was not generated, if corn leaves of 5 g were soaked for 24 hours in the mixed solution including the bleaching agent of 100 ml or 120 ml. Long vegetable fibers like string were produced. Since pulp was not generated even if soaked in the mixture including the agent of 120 ml for 5 days, it turned out that the leaf of 5 g couldn't be decomposed by the agent of 120 ml or less. On the other hand, the leaf of 3 g was pulpified with the mixture including the bleaching agent of 100 ml or 120 ml. Corn shuck of 5 g was pulpified even with the mixture including the agent of 100 ml.

For the shuck of 5 g, the yield increased with increase of the agent at the range of 100 ~ 150 ml and became the maximum at 150 ml (Figure 1(a)). The reason of the increase is unknown, further research is necessary. The result of decrease of yield with the increase in the agent can be explained. If using much the agent, fiber will be decomposed much and will become short. Then short fiber will flow out on the occasion of filtration. For the leaves of 3 g, in the range of 100 ~ 180 ml, the yield decreased with increase of the agent. (Figure 1(b)). In the range of 150 ~ 180 ml, both the leaves of 3 g and 5 g became pulp, and the leaves of 5 g had slightly higher yield.

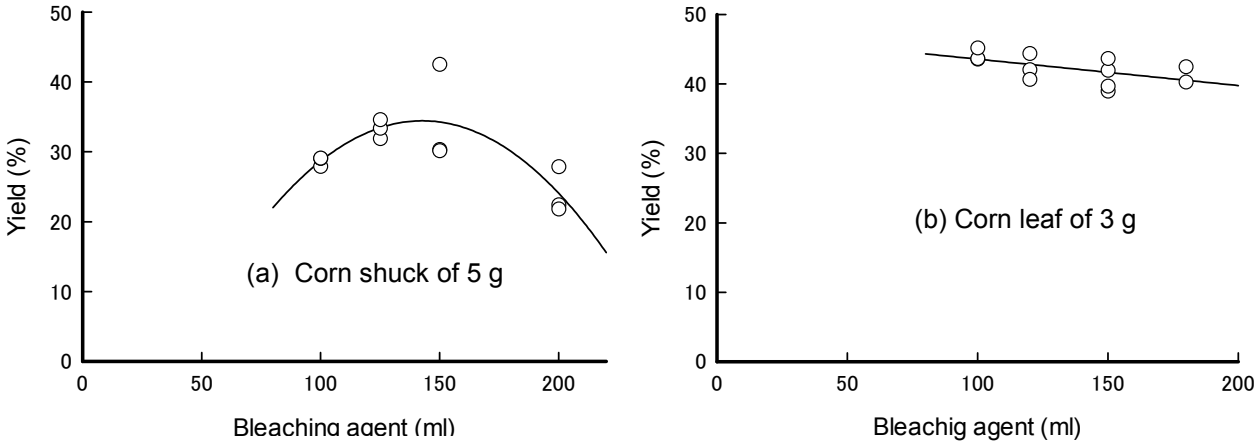

Figure 1: Relationships between the bleaching agent quantity and the yield

Notes: (a) $y = -0.0284x^2 + 2.71x - 29.9$, $R^2 = 0.612$
(b) $y = -0.152x + 47.4$, $R^2 = 0.317$

Half-split chopsticks were soaked in the bleaching agent for 7 days. The case of 250 ml bleaching agent, the chopsticks had become soft, and surface fiber could be peeled by hand. Even in this case, after crushing by mixer, wood chips were observed only a few. Also in the case of 200 ml, the chopsticks became also soft, but not as much as the case of 250 ml. After removal of wood chips from the pulp, oven-dry weight was measured and the yield was determined. The yield was increased with increase in the agent. The yield when raw material was soaked in the agent of 150 ml, 200 ml and 250 ml were 34.3 %, 39.8 % and 44.3 % respectively. This is because central portion of the chopsticks was not decomposed under few agents. The result will change if the chopsticks are peeled thinly before soaking. Since more than 70 % of wood is cellulose and hemicellulose, yield will rise by changing experimental conditions. The experiment of soaking in 250 ml agent for 23 days was also performed. The chopsticks of 23 days soaking became much softer than those of 7 days soaking, and was observed large bending by own weight. The yield was slightly increased, but was almost unchanged.

3.2. Relation between soaking time and the yield

For the shuck, the effect of soaking time was examined. In the range of 12 ~ 24 hours, the yield was decreased with increase of soaking time at the both condition of 125 ml and 200 ml（Figure 2）. Such a result might be caused by progress of fiber shortening.

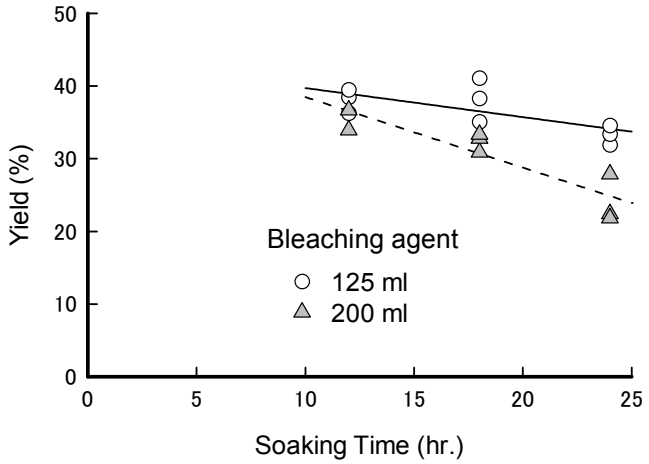

Figure 2: Relationships between the soaking time and the yield

Notes: Raw material is corn shuck of 5 g.
125ml: $y = -0.399x + 43.7$, $R^2 = 0.465$
200ml: $y = -0.972x + 48.2$, $R^2 = 0.797$

3.3. Physical properties of papers

The results of air resistance and compression properties are shown in Table 3 and Table 4 respectively. For created papers, average values were calculated according to raw material and shown in those tables. Three kinds of "Atsuyohsi" (thick Japanese paper) were measured and compared for their properties. Since differences among these papers were whether straw or hemp was included or not, differences were comparatively small. Therefore, averages of three "Atsuyohsi" were evaluated. The air resistance of various Japanese papers was too large to measure in this experiment. Apparent specific gravity and air resistance of created papers were smaller than those of commercial papers. The initial thickness T_0 of created papers were larger than those of commercial papers. In this research, after making paper, layer of pulp was not

compressed. Therefore, by compressing with appropriate level, these papers might be possible to approach properties of Japanese paper on market.

The difference of compression properties might be caused by fiber length. In most papers, the thickness at the maximum stress became 60 ~ 70 % of the thickness T_0. The value of Ganpi paper became 34 %. The reasons may be that the Ganpi paper is very thin and Ganpi fiber is shorter than that of hemp and mulberry. The papers which were made from the shuck (56 %) were compressed larger than the papers which were made from the leaf (72 %) and half-split chopsticks (67 %). The shuck's fiber was shorter than the leaf's fiber, which was evident from observation of fiber at edge of papers. The size of papers created from the shuck was changed readily by change in surrounding environment. Those reasons would also be same.

Table 3: Apparent specific gravity and air resistance

Created paper	Apparent specific gravity ($\times 10^{-2}$)	Air resistance (kPa·s/m)
Corn shuck	6.62	475
Corn leaf	6.12	366
Half-split chopsticks	8.95	700
Commercial Japanese paper		
Hemp paper	38.4	—
"Atsuyohsi"	30.3	—
"Minogami"	15.0	—
Mulberry paper	21.9	739
Unbleached mulberry paper	23.9	—
Handmade mulberry paper 1	22.1	—
Handmade mulberry paper 2	15.1	1523
Ganpi paper	27.8	—

Table 4: Thickness and compression properties

	T_0 (mm)	T_{50} (mm)	H (%)	W (gf·cm/cm^2)
Created paper				
Corn shuck	1.16	0.651	34.9	0.558
Corn leaf	1.20	0.866	26.1	0.469
Half-split chopsticks	0.912	0.609	29.6	0.413
Commercial Japanese paper				
Hemp paper	0.120	0.0807	20.8	0.0267
"Atsuyohsi"	0.313	0.221	41.8	0.0612
"Minogami"	0.364	0.204	31.9	0.120
Mulberry paper	0.116	0.0710	—	0.0407
Unbleached mulberry paper	0.168	0.0997	—	0.0460
Handmade mulberry paper 1	0.214	0.123	32.0	0.0643
Handmade mulberry paper 2	0.141	0.0690	21.8	0.0403
Ganpi paper	0.0383	0.0130	—	0.0217

When the shuck was soaked in 125 ml or 150 ml of the agent, created paper had less absorption at short-wavelength light, and had yellowish. Papers of 125 ml had stronger yellow tint than the papers of 150 ml. The papers of 200 ml had slightly less absorption at 460 ~ 480 nm light, compared with light of other wavelength. Papers had slightly orange tint.

The difference of papers of 18 hours soaking and 24 hours soaking was small, but papers of 12 hours soaking had less absorption at low wave-length. It means that these papers had yellowish.

Difference in reflectance of the both sides was small.

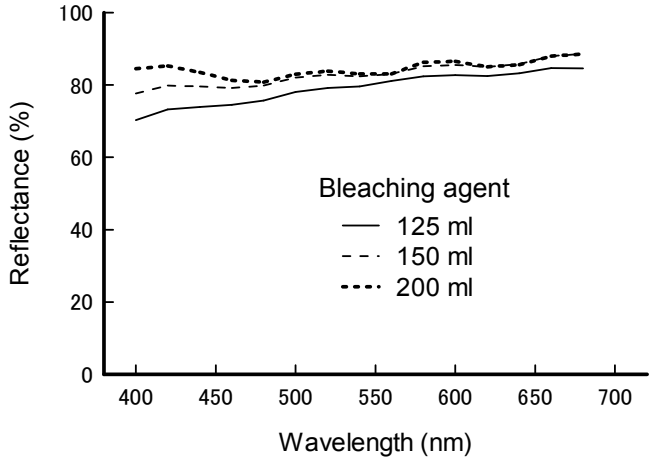

Figure 3: Reflectance of papers

Note: Raw material is corn shuck of 5 g. Soaking time is 24 hrs.

3.4. The sensory test of sample papers

High ventilation can say as a feature of Japanese paper, which suits to Japan's hot and humid climate. Slightly bright parts and slightly gloomy parts will be made if light passes through Japanese paper. Both of these was resulted from structural characteristics of Japanese paper as heterogeneous and porous, which are caused by Japanese paper fiber being long. Difference in brightness intensity induces fluctuation of light and brings comfort. In order to obtain fundamental data in examining such characteristics of Japanese paper, impression factors related to impression of heterogeneity/ high ventilation/ warmth were examined. Coefficients of correlation between each rating impression points were calculated.

If the paper was judged to be heterogeneous or rough by subjects, subjects felt the paper had high ventilation (Figure 4(a)). When a paper was evaluated as having few pores, it was estimated as low ventilation. Impression point of ventilation and air resistance measured was independent.

The impression point of heterogeneity was associated with many other impression points. If subjects felt a paper as porosity or rough surface, the paper was evaluated to be heterogeneous. If subjects felt a paper as heterogeneity, the paper was evaluated as natural. Thick papers were evaluated to be heterogeneous.

Surface smoothness has effect on ease of writing and visual evaluation of paper. It is important to examine what bring impression of smoothness. Smoothness impression was proportional to impression of homogeneity, and inversely proportional to impression of porosity, ventilation and thickness (Figure 4(b)).

If subjects estimated a paper had high homogeneity or high degree of artificial, the paper was estimated as low degree of warmth (Figure 4(c)).

Impression point of artificial level was proportional to the point of newness. If subjects felt a paper was white or less yellowish, subjects felt the papers was new (Figure 4(d)).

For the impression points of not-warmth and artificial level, created papers was evaluated to be similar to unbleached mulberry paper. For these points, seven papers shown in Table 2 had large difference, and could be divided into two groups. The one was consisted of “Minogami” and recycled paper, and these averages were 5.1 (not-warmth) and 5.3 (artificial level). Average points of other one were 3.2 and 3.0 respectively.

Ventilation degree and rough points had much difference among papers. The average ventilation points were 2.7 to 5.2, and these average was 4.0. The average rough points were 2.8 to 6.6 (the mean was 5.0). The difference in not-heavy impression point was very small (average points were 4.8 to 5.2), though the apparent specific gravities were much different. It was because subjects compared paper with other materials and made absolute evaluation.

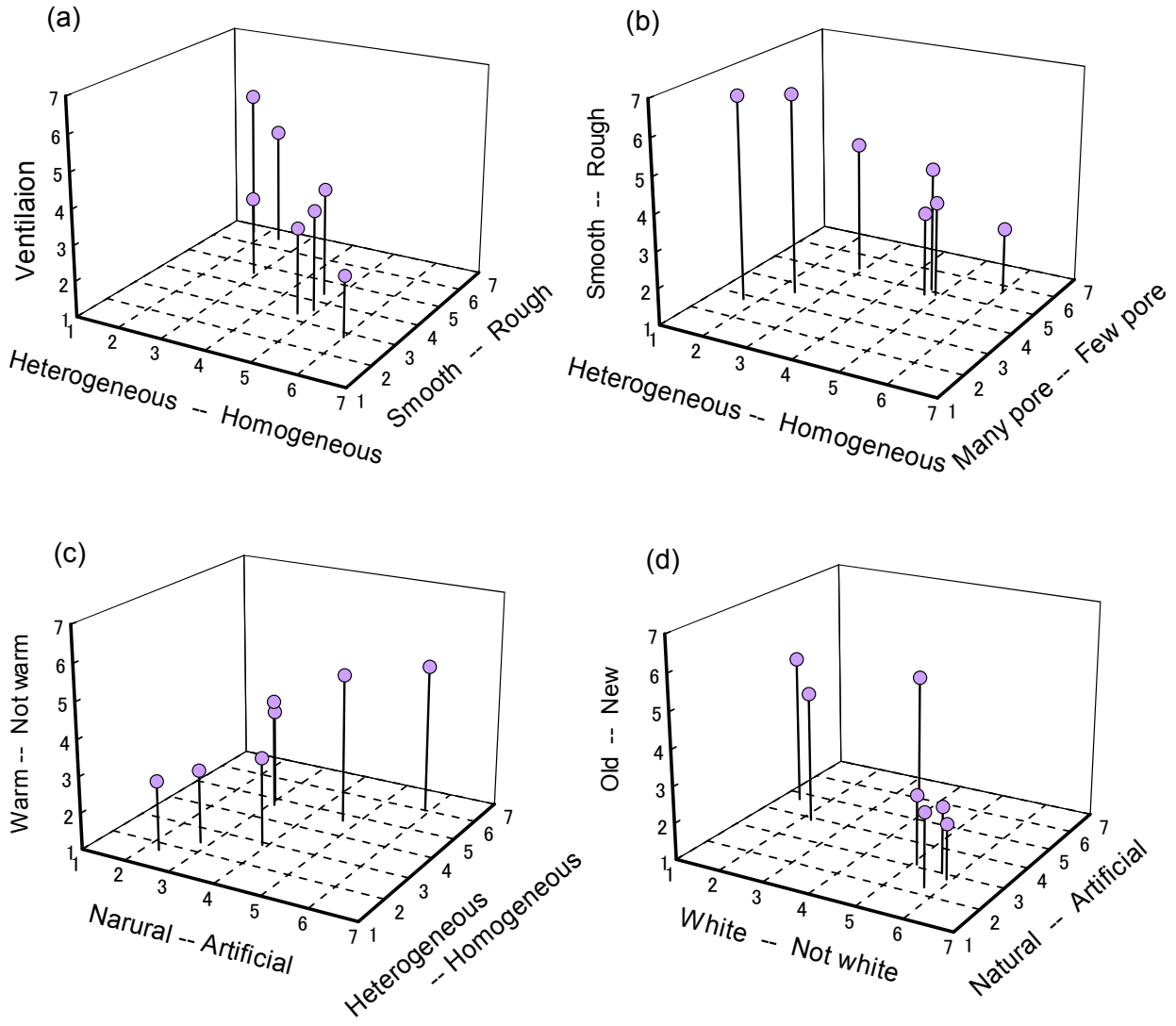

Figure 4: Relations of each impression point

To examine difference in the impression points among the subjects, standard deviation of the impression points was noted. Individual differences of the points related with visual and tactile were generally small in this study. For yellowness, individual difference was especially small (Figure 5). For 4 papers of 7 papers, the standard deviations were 1.0 or less. The average value of the 7 standard deviations was 1.0. The differences of whiteness, uniformity and roughness points were also small, the averages of the 7 standard deviations were 1.2, 1.2 and 1.3 respectively. But individual difference of judgment criteria of shiny degree was larger than those of color, uniformity and roughness. The average of the 7 standard deviations was 1.7, which was relatively large.

Impression points of items, which subjects might feel those as physical properties, had larger individual differences than those which might be evaluated by visual and tactile. Many of the standard deviations about judgment of warmness, softness and weakness were 1.6 or more.

For color, uniformity and roughness, individual difference had large variation among the papers, compared with other impression items. The standard deviation of the individual difference of 7 papers was noted. For color, uniformity and roughness, the standard deviations were 0.35 to 0.56. For other items, those were 0.084 to 0.31. The individual difference for certain paper was not always large or small.

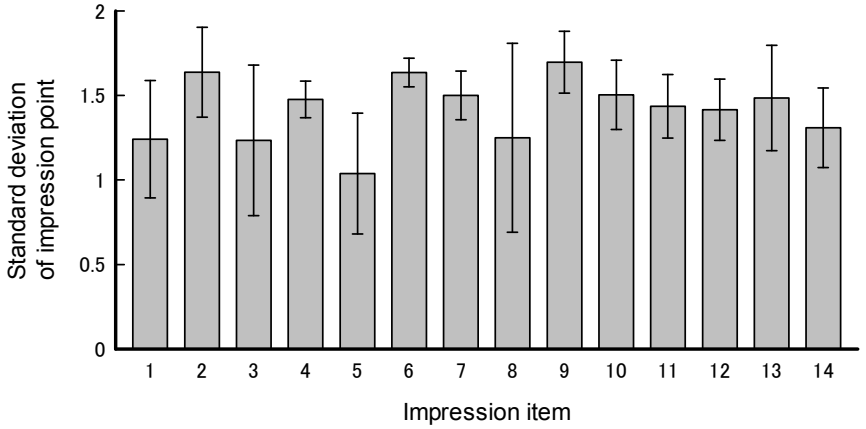

Figure 5: Individual difference of impression point

Legend: 1: uniformity, 2: softness, 3: whiteness, 4: weight, 5: yellowness, 6: warmness, 7: porosity, 8: roughness, 9: degree of shiny, 10: weakness, 11: degree of ventilation, 12: thickness, 13: newness, 14: artificial level

Note: Vertical bars and horizontal lines indicate averages of 7 standard deviations (individual difference) and standard deviation of those respectively.

4. CONCLUSION

By the simple method which raw material was soaked in commercial bleaching agent, shuck of corn/ leaf of corn/ half-split chopsticks was pulped. The quantity of the agent and soaking time were changed. The influences of these to pulp yield or paper properties were investigated. Moreover, the sensory test was conducted using both of created papers and commercial papers. The factors which gave the impression of high ventilation/ smoothness/ warmth/ etc. were examined. Results as follows:

The shuck was easy to become pulp than the leaf, but papers made from the shuck had insufficiently dimensional stability. For pulping the leaf of 5 g, the agent of 150 ml was needed at

least. On the other hand, the shuck of 5 g was pulped by the agent of 100 ml. In general, with increase of the agent or soaking time, the yield decreased. However, using less the agent, pulp generated had yellowish tint.

Impression of homogeneity was related to many other impressions. If homogeneity of paper was felt high by subjects, artificial impression was brought to subjects. Artificial impression indisputably brought not-warmth impression. Homogeneous paper gave rise to smooth impression. The impression of ventilation was influenced by surface appearance impression. Few pore/ smooth feeling resulted in low ventilation feeling.

Individual differences of impression points relevant to visual and tactile were apparently smaller than those which might be regarded as physical properties, in general.

These results will be big contribution, for the production of paper in environmental education. Outcome of this study shall contribute much to the environmental use of plant waste. By enhancing this study further, and finding the factors that determine the impression of paper, important data will be provided to create human-friendly paper.

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BIOGRAPHY

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Kento Tokumitsu is senior student of Hokkaido University of Education, and has been studying to become a science teacher, and has made study of making of paper from last year.

6C - Health

Study on Color Art Therapy Techniques

An examination of techniques which allow elderly patients with severe dementia and motor impairment of the hands to express themselves to the same extent as healthy people

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Abstract: This research project is focused on art therapy techniques which can be used with patients suffering from severe dementia, and considers the extent of expressive ability patients can achieve through their use. Art therapy is one type of psychotherapy, and consists of a variety of different techniques, such as painting, 3-dimensional expression through sculpture, and miniature garden tending treatments. This type of therapy is used as a treatment for patients' with mental health problems, and as a way of analyzing patients' state of mind. There have been reports that use of art therapy can improve concentration in elderly dementia patients, and there is an increasing need for these treatments at geriatric care facilities. However, implementing art therapy for patients with severe dementia or hand motor control impairments is difficult, and these conditions often result in limitations of the patients' self-expression. In cooperation with the psychotherapy department at The A Hospital, a Japanese facility where elderly dementia patients receive long-term care, this study observed the progress of art therapy treatments in order to clarify their contents, and confirmed the effectiveness of the use of color tile arrangement for expressing abstract themes, a specific method used to enable patients to express their feelings in spite of their dementia. In addition, a comparison of the artworks created by these elderly dementia patients with samples created by healthy people in their 20s showed that this therapy technique enables an equivalent diversity and individuality of expression in both groups.

Keywords: Psychotherapy, Art Therapy, Dementia, Impairment, Elderly

1. BACKGROUND INFORMATION: EFFECTIVENESS OF ART THERAPY AND APPLICATIONS FOR TREATMENT OF ELDERLY PEOPLE

Art therapy was originally developed as a technique for treating mental illness, psychological trauma, and other mental problems, and was first used in the fields of psychiatry, psychology, and clinical psychology. In Japan, art therapy has made use of materials from a variety of fields, including painting, music, and classical Japanese poetry. According to Tokuda, although each of these techniques has its own individual theory and methodology, what they all have in common is that there is a process of art creation, and this art is then used to go beyond ordinary expository language to make it possible for individuals to directly express their current circumstances or mental state (Tokuda, 2011, pp.2-21). In this way, art therapy is typically conducted, by using artworks created in a variety of situations, to determine patients' mental states and analyze their condition, in order to understand their current status and prescribe the appropriate treatment (Iimori, Nakamura, et al.,2011, pp.36-198). However, art therapy is currently being used for a wider variety of applications. In a nationwide survey of art therapists conducted in 2012 in Japan, the results showed that nearly the same number of therapists performed treatments on “people with no particular problems” as “people suffering from mental illnesses.” In addition, more therapists responded that “change of mood / stress relief” and similar effects could be expected from treatment than things like “improvement of symptoms,” and “problem resolution” (Kawata, Nishi, et al. 2012, p.9). New forms of art therapy with the objectives of “staring into one's own subconscious” and “self-healing” are being developed which individuals can perform on their own without the mediation of a specialist in art therapy (Yoshida, 2009 and 2005). In this way, art therapy is transforming from a technique for treating mental illness to a source of recreation, and is now being used as a means of achieving a variety of goals such as improvement of self-development and self-awareness. Also in the survey mentioned above, Kawata et al.(2012, p.28) stated that different types of art therapy can be broadly categorized into 4 groups: “psychotherapy,” “self-development,” “rehabilitation,” and “expression.”

Among these 4 groups, the focus of this study is the use of art therapy for "rehabilitation," which has been getting a lot of attention. Specifically, this is a use of art therapy for elderly patients suffering from dementia, and it is being implemented in a variety of locations in Japan, such as daycare centers, hospitals, and care facilities for the elderly (Nakagawa, 2001, pp.211-233), due to the aging population. Survey results have shown that the need for putting this type of art therapy into practice is the greatest in care facilities for the elderly (Kawata, Nishi, et al. 2012, p.9). Imai identified positive changes in the peripheral symptoms of dementia and emotional health of real-world patients after 12 art therapy sessions (Imai, 2006, pp.24-27), and introduced specific art therapy techniques which could be used by nurses, caregivers, and other medical personnel to achieve definite results (Imai, 2007). Also, Uno, Kaneko, Asada et al.(2004, pp4-9, pp84-85) used an extensive sample of art therapy patients' records to show that art therapy increased dementia patients' appetite, reduced their problematic activity, and improved their concentration. Patients with dementia index, CDR (Clinical Dementia Rating), scores ranging anywhere from 1 (slight dementia) – 3 (severe dementia), they were capable of taking part in art therapy sessions, and the report contains examples of works produced by these patients, as well as specific materials, tools, and coaching techniques used for the treatments. Regarding the reason why this art therapy improved the condition of dementia patients, Geijutsu Zokei Kenkyuujyo (2008,p.47), a sculpture research institute in Japan involved in the study of art therapy and its implementation suggested that the reason was the 4 healing properties of art: “the joy of using the 5 senses,” “the absence of right and wrong,” “the birth of communication,” and “the praise received from people who saw a displayed finished work” . In addition, Ohashi et al.(2008,pp180-274) treated art therapy works as

clinical art, and pointed out that the goal of prevention and improvement of dementia can also be developed into an activity that contributes to society and regional welfare through art.

Building on the background detailed above, this research considers the specific techniques best used to conduct effective art therapy for elderly patients with dementia.

2. CURRENT STATUS AND CHALLENGES OF ART THERAPY FOR ELDERLY DEMENTIA PATIENTS, AS SEEN AT THE A HOSPITAL

In cooperation with The A Hospital, a facility for the long-term care of elderly dementia patients, this research was carried out as a case study of the institution. This hospital focuses special effort on treatments for the elderly, and it functions as a final resting place for many of its patients. With specialized psychotherapists taking a leading role, it offers a variety of psychological care for patients and their families. As part of this care, art therapy is administered at fixed intervals upon request, but there are a number of practical issues with art therapy conducted in this kind of busy clinical environment. Results of observation and interviews identified the following 3 issues as the main problems with art therapy administered at The A Hospital.

The first issue was participants' lack of ability to use the artistic tools provided. Many elderly dementia patients cannot skillfully perform tasks with pencils and scissors. According to clinical psychotherapists, elderly patients often get discouraged and feel that “I couldn't do it very well” when they have trouble with coloring and other such tasks and then compare their pieces with the work of other patients. Psychotherapists also said that the assistance of other people often has an effect on the finished products. There is a need for a technique which uses simple methodology to create pieces that freely express patients' individuality and psychological state while producing a finished piece that is a thing of beauty.

The second issue is that because patients cannot freely choose the materials used, this limits their expression. Sometimes patients just use whatever color happens to be close by (Figure 1).



Figure 1: Hand Drawings painted with a blue color pencil

This same phenomenon was observed in miniature garden treatments as well. The tending of miniature gardens is a traditional psychotherapy technique, and according to Nakagawa's report (2011, pp.313-324) it boosts patients' self-recovery ability, and can also induce recovery from mental problems, as shown through detailed recounting of real-world example cases. Although this therapy has been shown to be effective, observations showed that in some cases patients simple grabbed figures that were in easily reachable positions and placed them in the sand one by one without any particular purpose. When questioned about the meaning of their creations, they had no particular explanation (Figure 2).



Figure 2: Miniature Garden Therapy Compositions

This issue also occurred with collage (Figure 3), and the process of “take one piece of paper from the pile and glue it into place” was difficult for many patients. Some simply glued one piece of paper and then said they were finished. An environment and support structure that enables patients to freely choose from a variety of materials that are all easily within reach is needed.



Figure 3: Collage

The third issue was problems with cost, preservation, and storage. Many of the materials used for painting are expensive, and both the tools used and finished works can be quite bulky and cumbersome. Saito (2006, pp.55-58) identified this as a problematic area for elderly care facilities conducting art therapy.

3. GOALS OF THIS RESEARCH

Based on these problem areas above, the goal of this research project is to devise and confirm the effectiveness of a technique for art therapy that enables elderly patients with dementia and motor impairment of the hands or other areas to create artworks without feeling like they are “embarrassing and no good,” while at the same time expressing their mental state, memories, or other feelings. In addition to asking participants in the course of their therapy what they are trying to express with their artworks, pieces created through this technique will also be displayed to a third party, who will then be questioned about what kind of impression the works give them. Also, in order to resolve the issues of art storage and painting supply costs, various configuration possibilities such as using digital data to store works, reusing consumable materials many times so that there are no expenses for the hospital, implementing a system which can be used by 10 people simultaneously at different elderly care facilities and hospitals, enabling patients to work in individual hospital rooms and bedsides, and allowing patients to quit at any time and then continue their work on another day were considered.

4. ART THERAPY TECHNIQUES USING COLORS

4.1. Requirements for Techniques Using Colors

At this facility, there were existing restrictions concerning painting materials and treatment areas, and although art therapy using a large number of colors was not currently being performed, colors are often tied to memory and can be used for psychoanalysis for this reason, so the decision was made to implement art therapy techniques focused on the use of colors. Dee, Taylor, et al. (2006, pp.6-10) described how colors each have individual meanings, and can have an effect on behavior and state of mind, operating on both conscious and subconscious thought. Also, Suenaga (2001, pp.110-115) introduced color therapy techniques for the elderly which was shown to have effects such as improvement of patients' stimulation, expressive power, concentration, and memory, as well as contributing to a recovery of self-awareness.

Grounded in the current problem areas, this study considers color-based art therapy which fulfills the following 7 requirements.

(1) Colors for expressing the patients' feelings can be chosen with a high level of freedom.

(2) Motor impairment and dexterity do not affect the quality of the finished works.

(3) Pieces show the individual personality differences of each participant.

(4) Artwork can be converted to a digital format and reused in a variety of forms.

(5) Creation of artwork is carried out by a simple process.

(6) When certain operations are difficult for patients, assistance can be provided easily, and this leaves no “supporter fingerprints” on the completed piece.

(7) The creation of artworks contributes to the original intentions of therapy, psychoanalysis and conversation with therapists.

4.2. 3 Techniques Considered for This Study

Because painting with many different colored paints would be difficult in a hospital setting, and colored pencils would be difficult to hold unassisted for some of the participants, the following 3 techniques for creating artwork using solid materials and color pieces were considered.

(1) Reciprocal Division-and-Coloring Method: The therapist and patient take turns drawing lines on a sheet of white paper, then select a crayon to color in the areas partitioned off by these lines with. This method is recognized as a way to conduct psychoanalysis, and the procedures are simple, but the finished product is not a personal expression of the patient (Figure 4).

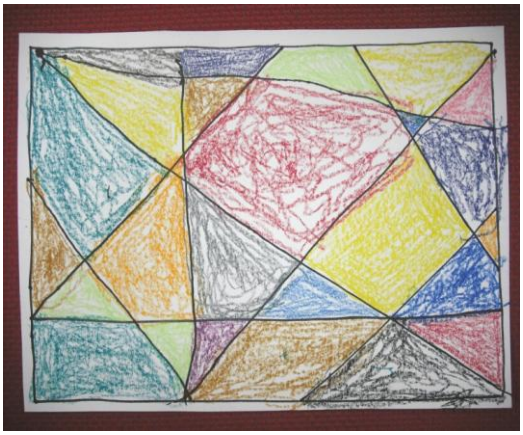

Figure 4: Finished Product from Alternate Color Partitioning

(2) Glued Paper Color Organization Method: 199 color scheme cards (Figure 5) pre-cut into small 10 millimeter squares to make colored paper pieces.



Figure 5: 199 Color Scheme Cards

These are then affixed to a white board with a weak adhesive applied to it to create a color configuration. (Sample created by a participant: Figure 6)

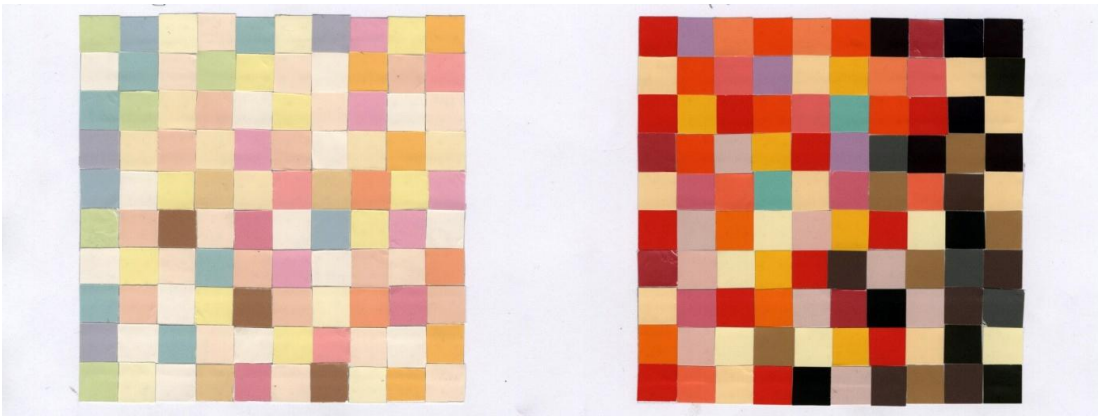

Figure 6: Color Configuration Using Color Scheme Cards (University Student) "Sweet"/"Spicy"

(3) Ceramic Color Tile (Figure 7) Color Configuration Method: 10 mm square tiles of many colors are lined up on one of 2 clear, square plastic plates with measurement markings (Figure 8) to create a color configuration. (Sample created by a participant: Figure 9)



Figure 7: Color Tiles



Figure 8: Plates for Lining Up Color Tiles



Figure 9: Color Configuration Using Color Tiles (University Student) "Hometown"

As a preliminary test of these 3 methods, elderly men and women in their 70s (2 of each gender) and men and women in their 20s (3 of each gender) were selected to participate in mock sessions. Based on these subjects interest in the tests, the ease with which they completed the operations, the time required for each, and their level of satisfaction with the pieces they created, the color tile method, (3), was selected to be used in this study. Several additional preliminary tests were then conducted using this method to consider the appropriate color selection, the type of tile storage system which would be easiest to use, the best way to support patients, and other issues.

5. EXPERIMENT PROCEDURE FOR CONDUCTING COLOR-BASED ART THERAPY AT THE A HOSPITAL “COLOR EXPRESSION USING TILES”

5.1. Tile Colors Used for the Experiment

Although there are 55 different colors of these tiles, this study classified them using the 11 simple color classifications of psychoanalysis. These are: 8 chromatic colors (red, orange, yellow, green, blue, purple, pink, brown), the neutral color, gray, and black and white. 3 shades of varying brightness for each chromatic color were used, along with 4 shades of gray and 1 tile each for black and white. These 30 tiles made up the total set for the experiment.

5.2. Tile Storage System Used for the Experiment

Based on the results of the preliminary experiments, an arrangement and storage system that would enable the subjects, in consideration of their motor impairment, to easily choose and take color tiles was implemented. Several compact plastic containers which allowed subjects to see the full range of colors at a glance were used (Figures 10 – 15). All of these containers were inexpensive articles.

A: 5 Cells * 6 Containers 30 Separate Colors (Figure 10)



Figure 10: 5 Cells * 6 Containers

B: 10 Cells * 3 Containers 30 Separate Colors (2 Sets) (Figure 11)



Figure 11: 10 Cells * 3 Containers

C: 14 Cells * 2 Containers 24 Separate Chromatic Colors + White + Black + 2 Light Gray Mixed Colors / 2 Dark Gray Mixed Colors (2 Sets) (Figure 12)



Figure 12: 14 Cells * 2 Containers

D: 10 Small Containers Similar Colors Mixed Together (Colors Mixed; Organized by Mental States) (Figure 13)



Figure 13: 10 Small Containers

E: 6 Large Containers (Organized by Color Phase Groups) (Figure 14)



Figure 14: 6 Large Containers

F: 3 Large Containers Warm Colors / Cold Colors / Neutral Colors (Figure 15)



Figure 15: 3 Large Containers

5.3. Experiment Themes

The task given to the subjects for this experiment was "Express your image of your favorite season using colors." Everyone has memories they associate with the seasons, and each season has specific scenery associated with it, events that take place during it, and various other connotations. As a result, a mental image of a season was considered relatively simple in spite of being an abstract concept. This is the reason for its selection.

5.4. Experiment Procedure

Sessions were conducted in a standard art therapy setting, with subjects sitting one by one at a C-shaped desk which stretched out horizontally to create their color configurations (Figure 16). Supporting staff sat in a position where they could easily provide the assistance required by each subject (Figure 17). This assistance mainly consisted of holding the color containers diagonally so that shorter subjects could see all of the colors (Figure 18), placing similar colors in the supporter's palms so they could easily choose from among them (Figure 19), and bringing the color containers to an easily reachable place (Figure 20).



Figure 16: The Therapy Room



Figure 17: Assisting Subjects with the Process



Figure 18: Placing Colors on a Diagonal So They Are All Visible



Figure 19: Color Selection By Pointing for Subjects with a Speech Impediment



Figure 20: Moving Color Containers to Positions Where Subjects Can Reach

Each participant was assigned one supporting staff member to observe and assist. While ensuring that all 30 colors were always within easy reach of the subject and providing assistance when necessary, these staff members also observed and recorded how easily each subject chose colors, grabbed the tiles, or instructed them to assist in doing so. A rotation of the different types of containers was used throughout the creative process in order to provide easy-to-use container systems for all subjects.

When the subjects' completed their configuration, staff asked each participant to explain what kind of intentions or ideas went into their color choices, and what they were trying to express. This information was also recorded. Subjects were also asked to give their pieces a title.

6. RESULTS OF COLOR TILE ART THERAPY EXPERIMENTS AND FURTHER CONSIDERATIONS

6.1. Subjects' Individual Characteristics and Working Environment

Ten subjects took part in the experiment, and 7 of these 10 were elderly people with dementia. Among these 7 were subjects who had poor motor control of the hands, tremors, inability to straighten their arms, difficulty seeing objects from far away, and other impediments. 4 of the subjects required assistance from support staff, such as taking the containers to them or showing them the tiles, but all subjects chose and placed tiles by themselves, regardless of how much time it took.

Even subjects with severe dementia, provided they did not have any motor impairments of the hands, were able to complete the process of placing tiles in all 144 cells within the 30 – 40 minute time period allotted. The 2 subjects who were unable to complete the task within this time period had speech

impediments and motor impairment in addition to their dementia, which caused communication to be time consuming, and as a result they were only able to complete placement of about half of the tiles. However, they were still able to focus on the task, and carefully choose and place each tile one by one, and continued to select tiles even after the working time had ended.

6.2. Comments from Participants Regarding the Intention of Their Pieces and Excerpts from the Data Recorded by Observing Staff

A-1 (Participant)　Spring, The Color of May (Composition Title) (Figure 21)

Male. Slight dementia symptoms. Speaks slowly, but can handle ordinary conversation. Carefully selected tiles by himself, picked them up, and placed them.

Intention of Composition,　Notes on Working Process:

Expressed the green of the trees of spring. Various colors of leaves (green), tree trunks, roots, and the ground (brown, pink, purple, etc.), the yellow light of the sun (filtering through the trees), white represented the space between the leaves of trees. Thought about memories of the many bonsai trees he kept in his home while working on the piece. Talked about how he liked bonsai trees and said "I used to have a lot of them at home" with a smile.

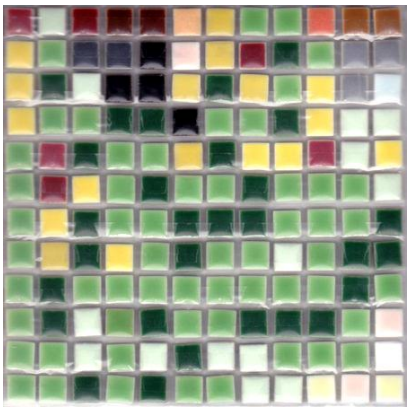

Figure 21: A-1:Spring, The Color of May

A-2　The Arrival of Fall (Figure 22)

Female. Slight dementia symptoms, but capable of conversation. Often says "I'm not good at drawing pictures." Chose and placed tiles independently.

Imagined autumn leaves and trees. Often sees leaves that appear black, so decided to use black tiles. Also added green and yellow ginkgo, brown leaves, and others. Put some blue in at the end because she hadn't used much of that color and wanted to try it. Said things like "the changing colors of fall are beautiful," "fall is all about autumn leaves," and "it's starting to look like the colors of fall" while working on it. After finishing, made statements like "my personality is a bit masculine, so that shows in the colors," "there's nothing feminine about it," and “I like clear and distinct colors like red and black. I'm a straight-forward kind of person.”

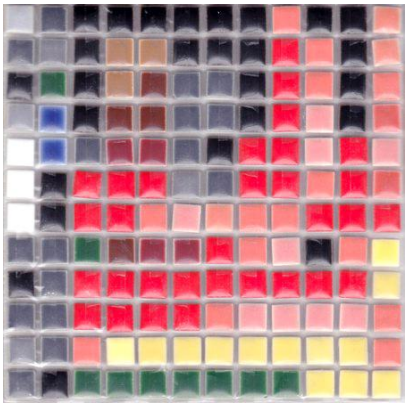

Figure 22: A-2:The Arrival of Fall

A-3 Spring Flowers (Figure 23)

Female. Dementia symptoms are becoming severe. Strong feelings of anxiety and fatigue, with poor concentration. Negative about herself. After staff brought the container she was able to choose and pick up tiles on her own, but placement took some time.

Imagined flowers such as tulips and hyacinths. Fixated on the depth of colors and their arrangement. Initially thought of fall, but changed to spring in the process of working on the piece. Looking at her finished work, said "I like this," and "It's nice and colorful."

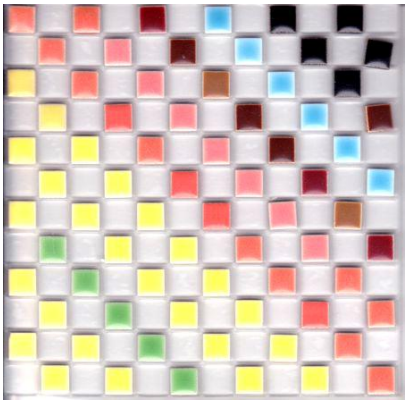

Figure 23: A-3:Spring Flowers

A-4 The Crisp End of Fall (Figure 24)

Female. Severe dementia, with difficulty speaking. Also suffers from vision impairment resulting from diabetes.

Her image of fall is leaves wilting and falling from trees, so she used brown. Also placed some purple, thinking it would stand out, which might be nice.

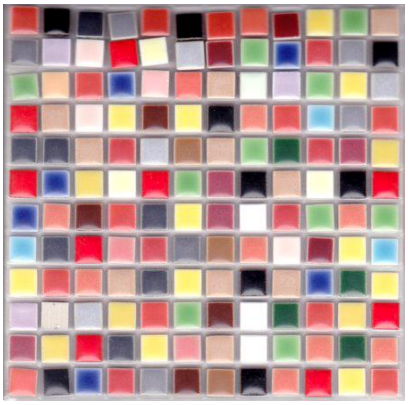

Figure 24: A-4:The Crisp End of Fall

A-5 Spring (Figure 25)

Female. Dementia symptoms present, but their extent is unclear. Difficulty having a conversation. Eyesight, hearing, and speaking ability are poor. No motor impairment of the hands. Placed the tiles promptly.

Couldn't express "spring" very well. She wanted to use more "deep blue" and "deep purple."

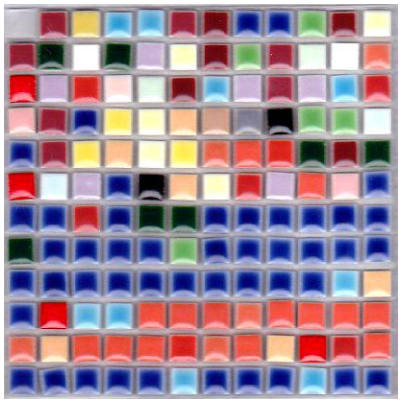

Figure 25: A-5:Spring

A-6 Fall (Figure 26)

Male. Slight dementia symptoms. Capable of conversation. Cannot extend his arms, and his hands shake. Although it is a very slow process, when support staff brought containers that are far away closer to him, he slowly selected tiles, thought carefully, and placed them on his own.

White stands for "daikon radish," and yellow is "mandarin orange." Also expressed a boundless blue sky. "It turned out a bit different from how I was thinking."

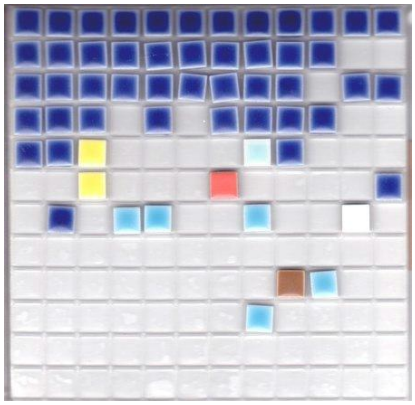

Figure 26: A-6:Fall

A-7 Summer (Figure 27)

Female. Dementia symptoms present, but their extent is unclear. Cannot carry out a conversation. Suffered motor impairment of the hands, and the process was extremely time-consuming. Very detail-oriented. Thought carefully before placing tiles.

Repeatedly said “the color of the sea.”

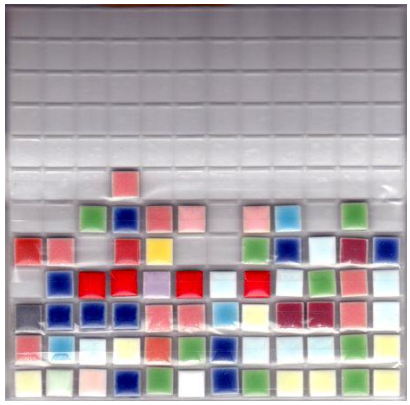

Figure 27: A-7:Summer

6.3. Considerations

Even in subjects with dementia, each was able to explain what they were trying to express related to the season theme of their choosing, and why they chose the colors that they did, although there was some variation in expressiveness. No piece was identical to any other (Figures 21-27), and these differences were not accidental, but reflections of the differing intentions, personal expression, and feeling of each participant. All subjects were given the same materials to choose from, and both selected materials and created their artworks independently. This means that these variations show the unique taste, artistic sense, and designs of each participant. Therefore, the goal of enabling each subject individual expression was achieved successfully.

For this therapy technique, support staff can do only 2 things: "have the subjects choose a color," and "place tiles in the position subjects indicate." Because there is no need for these staff members to produce anything, provided they can reach a mutual understanding, the finished works will be created completely by the subjects, although this may take some time.

Although there were some subjects who could not complete the procedures this time, they were able to

select colors they wanted to place on the boards, so if there were a compact color sample board available to help them confirm which colors they wanted support staff to pick up for them and come to a mutual understanding, the amount of time required for completing the color configuration would likely be shortened.

7. EVALUATION OF THE IMPRESSION EACH PIECE GIVES

7.1. Individual Evaluations of Each Piece

In order to check whether or not the goal of creating a system for art therapy which would not create any clear divide between "good" and "bad" works as a result of patients' experience with art, dexterity, and motor impairments of the hands, 5 pieces (B1-B5, Figures 28 -32) were also created by healthy adults in their 20s based on the same theme as described in 5.3.



Figure 28: B1:Spring Flower Garden

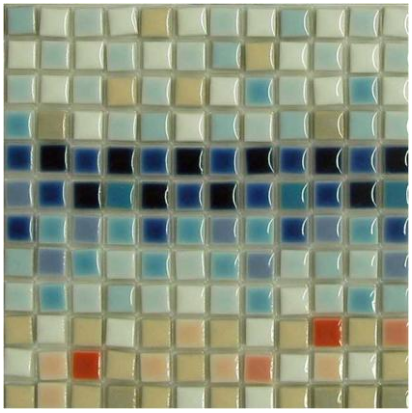

Figure 29: B2:Summer Seashore



Figure 30: B3:Autumn Leaves in the Mountain



Figure 31: B4:Summer Fireworks

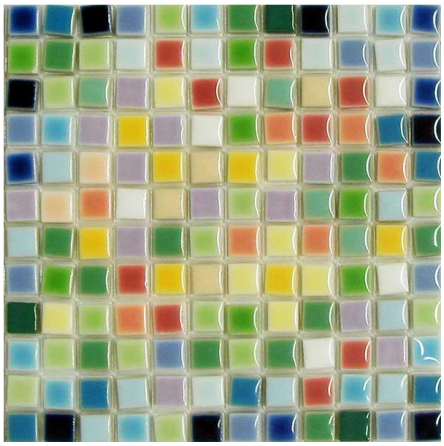

Figure 32: B5:Flower Garden

A questionnaire format survey was then conducted regarding both the 5 completed pieces created by elderly dementia sufferers (A1-A5) and the 5 pieces created by healthy adults mentioned above (B1-B5). 97 men and women rated each of the 10 pieces (a 5 point linear scale system was used for evaluation on an absolute scale, and there were 91 valid responses). The works were shown one by one in a random order, and participants were asked to evaluate the four statements below as “strongly agree:1,” “agree:2,” “not sure:3,” “disagree:4,” or “strongly disagree:5.”

Question 1: This piece is beautiful.

Question 2: This piece is skillful.

Question 3: This piece is unique.

Question 4: This piece matches my image of the title.

7.2. Image Evaluations for Each Group

The 5 pieces from the elderly dementia sufferers group (Group A: A1 - A5, completed pieces) and the 5 pieces from the healthy adults group (Group B) were each shown to a total of 108 men and women in their 20s, and they were then asked to evaluate the statement "This group's artworks have a lot of variety in their designs" on the same 5-point scale used in 7.1.

7.3. Evaluation Results

Regarding the beauty of the pieces, comparing the differences in average evaluations between groups A and B showed that the B's average scores (2.22) were higher than A's (3.02) by .80, or approximately 5%, indicating a statistically significant difference ($t = 11.610$, $df = 455$, $p < 0.05$). Comparing the individual pieces, there was no significant different between the evaluation of A-3 and B-2, B-3, or B-5 in terms of beauty, and A-3's evaluation was 1.14 points higher than B-4's. Also, there was no significant difference in the evaluations of A-4 and B-4.

For question 2's evaluation of the skillfulness of the pieces, the B group's average evaluation was 0.85 points higher, again a statistically significant difference. However, in individual comparisons, A-3's skillfulness evaluation was not significantly different from B-5's, and A-3 was rated 0.49 points higher on average than B-4. Also, there was no significant difference in the evaluations of A-4 and B-4.

Question 3's uniqueness evaluation was not significantly different between groups A and B. Comparisons of individual average scores also showed no major differences.

As for question 4, concerning whether or not each piece matched with the viewers' images of the title, the B group's evaluation average was 1.03 points higher, indicating a statistically significant difference. However, in individual comparisons, A-3's scores were not significantly different from the evaluations of B-3, B-4, or B-5, and A-1's scores were not significantly different from the evaluations of B-4. (Table 1 ,2)

In the evaluation of the variation in artworks of each group, A's rating was a statistically significant 0.77 points higher that B's. (Table 3)

Table 1: Average Scores for Each Piece: the elderly dementia sufferers group (n=91)

strongly agree:1, agree:2, not sure:3, disagree:4, strongly disagree:5	A1	A2	A3	A4	A5
1: This piece is beautiful.	3.352	3.220	2.077	3.011	3.418
2: This piece is skillful.	3.319	3.264	2.473	2.956	3.429
3: This piece is unique.	2.912	2.462	3.055	2.505	2.484
4: This piece matches the image of the title.	2.637	3.308	2.319	3.110	3.978

Table 2: Average Scores for Each Piece: the healthy adults group (n=91)

strongly agree:1, agree:2, not sure:3, disagree:4, strongly disagree:5	B1	B2	B3	B4	B5
1: This piece is beautiful.	1.604	1.934	2.154	3.220	2.176
2: This piece is skillful.	1.769	1.945	2.165	2.967	2.352
3: This piece is unique.	2.736	2.736	2.462	2.758	2.560
4: This piece matches the image of the title.	1.791	1.681	2.044	2.429	2.253

Table 3: Average Image Evaluation Scores for Variation Within Each Group(n=108)

strongly agree:1, agree:2, not sure:3, disagree:4, strongly disagree:5	**Group A**	**Group B**
This group's artworks have a lot of variety in their designs.	2.241	3.009

7.4. Image Evaluation Considerations

From the results of 7.3, although as a whole the image evaluations of the works produced through the experimental color-based art therapy method “color expression using tiles” at The A Hospital by healthy adults in their 20s were evaluated more highly than those produced by elderly dementia sufferers in terms of beauty, skillfulness, and matching the image with the title, individual comparisons showed that some of the works from the dementia sufferers group were evaluated equivalently and even more highly than some of the healthy adult group pieces in these categories. The fact that the healthy adults group used in this experiment, although they performed the same procedure as the elderly dementia sufferers group for creating artworks, was comprised entirely of people with an interest in color and design could have affected the results. In addition, because the evaluations were performed by a similar age group, they may have tended toward some of the same preferences, resulting in a bias. Forming a new control group of elderly people without dementia symptoms who have no particular interest in color and design to produce artworks which can be comparatively evaluated is required to clarify this point.

No significant difference was found in uniqueness between the two groups, and the variety of the compositions received a slightly higher evaluation in the elderly dementia sufferers group. This shows that using this technique gives participants room to express their unique individuality even if they suffer from dementia symptoms.

8. CONCLUSIONS AND CHALLENGES FOR THE FUTURE

In this experiment, the number of sample pieces in each group is small(5), so it should be necessary to pick up more samples and further testing is required to prove the result of the Image evaluation experiment. But the technique suggested in this research, "using colored tiles to create a color configuration representing an abstract concept," was successful in achieving the goal of "creating a specific art therapy system in which patients can express their individual senses without concern for whether they are skilled artists, regardless of whether they are suffering from dementia or not." Although support staff are required to assist patients who have motor impairments of the hands, it was clear that even in those cases these staff did not influence the complete works.

Also, the problems of storage and material costs were solved by making digitized copies of patients' art for safekeeping. As for reuse, there are actually plans to continue treatments with this technique and organize this saved data into a poster to be displayed in the hospital, and this plan was popular with many participants, their families, and hospital staff members. Some other ideas for using this data are also currently being considered, such as making postcards, displaying the images with a projector, and setting up an online exhibition.

Implementation for 10 subjects simultaneously was accomplished, but enabling the treatment to be used in hospital rooms and bedsides is a challenge for future studies. The materials used do not dry out or degrade, so treatment can be stopped and resumed at a later date without any problems, but some tool improvements such as a color sample board for use in helping patients communicate to support staff which color they want are necessary to ensure that patients can finish within the prescribed time limits.

At present, no psychoanalysis has been conducted using the finished works, but with the use of themes suited to psychoanalysis along with data regarding how conversation with the therapist progressed, the technique could be used for this purpose. Further testing is required to determine whether the goal of psychotherapy adaptability has been achieved.

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KEER2014, LINKÖPING | JUNE 11-13 2014
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Implementation of the Healthy Eating Habits Support System Based on User Taste Preferences and Nutritional Balance

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Abstract: This paper proposes a healthy eating habits support system that recommends menu selections based on a user's taste preferences and the requirements of long term nutritional balance. This system is comprises a nutritional management system (NMS) and a Kansei retrieval system (KRS). NMS adopts a tabu search method to generate a large number of nutritionally balanced menus by combining multiple recipes from a recipe database and stores these menus in a "candidate list." From this candidate list, KRS retrieves menus that are compatible with a user's taste preferences and presents these menus to the user. KRS utilizes Kansei retrieval agents that represent a user's taste preferences and impressions that, subject to a user's evaluation of the presented menus, evolve based on a hybrid model composed of a genetic algorithm and simulated evolution. A simulation using 7,260 actual recipes incorporating 13 types of nutrients demonstrated that the system presented a large number of menus nutritionally balanced over the long term, and predicted a user's taste preferences with more than 80% accuracy after continuous use for eight weeks.

Keywords: Eating Habits Support, User's Taste Preference, Nutritional Balance, Interactive Evolutionary Computation.

1. INTRODUCTION

It is impractical for people who cook every day for their family to plan a new menu on a daily basis. Thus, they often consult websites when they need new ideas for their menus (Allrecipies.com, CDKitchen.com, FOODILY). The popular recipe retrieval website "Allrecipes" (Allrecipies.com) is accessed by over 24 million unique visitors each month (Allrecipes.com – Newsroom). This

indicates that a large demand for recipe retrieval sites is in evidence. However, contemporary recipe retrieval sites generally retrieve a recipe either by using a keyword or by recommending a popular recipe. In these conditions, a user's taste preferences are not considered, since these sites yield the same retrieval results for all users. In addition, the search results for many recipes do not describe the nutritional details of the recipes. Almost all recipe retrieval sites need a keyword for retrieval and display the nutrients included in a recipe. Therefore, we propose a healthy eating habits support system (HEHSS) that presents recipes based on a user's taste preferences and health needs without requiring the use of keywords.

HEHSS is composed of two main components. The first component is a nutritional management system (NMS) that was introduced in our previous study (Tokumi, Hakamata & Tokumaru, 2013). The second is a Kansei retrieval system (KRS) that was also introduced in another previous study (Hakamata, Tokumi & Tokumaru, 2011). In addition, we employ the "interactive evolutionary computation model," using a Kansei retrieval agent (Tokumaru & Muranaka, 2008) for KRS.

In our previous studies, these two systems were developed independently and their effectiveness was confirmed by numerical simulation. However, HEHSS has not been implemented. Therefore, this study implements HEHSS by integrating NMS and KRS and evaluates its effectiveness, using the real recipe data.

2. HEALTHY EATING HABIT SUPPORT SYSTEM

HEHSS considers user taste preferences and health requirements to present recipes. However, when only a single recipe is presented, as shown in Fig. 1, the user must combine the presented recipe with other recipes to create a complete meal. This represents an undesirable burden for the user. Therefore, we propose a system of menu creation that combines multiple recipes for complete meals that are presented to the user, and thus alleviates user burden.

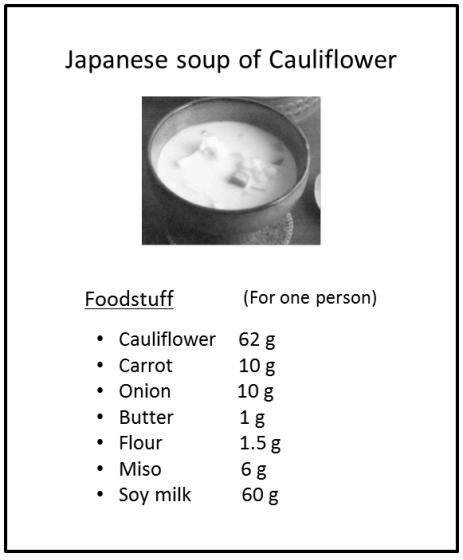

Figure 1: An example of recipe data used in HEHSS.

HEHSS is comprises NMS and KRS. The structure of this support system is shown in Fig. 2. First, NMS creates nutritionally balanced menus that combine multiple recipes, using the tabu search (TS) method (Glover, 1989 & 1990), and stores the generated menus in a "candidate list." The TS method is a metaheuristics type method and is often used in cases where the problem is one of combinatorial optimization. Next from the candidate list, Kansei retrieval agents (Agents) retrieve

and present menus based on a given user's taste preferences. Agents are used as representations of the user's taste preferences and impressions. The user selects a menu and cooks and consumes the meal. The nutrients the user will consume in this single meal are included in the presentation of the menu selected by the user. Next, the user evaluates the consumed menu, and the Agents evolve using a hybrid model combining a genetic algorithm (GA) and simulated evolution (SimE) scheme (Kling, 1987) on the basis of the user evaluation. GA and SimE refer to a type of metaheuristics that simulates the evolution process of organisms. Through repetition of this process, the taste preferences of Agents evolve to become similar to those of the user. Consequently, an Agent can present the user with a menu that suits their tastes with increasing accuracy.

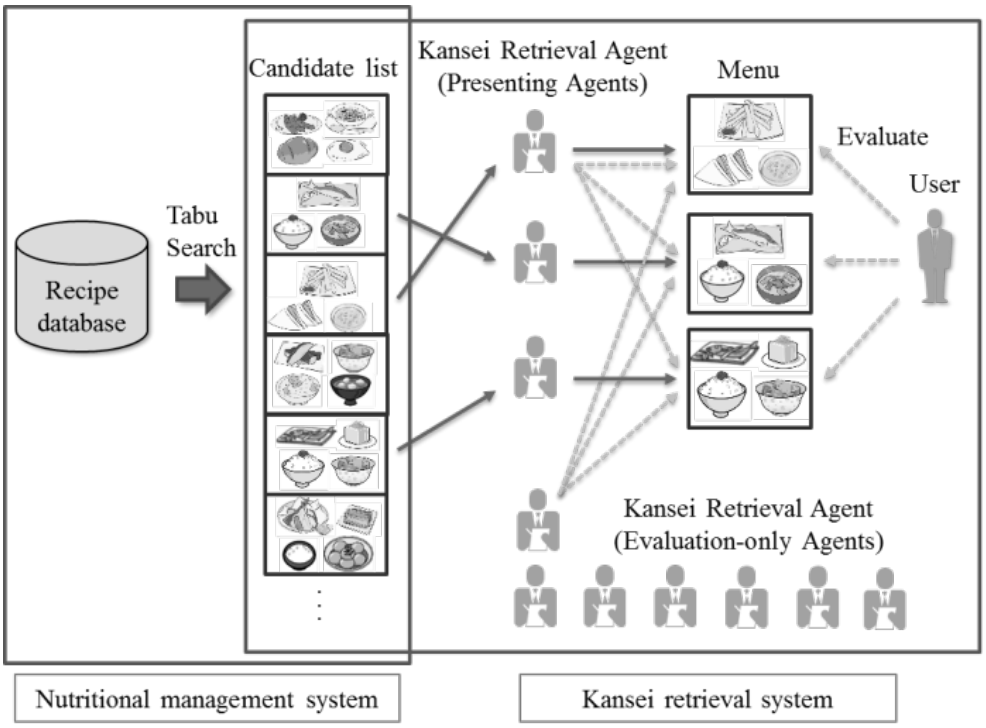

Figure 2: A schematic of the healthy eating habit support system (HEHSS) illustrating NMS on the left and KRS on the right. Agents mediate the retreival of menus that the user consumes and evaluates; thus, Agent preferences evolve to increasingly correspond to those of the user.

3. NUTRITIONAL MANAGEMENT SYSTEM

3.1. Processing

We describe the procedure used by NMS for a case in which the menu is composed of three recipes, as illustrated in Fig. 3. First, NMS randomly selects three recipes, $recipe_a$, $recipe_b$, and $recipe_c$, from a database. The selected recipes represent the initial solution obtained using the TS method. Next, NMS selects one recipe at random from the initial solution set. Then, NMS forms a neighborhood solutions group based on the selected recipe. The example shown in Fig. 3 indicates that NMS selects $recipe_a$ and forms a neighborhood solutions group consisting of $recipe_{a1}$, $recipe_{a2}$, …, $recipe_{an}$ that include nutrients similar to $recipe_a$.

Next, NMS evaluates the menu composed of $recipe_{a1}$, $recipe_b$, and $recipe_c$, and then consecutively substitutes $recipe_{a1}$ with $recipe_{a2}$, $recipe_{a3}$, …, $recipe_{an}$ in sequence. NMS similarly evaluates each combination of recipes in sequence. The details of this evaluation are described in Section 3.2. NMS examines the recipe included in the neighborhood solutions group exhibiting the highest evaluation. If the recipe does not exist in the tabu list, NMS forms a new solution. In the

example shown in Fig. 3, this solution is composed of $recipe_{a2}$, $recipe_b$, and $recipe_c$, because $recipe_{a2}$ returned the highest evaluation and thus substitutes for $recipe_a$. At this time, NMS adds $recipe_a$ to the tabu list to avoid cycling. While processing TS, menus with an evaluation value larger than the threshold are selected and added to the candidate list if not already present. Standard TS aims to find the single best solution. In contrast, the TS method employed by NMS aims to search numerous menus with evaluation values more than the threshold. Therefore, if the solution does not change, NMS forms a new initial solution and restarts TS. In this case, NMS clears the tabu list (Glover, 1989). NMS repeats the TS process until termination conditions are reached.

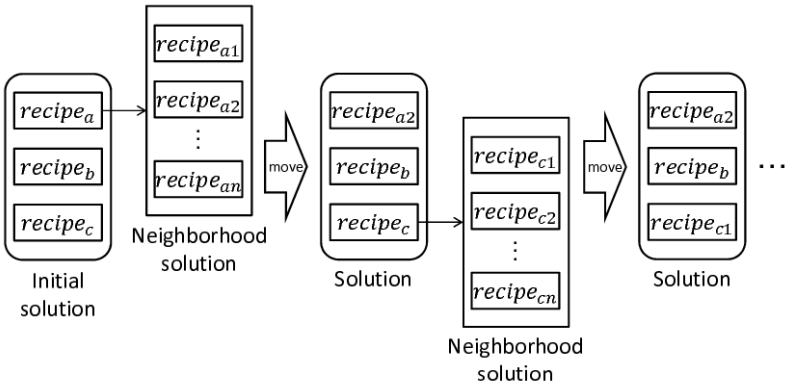

Figure 3: A schematic of the tabu search (TS) method employed by the nutritional management system (NMS) that seeks to locate numerous menus with evaluation values higher than the established threshold.

In this study, NMS retrieves menus by considering 13 types of nutrient categories, given as Energy, Fat, Saturated fatty acid, Vitamin A, Calcium, Iron, Protein material, Vitamin B1, Vitamin B2, Vitamin C, Alimentary fiber, Kalium, and Sodium chloride equivalent. In “the dietary reference intakes of the Japanese in 2010” (Ministry of Health, Labour and Welfare in Japan, 2010), these 13 types of nutrients are categorized into 5 types according to the preference order of intake. Table 1 shows the preference order of intake of these 13 nutrient categories in detail.

3.2. Calculation evaluation

In this section, we describe the method for evaluating a menu by providing a value *E*, as expressed by Equation (1).

$$\boldsymbol{E = \prod_{i=1}^{N} e_i} \qquad (\mathbf{1})$$

where *i* denotes types of nutrients, *e* ($0 \le e_i \le 1.0$) denotes evaluation of each nutrient included in the menu, and *N* denotes the total nutrient count. NMS considers 13 types of nutrients to create menus; therefore, the value for *N* is 13 and NMS considers all nutrients when creating menus. In summary, we cannot overlook the absence of any single nutrient; therefore, we calculate all nutrients in *E* by multiplying the values of e_i. This allows for assessment and correction of excessive or deficient nutrient intake.

The 13 nutrients considered by NMS are shown in Table 1. The necessary intake for each nutrient is defined by the “the dietary reference intakes of the Japanese in 2010,” and we configured the nutrient evaluation functions to calculate e_i on the basis of the features of each individual nutrient.

For example, Energy, given as Type 1 in Table 1, has very specific intake requirements, and we

evaluated its intake using the function shown in Fig. 4. We define this function as a Type 1 function.

Table 1: List of nutrients

evaluation function	Kind of Nutrient
Type1	Energy
Type2	Fat, Saturated fatty acid
Type3	Vitamin A, Calcium, Iron
Type4	Protein material, Vitamin B1, B2, C, Alimentary fiber, Kalium
Type5	Sodium chloride equivalent

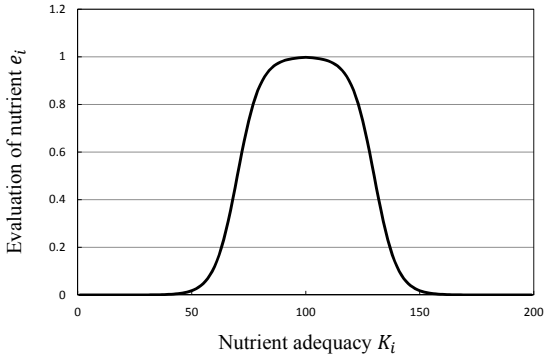

Figure 4: Evaluation function used to evaluate menu Energy requirements, given as Type 1 in Table 1.

Similarly, Fat and Saturated fatty acid also have specific intake requirements, which must be satisfied almost exactly. In this context, “almost” means approximately ±10% of the required intake. We use the evaluation function shown in Fig. 5 to assess Fat and Saturated fatty acid intake, and define this function as a type 2 function. In Fig. 5, *Llimit* is the lower intake requirement and *Ulimit* is the upper intake limit. If a user intakes less than *Llimit* or more than *Ulimit*, the value of e_i is decreased.

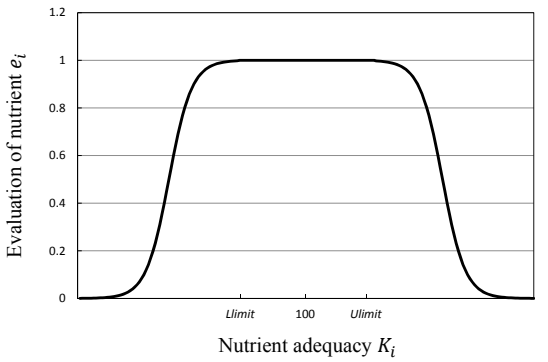

Figure 5: Evaluation function used to evaluate menu Fat and Saturated fat requirements, given as Type 2 in Table 1, where *Llimit* is the lower intake requirement and *Ulimit* is the upper intake limit.

To evaluate the nutritional intake of Vitamin A, Calcium, and Iron, we use the evaluation function shown in Fig. 6 and define this function as a Type 3 function. In Fig. 6, *UL* denotes the “Tolerable Upper Intake Levels” (Ministry of Health, Labor and Welfare, 2010) configured for each nutrient’s intake. Unlike *Ulimit* in Fig. 5, if a user intakes a greater quantity of these nutrients than *UL*, the value of e_i becomes 0.

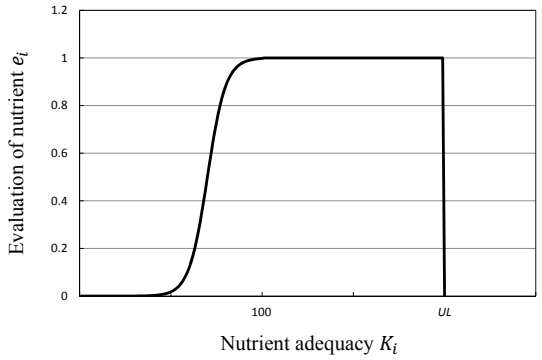

Figure 6: Evaluation function used to evaluate menu Vitamin A, Calcium, and Iron requirements, given as Type 3 in Table 1, where the upper limit *UL* is configured for each nutrient's intake.

For Protein material, Vitamin B1, Vitamin B2, Vitamin C, Kalium, and Alimentary fiber, an upper nutrient intake limit is not configured. However, the lower limit is configured. Thus, we evaluate these nutrients using the evaluation function shown in Fig. 7 and define this function as a Type 4 function.

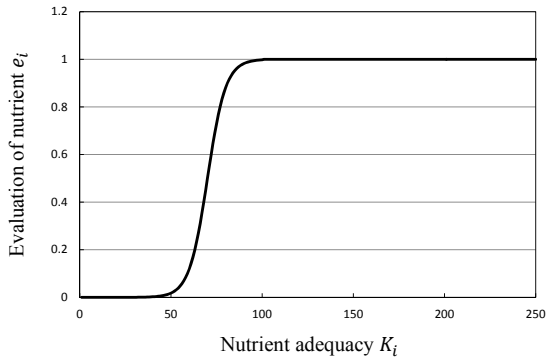

Figure 7: Evaluation function used to evaluate menu Protein material, Vitamin B1, Vitamin B2, Vitamin C, Alimentary fiber, and Kalium requirements, given as Type 4 in Table 1.

For the Sodium chloride equivalent, the lower limit is also not configured. However, the upper limit is configured. Thus, we use the evaluation function shown in Fig. 8 to assess the nutritional intake of the Sodium chloride equivalent and define this function as a Type 5 function.

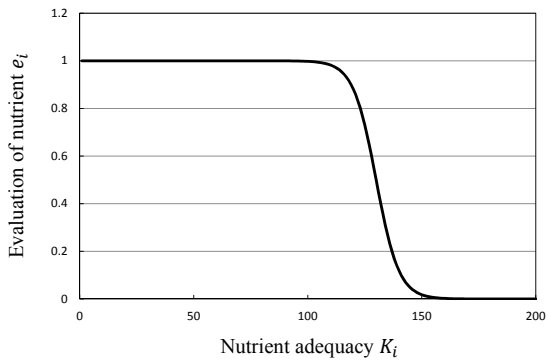

Figure 8: Evaluation function used to evaluate menu Sodium chloride equivalent requirements, given as Type 5 in Table 1..

By configuring the evaluation functions for e_i on the basis of the features of each nutrient, e_i can be calculated using equation (2).

$$e_i = f_j(K_i) \qquad (1 \le j \le 5) \qquad (\mathbf{2})$$

where K_i denotes the percentage of the required nutrient intake in a meal and $f_j(K_i)$ denotes the evaluation functions that normalize K_i into a numerical value from 0 to 1.0. The evaluation function type is represented by the numerical index j (for j = 1–5), which corresponds to the 5 function types. K_i is expressed by Equation (3), where *Sum* represents the sum of the nutrients included in a menu and $NesIntake_i$ denotes the nourishment a meal must provide.

$$K_i = \frac{Sum_i}{NesIntake_i} \times 100\% \qquad (\mathbf{3})$$

3.3. Considering nutrient balance for the long-term

The daily nutrient requirement for a person was configured using "the dietary reference intakes of the Japanese in 2010." However, it is difficult for users to obtain the configured nourishment every day. Therefore, NMS aims to provide for intake of the configured nourishment over the long term.

First, NMS stores a menu chosen by the user that is presented by KRS. Next, *IntakeError* is calculated using Equation (4).

$$IntakeError_{i,t} = FactIntake_{i,t} - NesIntake_{i,t} \qquad (\mathbf{4})$$

where *IntakeError* denotes the accumulation of the intake error, *FactIntake* represents the nourishment included in the selected menu, *NesIntake* is the nourishment that the user needs to obtain in a given meal, i represents any one of the 13 types of nutrients, and t is the number of meals. $NesIntake_{i,t+1}$ is calculated using Equation (5).

$$NesIntake_{i,t+1} = BaseIntake_i - IntakeError_{i,t} \qquad (\mathbf{5})$$

where *BaseIntake* shows the standard value of intake, as specified according to "the dietary reference intakes of the Japanese in 2010." *IntakeError* is improved by renewing *NesIntake*. In our study, if e_i (discussed in Section 3.2) is 1.0, NMS does not calculate *IntakeError*.

4. KANSEI RETRIEVAL SYSTEM

4.1. Processing

We describe the procedure employed by KRS using Agents. These Agents are models that learn a user's preferences and use this information to retrieve menus from the candidate list where NMS stores menus. Agents are optimized by consulting user evaluations. KRS uses two types of Agents, given as presenting Agents and evaluation-only Agents. Each presenting Agent selects a menu from the candidate list on the basis of its knowledge of the user's preferences. The Agent then recommends the selected menu to the user, and the user evaluates the recommendation. The presenting Agent also evaluates menus recommended by other presenting Agents, using their knowledge of the user's preferences. The evaluation-only Agents, using their knowledge of the user's preferences, only evaluate menus recommended by the presenting Agents even though they do not themselves present any menus to the user.

Presenting Agents and evaluation-only Agents have the same structure and evaluate menus recommended to the user by presenting Agents. Then, an Agent whose evaluation values are similar to those of the user gets recognized as an appropriate Agent fitting the user. In the optimizing process, the more appropriate Agents become new presenting Agents and recommend menus to the user

4.2. Kansei Retrieval Agent

An Agent evaluates a menu on the basis of items contained in the menu. Recipe data include cooking ingredients such as carrots and onions, seasoning such as sugar and salt, food categories such as Italian or French, taste such as sweet or hot, and cookery methods such as fry or boil. The values of cooking ingredients and seasonings, which are real-valued attributes, take the number of grams if the item is used in a recipe, otherwise 0. The values of other categories take a value of 1 if the recipe belongs in the category, otherwise 0.

The Agent codes for the same elements in correspondence with recipe data. An example of Agent and recipe coding is shown in Fig. 9. Each element of the Agent takes the values of P (Positive), N (Negative), or D (Don't care) in correspondence with the recipe data. For example, Fig. 9 indicates that, when an Agent recognizes that the user dislikes carrot, the Agent element corresponding to the recipe element of carrot takes the value of N, and the Agent seeks recipes that exclude carrot. Similarly, when the Agent recognizes the user likes onion, the value for the onion element is P, and the Agent seeks recipes that include onion. A value of D means that the user is unconcerned about the element and, in Fig. 9, the Agent does not discriminate between recipes on the basis of the sugar element.

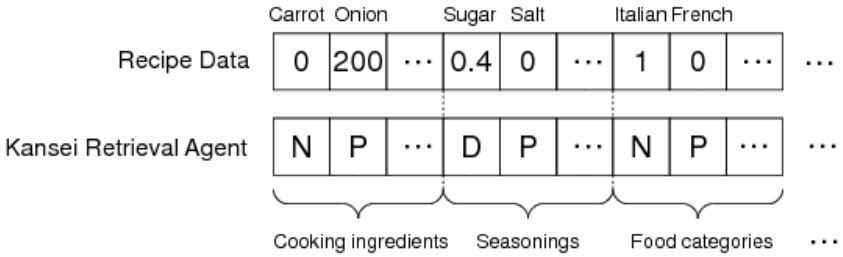

Figure 9: Coding of recipe data and that of the Kansei retrieval agent (Agent), showing a correspondence between the elements of the two groups.

When the Agent searches for a menu in the candidate list that is to be presented to the user, the Agent evaluates menus and assigns a grade to it. The overall grade of the menu is computed by the sum of the evaluated values of recipes that are contained in the menu. The Agent evaluates recipes using Equation (6).

$$V = \sum_{i=1}^{S} (P_i \times W_i) \qquad (6)$$

where S is the number of elements, P_i is the value of the fundamental point listed in Table 2, and W_i is the weight. If an Agent element is denoted by P, and the element of the recipe is denoted by 200, such as is the case of the onion element given in Fig. 9, the fundamental point takes a value of +1.

Table 2: F Fundamental points based on correspondence between Agent and recipe elements.

Kansei Retrieval Agent	Recipe	Fundamental Point
P	0	0
P	1	+1
N	0	0
N	1	−1
D	0	0
D	1	0

Similarly, if an element of the Agent is denoted by N, and the element of the recipe is denoted by 1, which is in the case of the Italian element in Fig. 9, the fundamental point takes a value of −1. The weight is a degree that indicates the impression an element conveys for a user. In general, favorite and less favorite foods do not change. However, likes and dislikes of a particular food category might change according to mood. Thus, the weight of a desirable food category needs to be higher than that of other items. An Agent estimates that higher the evaluation value of a menu greater is the user preference.

4.3. Fitness Function

I n KRS, the Agent evolves using a hybrid model combining a GA and SimE, which is described in Section 4.4. The Agent has a fitness function to determine how similar its knowledge of the user's preference is to the user's actual preference. The closer the user's evaluation is to the Agent's evaluation, the higher the fitness given to the Agent. The fitness of the Agent is computed using Equation (7).

$$F = \sum_{i=1}^{N_m} \sum_{j=1}^{N_r} \left| V_{ij}^{agent} - V_{ij}^{user} \right| \qquad (7)$$

where N_m is the sum of the presented and recoded menus, N_r is the number of recipes included in the menu, and v^{agent} and v^{user} are the Agent's and user's evaluations given by Equation (6) for recipe j of menu i, respectively.

4.4. Hybrid IGA-SimE Learning Technique

KRS uses a hybrid IGA-SimE learning technique proposed in our previous study to evolve the Agents. This technique combines an interactive genetic algorithm (IGA) (Smith, 1991) and SimE. IGAs are among the methods used in interactive evolutionary computing. While a conventional GA uses an evaluation function to determine fitness, IGA obtains fitness by consulting user evaluations.

SimE mimics biological evolution, much like GA, but SimE does not share the problem of converging to localized solutions, as is present in standard GAs. Every element in a SimE scheme is considered to be an individual with some level of fitness. The basic procedure performed by SimE consists of three steps: evaluation, selection, and allocation.

Fig. 10 shows a flowchart for the hybrid IGA-SimE learning technique. Although the method is based on IGA, it uses SimE to process mutations.

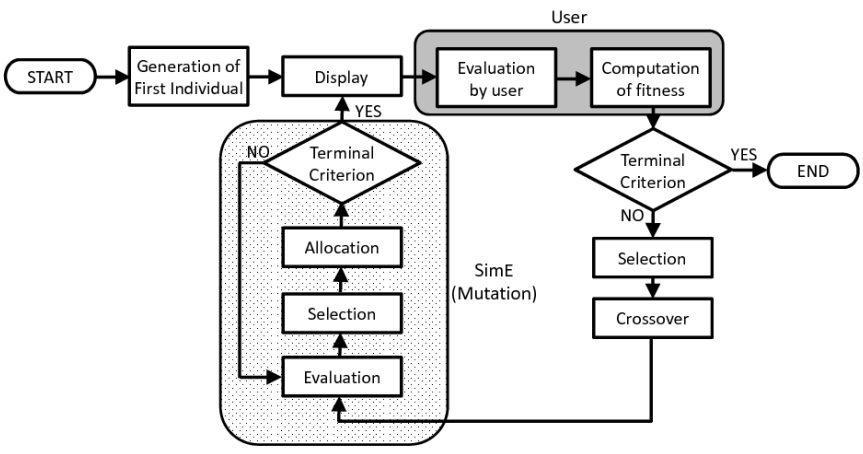

Figure 10: IGA-SimE flowchart

5. SIMULATION

5.1. Outline

In this section, we discuss the simulation study performed to examine the effectiveness of the HEHSS, using real recipe data. This simulation adopted a user interface that allows actual users to easily evaluate menus recommended by the system. This simulation used a simple method in which users rearranged menus in the order of their preference.

For the simulation, we stored 7,260 real recipes utilizing all 13 types of nutrients into the database, 7,048 of which were from two well-liked recipe retrieval websites in Japan (COOKPAD & Calorepi) and 212 of which were from recipe books (TANITA CORPORATION, 2010). We also selected the most popular 100 cooking ingredients affecting user preference for coding Agents and recipes by eliminating cooking ingredients, for example, snails and peanuts, that are seldom used in recipes, or combining several cooking ingredients, such as green peppers and red bell peppers, that give users a similar taste. Thus, the number of elements for Agents and recipes was 100.

5.2. Simulation Conditions

The simulation assumes that HEHSS continues to recommend menus to a user for over 60 days. In this case, the user needs to evaluate menus over 180 times, using the system three times a day for breakfast, lunch, and dinner. Since it is difficult to perform this series of interactions with actual users, in the simulation we used an Agent that has a particular preference to evaluate menus instead of an actual user. We call this Agent a quasi-user. In this simulation, the quasi-user had P, N, or D values for each cooking ingredient, which was randomly selected under the condition where the quasi-user liked 25% of the 100 total cooking ingredients, disliked 25%, and had no preference regarding the remaining 50%. Therefore, the number of elements for the quasi-user having P values was 25, N values was 25, and D values was 50.

In this simulation, NMS retrieved menus by considering that the quasi-user ate a larger portion at lunch, providing for approximately 40% of the daily nutritional requirement, and breakfast and dinner each provided 30%. Each meal had a menu including three recipes, which was recommended by the system and a portion of white rice. NMS held up to 30,000 menus in the candidate list.

KRS utilized 200 Agents in the simulation, five of which were presenting Agents and 195 of which were evaluation-only Agents. Thus, KRS recommended five menus from the candidate list for each meal. The quasi-user evaluated and rearranged those menus in its preferred order.

The hybrid IGA-SimE learning technique requires a sufficiently high number of menus that have been evaluated by a user because the accuracy of the Agent fitness evaluation affects the performance of the optimization positively. Therefore, the quasi-user evaluated 100 menus randomly selected before performing IGA-SimE, and, after this pre-evaluation, KRS optimized the Agents, using evaluation data of those 100 menus and adding evaluation data of new menus presented to the quasi-user in each recommendation. While performing IGA-SimE, the quasi-user repeated menu evaluation 210 times, which means that the system had been, in effect, used for 70 days.

5.3. Simulation Results

Tables 3 and 4, and Fig. 11 show the simulation results. The data presented in Table 3 confirm that NMS could adjust the user's nutritional intake over the course of 70 days while satisfying all 13 nutritional needs.

Fig. 11 shows the average learning performance of KRS in 100 simulation trials, in each of which a quasi-user with different preferences was used. The results show the difference in the codes of the Agent whose fitness is the best and those of the quasi-user. Two types of errors are used, as described below.

1） Errors using the complete consistency criterion

Errors using the complete consistency criterion measure the differences of identical elements between the Agent and quasi-user. These errors are the output of the number of elements that are not completely consistent.

2） Removed-D errors

Removed-D errors output the number of consistent elements unless the element of the Agent and quasi user is D.

Table 3: Comparison of nutritional needs and average quantity of nutrients included in a day

Name	nutritional needs during one day	FactIntake for 3 meals
Energy	2,120 — 3,180 kcal	2,643 kcal
Protein material	50.0 g —	102.0 g
Fat	58.9 — 88.3 g	73.5 g
Saturated fatty acid	13.3 — 20.6 g	17.0 g
Vitamin A	600 — 2,700 μg	831 μg
Vitamin B_1	1.2 mg —	1.6 mg
Vitamin B_2	1.3 mg —	1.7 mg
Vitamin C	85.0 mg —	257.2 mg
Calcium	650 — 2,300 mg	756 mg
Iron	6.0 —50.0 mg	13.6 mg
Alimentary fiber	19.0 g —	32.1 g
Sodium chloride equivalent	— 9.0 g	7.7 g
Kalium	2,500 mg —	5,303 mg

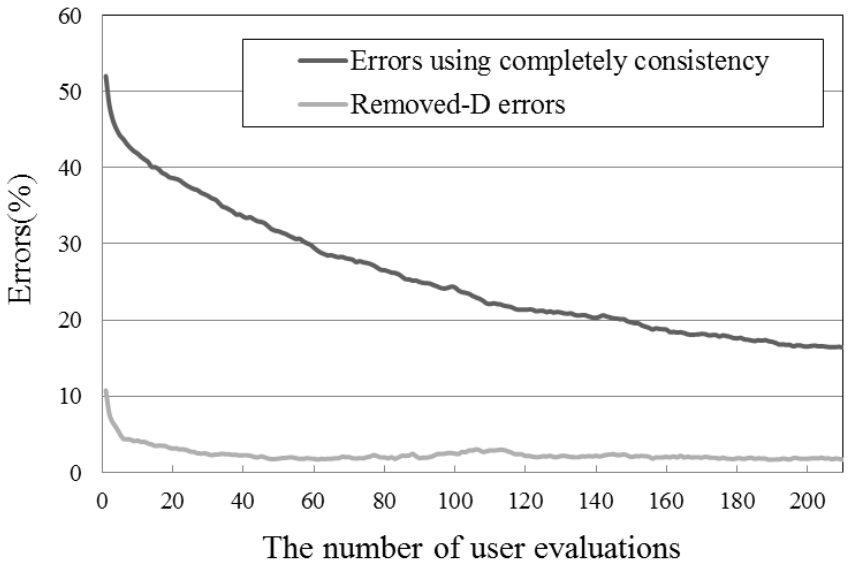

Figure 11: Output of errors

The errors are reduced as the user progressively evaluates the menus. This also confirms that the system was able to learn about 75% of the user's preferences after 100 evaluations (by reducing the errors to approximately 25%) and over 80% after 200 evaluations. Moreover, the removed-D errors are less than 5% after 20 evaluations. This result indicates that the system could learn the user's preferences rapidly and predict which cooking ingredients the user liked or disliked.

Table 4: Example of menus selected to the user

Date	Menu
Day 16 : Breakfast	①Simmered radish ②Lettuce salad ③Stir-fried spinach and pork with oyster sauce
Day 16 : Lunch	①Vinegared vermicelli ②Thai rice ③Fried burdock and chikuwa
Day 16 : Dinner	①Kimchi fried rice ②Japanese style deep-fried chicken ③Fried Japanese mustard spinach and radish Kimchi
Day 17 : Breakfast	①vegetable gelatin ②Fried vegetables ③Okra and grated yam with grated radish
Day 17 : Lunch	①Apple yogurt cake ②Grilled eggplant with grated radish ③Simmered sweet potato and apple
Day 17 : Dinner	①Fried potato and beef ②Japanese mustard spinach and eggplant and bean sprouts with grated radish ③Wholesale ponzu sauce of grilled eggplant
Day 18 : Breakfast	①Plum cake ②Spicy salad of Bean Sprout and Japanese mustard spinach ③Fried eggplant and Japanese mustard spinach
Day 18 : Lunch	①Simmered eggplant ②Sesame salad of steamed chicken and broccoli ③Grilled eggplant and green pepper with onion and bonito
Day 18 : Dinner	①Apple pastry ②Stir-fried sweet and spicy radish leaf ③Fried egg and Chinese chive and whitebait
Day 19 : Breakfast	①Pork and Japanese mustard spinach with grated radish ②Seasoned ground meat rice ③mushrooms with grated yam
Day 19 : Lunch	①Curry pilaf ②Bread of steamed spinach ③Hamburger of spring vegetables
Day 19 : Dinner	①Fried pork and potatoes ②Chicken nugget with curry sauce ③Japanese mustard spinach with mustard

Table 4 shows examples of menus presented to the user for each meal after system learning for 15 days, which means after 45 evaluations. In this example, the quasi-user preferred radish and eggplant. The result shows that HEHSS learned the user's preference and often recommended recipes that used radish (seven recipes) or eggplant (six recipes).

6. CONCLUSION

In this study, we developed HEHSS, integrating NMS and KRS. This study focused on a performance evaluation of the system for long term use of real recipe data. Using 7,260 real recipes, the system could recommend various menus adjusting the user's nutritional intake for eight weeks while satisfying all 13 nutritional needs. Moreover, KRS could learn more than 80% of a user's preferences after eight weeks' evaluation and recommend various user preferred menus. However, only quasi-users (Agents of set preferences) were used in this simulation, and we plan to test the effectiveness of the system by using real users in future.

ACKNOWLEDGEMENT

This research is partially supported by MEXT–Supported Program for the Strategic Research Foundation at Private Universities, 2013-2017 from Ministry of Education, Culture, Sports, Science and Technology.

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BIOGRAPHY

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KEER2014, LINKÖPING | JUNE 11-13 2014
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Fostering Trust-based Relationship between Self-care Users and Home Medical Device in Thai and Japanese

Research on the Methods for Incorporating Social Roles in Blood Pressure Monitor to Increase Thai and Japanese User's Perception of Trustworthiness

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Abstract: This paper presents a cross-cultural research on the perception of trustworthiness in self-care home medical device - in particular, blood pressure monitor - in Thai and Japanese young adults. The study focuses on the method of incorporating social role image into the device to strengthen the image of trustworthiness, and its effects on Japanese and Thai users.

The emerging challenges in home medical device design call for the integration of trustworthy image in order to help alleviate the feeling of fear and worrying of non-professional users when interacting with medical devices. This research focuses on one particular methodology for creating perception of trustworthiness in technological agent: the incorporation of social role image. The first part of the research includes a cross-cultural survey (Thai and Japanese) on trustworthiness impressions of 7 social roles that are related to home medical products. The second part is comprised of an experiment to investigate different methods of incorporating "Caretaker/Nurse" social role into blood pressure monitor (BPM)'s cuff, and their effectiveness in conveying impression of trustworthiness of BPM to Thai and Japanese young adult users. The result shows no significant differences in direct trustworthiness rating between designs with social role image and design without, in both Thai and Japanese. However, there are significant changes in mood and ratings of components that are found in literature reviews to be related to perception of trustworthiness.

Keywords: Trustworthiness, Home medical device, Social roles, Cross-cultural, Blood pressure monitor

1. INTRODUCTION

The perception of trustworthiness is central to creating “trust” between users and devices. Trust is a complex phenomenon that lies at the foundation of interpersonal relationship and how we interact with the world around us (Simpson, 2007). The targets of trust range from people with close personal relationship to more abstract ideas such as political institutions, enacted law and in technological systems and products existed in our everyday life. By trusting technology, the need to fully understand how it works and to consider the many different factors that affect its operation is eliminated. Although the absence of understanding can have detrimental effects, it also works to help reduce complexity and allows us to use technology more smoothly and efficiently.

The complexity of trustworthiness perceptions is also attributed to the contextual and cultural factors involved. For example, a Japanese person may find a colorful, friendly-looking medical device trustworthy, but Thai person might think otherwise. Hence, accounting for cultural differences is an important point when designing the device to look trustworthy.

The researches on how to create an image of trustworthiness in technological device have been few, with most focusing on digital applications or branding. As such, there is a need to investigate how perception of trustworthiness could be incorporated into physical device. The emerging challenges in home medical device design also call for the integration of trustworthy image in order to help alleviate the feeling of fear and worrying of non-professional users when interacting with medical devices.

The objective of this paper is to investigate how self-care home medical device can be designed to convey a greater sense of trustworthiness and to compare and contrast the resulting effects between Thai and Japanese users. The paper will focus on one particular methodology of creating perception of trustworthiness in technological agent: *the incorporation of social role*.

2. INTERPERSONAL TRUST

2.1. Trust in Interpersonal Relationship

“Trust” or “interpersonal trust” has been recognized as an important facet of human’s relationship (Simpson, 2007). A simplified model by Hardin (1993 cited Sztompka, 1999, p. 55) defines trust relation as having three parts:

$$\text{“}A \text{ trusts } B \text{ to do } X\text{”}$$

This refers to when someone (A) trust or willingly rely on another person (B) to accomplish certain thing (X). This model explains in very simple terms how three different components of trust interact in the relationship, as well as suggests a relative nature of trust dynamic relationship. That is, person A specifically trust B with regards to X, but might not trust B with regards to other things.

2.2. Cognitive and Affective Trust

In an attempt to better understand interpersonal trust, Lewis and Weigert identified 3 bases of trust: cognitive, affective and behavioral. The 3 bases were later generalized into two types of trust: *cognitive* and *affective* (1985). Cognitive trust relies heavily on the objective, rational process, while affective trust is dependent on emotional aspects (Lewis & Weigert, 1985). Recent studies in marketing apply this distinctions to explain service relationships as followed:

Cognitive trust

This type of trust refers to the "customer's willingness or confidence to rely on a service provider's competence and reliability" (Johnson & Grayson, 2005, p.501). The trust assessment is based on knowledge and evaluation about the potential trustee's ability and related likelihood of accomplishing certain goals.

Affective trust

On the other hand, affective trust is formed on the "basis of feeling generated by the level of care and concern" demonstrated by the trustee (Johnson & Grayson, 2005, p.501). The emotional trusting bond is often created through benevolent or caring responses from the trustee, which accumulate into personal experience that deepens over time.

3. TRUST AND TECHNOLOGY

3.1. Computer-are-Social-Actors (CASA) Paradigm

The rapid advancement in computational technologies has allowed human and technology to form extensive interactions with each other. The Computer-are-Social-Actors or CASA paradigm pioneered by Clifford Nass (1994) demonstrated that:

> "*...Once a computer (or a computer agent) looks, 'talks' (via either text or speech), or behaves like a person - however minimal these cues might be - people would respond to it as if it were a real person*."
>
> - Lee & Nass, 2010

When applying the CASA approach to the concept of trust between human and computer, it was found that people's perception of computer's trustworthiness is subject to the same conditions in that of interpersonal trust (Lee & Nass, 2010). Several empirical studies relating to different aspects of trust formation were conducted to help better understand how trust relationship can be created between users and technology. For example, Tschannen-Moran & Hoy established that people are more inclined to trust those they perceive to be similar. (2000). In a study by Nass & Lee (2001, cited Lee & Nass, 2010), based on Tschannen-Moran & Hoy's theory, text-to-speech system or TTS was used to create extrovert and introvert personality in computers (by altering intensity, frequency and speech rate). The speech was then synthesized, which acts as a reminder for people that they are, in fact, interacting with lifeless digital system and not a real person. Participants, a mixture of extrovert and introvert personalities, were split into two separate group. They were asked to listen to book reviews on an online shopping website, with one group being read by the extrovert voice and the other by the introvert voice. The result shows that, firstly, participants were able to distinguish between extrovert and introvert voices. Secondly, they prefer the voice that match their personality more. Moreover, even when the review texts were the same for both group, the participants rate the review as more trustworthy and trusted the reviewer more when the personality of the reader's voice matches their own personality.

The study illustrates the possibility of fostering trust relationship between users and computer through integrating caring and extrovert/introvert personality into the interactive computer agents. It also allows for a better understanding of the emotional connection between technology and its users, and pave the way for developing trustworthy technology in the future.

3.2. Cues and Mindless Social Responses

Several studies in the CASA paradigm have showed that people respond to interactive technological agents, mindlessly and automatically, as social actors (Nass & Moon, 2000). The concept of mindless responses have been observed in many social situations (Langer, 1989, cited Nass & Moon, 2000). The process of eliciting these mindless social responses begins when individuals encounter an object that has "enough *cues* to lead the person to categorize it as worthy of social responses" (Nass & Moon, 2000, p. 83).

Although there have not been conclusive studies with clear findings about what kind of cues encourage users to identify a non-human, technological agent as social actor, it was observed that even primitive cues, such as text and voices, that are associated with human are powerful enough to elicit social responses (Nass, C., Steuer, J. & Tauber, E. R., 1994). Initially, 3 types of cue were identified: words for output, interactivity and filling of roles traditionally filled by humans (Nass & Moon, 2000). Fogg, in his book about persuasive technology (2003), later expanded and categorized social cues into 5 types: physical, psychological, language, social dynamics and social roles.

Incorporating social roles into computer agents was dated back to the 1960's when ELIZA, a program that takes the role of a psychotherapist. Fascinatingly, its creator found that people would sometimes interact with ELIZA as if the program is a real therapist. (Weizenbaum, 1966). Computing products that are presented as a social role often adopts roles that are in the positions of authority, such as, teacher, expert, or judge. The level of incorporation can range from a still image of the role to interactive animations with movements and voice-overs.

Although Fogg categorized these cues into 5 distinct types, it is obvious that they are often interconnected when incorporated into products to elicit social response. For example, creating an effective social role might require a mixture of physical characterizations as well as language to convey appropriate image of that social role to the users.

3.3. "Social Roles" as Cue

Many social roles in our everyday life are clearly defined. (Golder & Donath, 2004). Some roles are defined by governmental mean, such as police officer and prime minister; others are recognized by their profession and prestige, such as doctors and supervisor. Interestingly, family roles take on both personal and legal foundation. Within a society, each social role is usually expected to have a specific set of skills, responsibilities and privileges. For example, doctor social role is expected to have skill sets required to practice medicine, to be competent, efficient, reliable and helpful (Sztompka, 2003).

Over the years there have been several notable products that implement social roles to elicit desired behaviors from their users. For example, "Ask Jeeves" (currently "Ask") was a search engine that employ the use of butler social role by the name of "Jeeves". The image of a butler could influence the users to feel more served or helped. The visual character and the easy-to-remember name would also help to create an on-going relationship between users and the search engine, which could influence them to come back and use Jeeves' service more often.

4. PRELIMINARY SURVEY ON TRUSTWORTHINESS IMPRESSIONS OF MEDICAL-RELATED SOCIAL ROLES AMONG THAI AND JAPANESE

4.1. Survey Design

According to CASA paradigm, trust relationship between users and product could be fostered by incorporating social cues into the product and applying the same social principles that govern human-to-human trust. The focus of this paper has been to create an impression of trustworthiness in self-care home medical devices through incorporating "social roles" into such devices.

A preliminary survey was conducted to evaluate the trustworthiness perceptions and character trait impressions Thai and Japanese people have towards seven selected social roles that are related to the use of home medical devices. Stakeholders map for medical product created by Prestero (2012) was examined. Several medical-related roles such as doctor, nurse, hospital lab technician and health consultant were considered; this is coupled with roles that have personal connection with self-care user, such as parents, friends and lovers. The number of roles were narrowed down to seven, combining both medical-related and personal-related roles and ranging from most personal to most distant roles:

1. Friend
2. Spouse/Boyfriend & Girlfriend
3. Parents
4. Caretaker/Nurse
5. Fitness Trainer
6. Doctor
7. Hospital Lab Technician

To estimate trustworthiness perception of each role, 10 items with 7-point semantic differential scales were used. The items were adapted from Wheeless and Grotz's Individualized Trust Scale (1977). In the selection and adaptation of items, the concept of cognitive and affective trust by Lewis & Weigert and Johnson & Grayson, and Tschannen-Moran & Hoy's 5 facets of trustworthiness perception were considered. The final trustworthiness perception items are as followed:

- Uncaring-Caring
- Passive-Helpful
- Strict-Kind
- Authoritative-Friendly
- Subjective-Objective
- Unintelligent-Intelligent
- Hard to Understand-Easy to Understand
- Discreet-Open
- Different-Similar
- Untrustworthy-Trustworthy

4.2. Survey Result

26 Japanese participated in the study, 14 of which were male. 31 Thai participated and 12 of which were male. The combined number of participants was 57 with 46% male and 56% female. Principal Component Analysis was applied to the survey's data. For trustworthiness

perception items, there were two components with eigenvalues greater than 1 and both account for 50.26% of total variance. In interpreting the corresponding factor loading data, items with factor loading greater than 0.6 were considered. Note that "Untrustworthy-Trustworthy" item was not included in the PCA, as the items are presumed to be dimensions of trustworthiness perception. The 2 components and factor loadings for each items are as followed:

Table 1: 2 Principal Components and corresponding factor loading for each items

Component 1	
Friendly	.773
EasytoUnderstand	.664
Kind	.660
Similar	.527
Open	.481
Caring	.436
Helpful	.413
Intelligent	-.014
Objective	-.222

Component 2	
Intelligent	.772
Objective	.717
Helpful	.643
Caring	.582
EasytoUnderstand	.344
Similar	.193
Friendly	-.027
Kind	-.070
Open	-.324

Based on Johnson & Grayson's definition of cognitive and affective trust (2005) presented in Section 2.2, component 1 exhibits the requirements for affective trustworthiness, which comprises of feeling of care and concern or in this case "friendliness" and "kindness". Interestingly, being "easy to understand" is also loaded on component 1.

Component 2 is comprised of "intelligence", "objectiveness" and "helpfulness", this exhibits the requirements for cognitive trustworthiness, which is based on competence and reliability of the target of trust.

The residuals of PCA was plotted to create an image map of trustworthiness perception, based on the 2 components, for the 7 social roles. A total of 3 maps are presented here: Fig. 1. Combined score from Japanese and Thai participants, Fig. 2. Score from Thai participants, Fig. 3. Score from Japanese participants

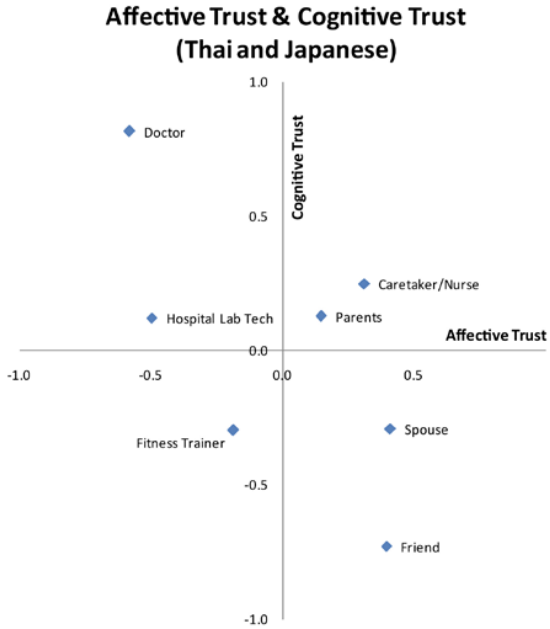

Figure 1: Image map of 7 social roles based on Affective and Cognitive Trustworthiness components (combined score between Thai and Japanese participants)



Figure 2: Image map of 7 social roles based on Affective and Cognitive Trustworthiness components (score from Thai participants only)

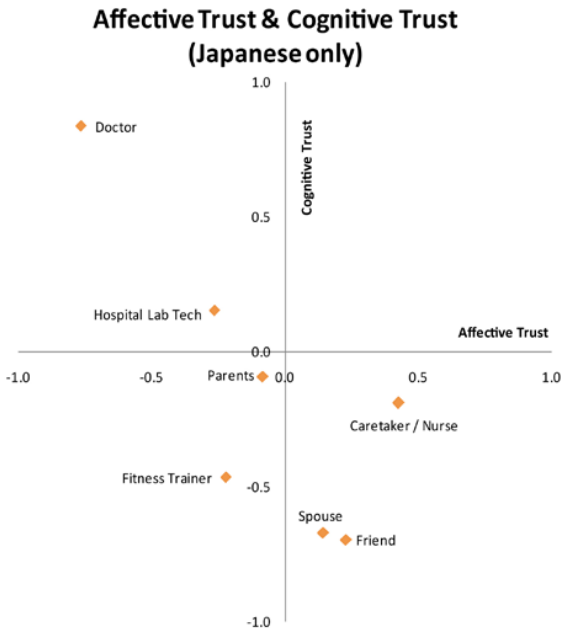

Figure 3: Image map of 7 social roles based on Affective and Cognitive Trustworthiness components (score from Japanese participants only)

The trustworthiness rating for “Friend”, “Doctor”, “Hospital Lab Technician” and “Fitness Trainer” social roles were consistent across Thai and Japanese participants.

Friend, in general, was rated very low regarding cognitive trustworthiness, but scored as one of the highest regarding affective trustworthiness. Doctor on the opposite end scored extremely high on cognitive trustworthiness, but very low on affective trustworthiness. Interestingly, Thai generally rated both social roles slightly higher in affective trustworthiness.

Hospital lab technician was perceived as somewhat cognitively trustworthy, but scored negatively regarding affective trustworthiness. Japanese gave a higher rating for both components. Fitness Trainer was rated negatively for both cognitive and affective trustworthiness. For this role, Thai gave a higher rating for both components.

The roles of “Spouse”, “Parents” and “Caretaker/Nurse” show very interesting results. For Spouse, Thai participants generally gave positive rating to both affective and cognitive trustworthiness, with the affective trustworthiness rating being the highest among the 7 social roles. Japanese, however, rated spouse role as somewhat affectively trustworthy, but very negatively with regards to cognitive trustworthiness.

Similarly, the role of parent was rated relatively high with regards to both cognitive and affective trustworthiness among Thai respondents, but slightly negative on both cognitive and affect among Japanese respondents.

The overall combined score shows Caretaker/Nurse social role to be in positive quadrant for both components, which means that the role is generally perceived as having a combination of both affective and cognitive trustworthiness across Thai and Japanese respondent. However, when Thai and Japanese ratings were examined separately, the role is perceived by Thai as being very cognitively trustworthy, but only slightly affectively trustworthy. Conversely, it is perceived by

Japanese as being more affectively trustworthy (in comparison to Thai), but not so cognitively trustworthy.

Table 2: Showing mean score for "trustworthiness" for 7 social roles (the "1 to 7" scale in the survey was converted to "-3 to 3" scale for PCA, with 3 being most trustworthy)

Untrustworthy-->Trustworthiness	Overall	Japanese	Thai
Friend	**1.91**	2.12	1.74
Spouse&BF,GF	**2.42**	2.73	2.16
Parents	**2.61**	2.62	2.61
Nurse/Caretaker	**2.42**	2.54	2.32
Fitness Trainer	**2.09**	2.08	2.10
Doctor	**2.63**	2.62	2.65
Hospital Lab Technician	**2.32**	2.38	2.26

The mean scores for untrustworthy-trustworthy item above show roughly similar score across the 7 social roles as well as both Thai and Japanese. For the overall score, Friend is rated least trustworthy while doctor is rated most trustworthy.

4.3. Discussion

The image maps of trustworthiness perception for the 7 social roles may prove to be useful when determining which social roles to incorporate into products. When the product is required to look trustworthy with regards to its functionality and efficiency, social roles that score higher on cognitive trust component, for example, doctor, may be more appropriate, as they are perceived as being objective and intelligent. On the other hand, products that want to establish an easy-to-use and friendly image may want to incorporate roles that score higher on affective trust component, for example, friend social role.

The role of spouse, caretaker/nurse and parents show a very interesting result with regards to cultural differences. They both score as one of the highest in untrustworthy-trustworthy items across the two cultures, but Japanese tend to give a lower score with regards to cognitive trustworthiness component. Again, this may account for contextual differences, or in this case cultural differences with regards to the combination of trustworthiness dimensions. In other words, simply fulfilling every cognitive and affective trustworthiness criteria may not result in the social role being perceived as trustworthy, as the combination of these facets of trustworthiness perception may be different from one culture to the next.

The social roles that are in positive quadrant for the image map could be considered effective in projecting an image of trustworthiness, as they both exhibit both cognitive and affective qualities of trustworthiness perception. That is, they are perceived as both intelligent and friendly with regard to trust-related characteristic. When compared to the mean score of untrustworthy-trustworthy item, roles in positive quadrant (parents and caretaker/nurse) have one of the highest scores. It might be safe to generalize that roles that fulfill both cognitive and affective criteria would generally be perceived as trustworthy overall. Again, this will also depend on the context in which roles are presented, or, in relation to social cues, how they are integrated into the products.

5. EXPERIMENT

5.1. Overview

In the preliminary survey, selected social roles were investigated on how they are perceived in relation to different dimensions of trustworthiness perception. As a follow-up, the main experiment for this paper will be about how social roles would be best presented in self-care medical device in order to bring highest perception of trustworthiness to that particular product.

The specific aim of the experiment is to investigate different methods of incorporating "Caretaker/Nurse" social role into blood pressure monitor's cuff, and their effectiveness in conveying impression of trustworthiness of BPM device in Thai and Japanese young adult populations (20-39 years of age).

In choosing the social role to be used as cues in this experiment, the cross-cultural evaluation of trustworthiness as represented in Figure 1 was considered. From the image map, Caretaker/Nurse seems to be perceived as being positive on both cognitive and affective trust components (highest in the top-right quadrant). The role's overall score in untrustworthy-trustworthy item are also among one of the highest. As the planned experiment would be focused on the methods for implementing social roles into medical product, choosing Caretaker/Nurse would be most appropriate, as its high rating on trustworthiness item itself as well as related dimensions of trustworthiness would likely produce a stronger impression when presented as a social cue in products.

The cuff-type blood pressure monitor is chosen as the target self-care medical device for the experiment. User's familiarity and the importance of blood pressure monitor in self-care environment are the main reasons it is selected.

5.2. Method

The incorporation of social role is executed on the most basic level: static image printed on device. Also, as the patients have to manually wrap the cuff around their upper-arm, the user-device interaction involved in this experiment is mainly physical or "non-digital" in nature. The mere incorporation of static image of social role, if proved to be enough to generate positive psychological effects on the users, could be used on a wide variety of medical equipments - manual and highly technological. It will also serve as foundational study for future studies on more dynamic and interactive incorporation method.

The specific method of social role incorporation conducted in this study is to alter the graphical design on the blood pressure monitor's cuff. The content of the design will be a graphical image of nurse, different at each level to alter the strength of social role visual characterization. The alteration methods are based on examining different types of social cues and examples of design with social roles.

The most common methods of incorporating social roles that were observed in the examples and examined as social cues by Fogg (2003) are the inclusion of facial features and use of text to convey social dynamics (in this case, naming). This was taken into considerations and the treatment levels, were developed as followed (figure 4):

Design A - Cuff with Omron's Pre-made Design

Design B - Cuff with Blank Design

Design C - Cuff with Image of Caretaker/Nurse with no face

Design D - Cuff with Image of Caretaker/Nurse with face

Design E - Cuff with Image of Caretaker/Nurse with face and name “Mary”

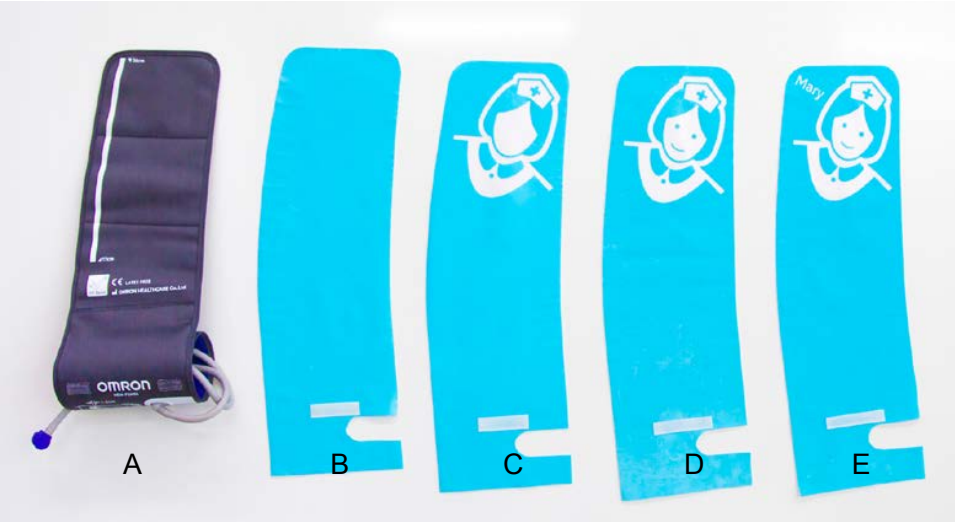

Figure 4: 5 cuff designs from Design A to Design E

Omron’s pre-made original design (A) was included as a treatment level to assess user’s impression of current medical design of cuff. The final designs and naming for the caretaker/nurse image were derived from the result of preliminary survey as well as review of designs by focus group.

The designs of Caretaker/Nurse role was fitted onto an outline in the shape of the cuff and the positioning of the image undergone several revisions to make sure that the caretaker/nurse image is maximally exposed when the participants wrap the cuff on their upper-arm. After the positioning was finalized, all the designs were printed onto white cloth using flock printing technique in the monotonic blue color – design that was tested best in pre-experiment design reviews. Flock printing gives the cuff’s cover a soft-to-the-touch texture. The printed covers were then attached to Omron’s cuff using adhesives and were alternated according to treatment groups.



Figure 5: Experimental set-up, including cuff with caretaker/nurse cover on and BPM screen with white felt cover

The set-up for the device is shown in Figure 5. The monitor itself is covered with white felt cloth, cut out into the shape of the screen and only shows the reading necessary for this experiment

(blood pressure readings and pulse rate) and the “measure” button. This allows the participant to focus solely on the design of the cuff.

To investigate the differences in response for the 5 design variations from 2 nationalities, the experiment included 10 treatment groups, each with 5 participants (N = 50). 5 groups were Thai participants and another 5 Japanese. Each group has approximately equal amount of male and female. Due to small numbers of participants, some were asked to participate in 2 treatments. The order of the treatments are randomized and each group contained approximately equal amount of “before” and “after” participants.

User's perceptions of the cuff designs were evaluated through responses to a questionnaire. The first part of the questionnaire is designed to evaluate user’s emotional states and feeling when he or she was using the device. It includes 4 items from Two-Dimensional Mood Scale (TDMS) for momentary mood states (Yosuke, Kentaro, Takeshi, 2013) and 3 items adapted loosely from Brave, et al. (2005). Note that the TDMS items are given to the participants to complete before and after using the blood pressure monitor, in order to measure momentary mood change. Emotional and mood measuring items are included to account for any emotional effects the different level of trustworthiness perception may have on the users. For example, according to Tschannen-Moran and Hoy (2000), one of the benefits of trust is to reduce the “anxiety” of having to worry about many uncertainties in our increasingly complex world.

The second part consists of 6 items that measure user’s impression or opinion about the cuff. 4 items are based on components in perception of trustworthiness: cognitive trust component represented by “impression of high functionality” (translated from “intelligence” item in impression of social role survey) and affective trust component represented by “easy to understand” and “easy to use”; another item asks users directly how much they perceive the device to be “trustworthy”. The remaining 2 items were adapted from likeability items from Brave, et al. (2005): “pleasant” and “attractive”.

The third part includes nine 7-point-semantic-differential items, designed to assess the personality of cuff designs.

The final part is consisted of 2 questions, and are meant to evaluate user’s trustworthiness impression of the BPM result and satisfaction with the product in general.

The questionnaire was originally written in Japanese and was translated to Thai. All Thai participants completed the questionnaire in Thai and all the Japanese in Japanese.

5.3. Result

It was found that there was no statistical difference in user’s perception of cuff’s trustworthiness across 5 designs, as assessed from “impression of trustworthiness” item in the questionnaire. ($F(4,40) = 0.800$, $p = .406$, partial $\eta 2 = .093$). Users found all of the cuff designs to be quite trustworthy, scoring between 3.2 and 3.6 out of 5 ($M=3.42$) across five designs in both nationalities. Cross-cultural comparison shows that Thai perceived the five cuff designs in general to be more trustworthy than their Japanese counterpart. ($F(1, 40) = 5.769$, $p = .021$ partial $\eta 2 = .126$)

However, from the evaluation of components affecting perception of trustworthiness, Japanese found Design C (nurse with no face) to be easier to use than medical-looking Design A ($F(4, 40) = 2.639$, $p = .048$, partial $\eta 2 = .209$), and felt more confident when using Design D than when using Design A ($F(1, 40) = 8.100$, $p = .007$, partial $\eta 2 = .168$). These results show that Japanese found the image with no face to be more reassuring and easier to use than normal medical design.

Furthermore, after using cuff with Omron's medical design (Design A), Japanese users became more irritated ($t(4) = -4.000$, $p=0.016$, $d=-1.78885$) and felt less pleasurable ($t(4) = -6.000$, $p=0.004$, $d=-2.68328$) according to TDMS, while there was no negative change in pleasurable feeling after using other designs. This illustrates that Japanese seem to be negatively affected by medical-looking products, becoming more displeasured and irritated after using them.

There was no significant differences among the ratings of the 5 designs by Thai participants. The momentary mood states before and after cuff usage also show no different except in Design E (nurse face with name), where there was a positive increase in liveliness after using the cuff ($t(4) = 3.162$, $p =0.034$, $d=1.4142$).

Cross-cultural comparison shows that Thai rated the five designs significantly higher than Japanese in many items. They found the five cuffs to be more trustworthy, of higher functionality, easier to understand, more pleasant and attractive in general. Thais also perceived Design A, C and D to be more interesting than Japanese did.

The perception of price and quality was assessed in "expensive-looking -- cheap-looking" item. Blank Design B was perceived as looking cheap in comparison to Design A ($F(4,40) = 0.509$, $p = .730$, partial $\eta 2 = .048$); however, the other designs with nurse image are perceived as equally expensive-looking as A. Note that the materials used to make design B, C, D and E are the same. This may suggest that without the incorporation of social role (Design B), the cuff with plain, blank color design is perceived as being cheaper than the designs with social role image.

6. DISCUSSION

The inclusion of static image of caretaker/nurse social roles did not improve the *direct* perception of trustworthiness of the BPM cuffs. It also did not reduce the trustworthiness level, when compared to Omron's original medical design. However, Japanese generally found cuff designs with nurse image to be more reassuring and easier to use, and Thai felt more lively after using one of the designs with nurse image. In addition to this, blank design with plain blue background (B) and medical-looking design (A) had a tendency to irritate Japanese. This observation suggests existing effects of incorporating social roles image into the design. Although it does not illustrate that there was a positive *direct* effect on trustworthiness perception when pictures of nurse were incorporated into the blue color designs, the incorporation of social roles did maintain the level of trustworthiness evaluation, while improved the mood and overall usage experience of the BPM that can be linked to trustworthiness perception (i.e. positive changes in TDMS, reassuring, easier to use); noted that this is in comparison to original medical design (A) with no social role image included.

In addition, cross-cultural examinations suggest that Japanese are more negatively affected by medical-looking designs than Thai are, especially with regards to pleasurable feeling. This suggests a significant difference in cultural perceptions of medical device. Whereas Japanese seem to associate medical-looking products with irritation and unpleasurable feelings, Thai are less susceptible to such negative impacts from these products. When compared to Japanese, Thai also gave higher ratings on cuff's trustworthiness, functionality and attractiveness. This suggest that Thai users generally view medical devices more positively than Japanese do, which would also explain why they were not easily affected with regards to momentary mood change by using such medical-looking product.

The preferences of incorporation methods - image without face, image with face, image with face

and name - are also noteworthy. Japanese found nurse image with no face to be reassuring and easier to use, but felt more confident when using the image with face, both in comparison to medical looking design. Thais were unaffected emotionally by these two designs. However, when the name “Mary” was added to the nurse’s image, both Thai and Japanese reacted positively after using the design. Thai became livelier while Japanese felt more energetic. This may suggests that as the image of social role is perceived as more “human” - with face and then name - the user associate the product more with the stereotypical characters of the included social role, which may help to explain the positive effects of social role observed in the experiment.

Although the main experiment in this paper was not successful in increasing the direct impression of trustworthiness in home-use medical device through incorporating static image of caretaker/nurse social roles into the external design, the nurse designs did evoke some positive responses that can be linked to trustworthiness perception from the users. Future research could perhaps focus more on a dynamic or interactive method of role incorporation that will hopefully create a stronger impression of social role and become a more effective cue in general. Moreover, if we were to think of integrating social roles as building a personality into the device, it might also be interesting to observe how users develop a relationship with the product over a longer period of time.

ACKNOWLEDGMENTS

This work was supported by the Japanese Government Scholarship (Monbukagakusho).

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6D - Design

KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Principles for User Experience

What We Can Learn from Bad Examples

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Abstract: The idea of User Experience (UX) is to achieve a positive emotional reaction of users on a product interaction and thereby to create a unique selling proposition. However, people's needs, perception and resulting emotions are subjective and very diverse. Furthermore, UX is dependent on the physical and social context. We developed the Customer Experience Interaction Model (CEIM) which consists of UX-relevant elements from different relevant disciplines to handle this complexity. In order to support real designers without theoretical background, we surveyed real customers' product reviews describing good respectively bad UX from different sources and extracted UX principles. We already presented principles taken from positive samples in another publication. In this paper we discuss principles based on reviews with negative examples. These UX principles shall clarify to developers how to avoid negative experiences. Thereby, we combine a theoretical approach and concrete principles and examples, which illustrate the application of theory and help preventing bad UX.

Keywords: User Experience, Emotional Design, User-Centered Design.

1. INTRODUCTION

1.1. User Experience

Beyond usability, which has been a point of interest in science and industry for several years, the quite young approach of User Experience (UX) extends the view on user product interaction by emotional aspects. The motivation of UX is to develop positive experiences and emotions. Therefore, products have to meet psychological needs and motives of the customer (Kim et al., 2011). By triggering the user's emotions and thereby create a brand loyalty, UX can help differing products in saturated markets.



Figure 1: Bottle closures designed for usability (left), UX (right) and as a compromise (center)

UX is understood in many different ways by several disciplines. The definitions and approaches range from a psychological to a business perspective (Roto et al., 2014). The challenge is to bring these views and strengths together and to enable multidisciplinary development teams to effectively work together on UX. Mostly, psychological experts and competencies are missing in product development teams. This deficit needs to be considered when creating an approach to support designers developing or designing for UX.

1.2. Problem

The scientific state of the art offers a lot of theoretical descriptions of UX as well as methods for measuring it like AttrakDiff (Hassenzahl et al., 2003) or PrEmo (Desmet, 2003). This analytical view is widely covered. However, there is a deficit of concrete tools and methods supporting the synthesis of experiences. Approaches like the «psychological needs-driven experience design approach» (Kim et al., 2011) or Kansei Engineering (Nagamachi & Lokman, 2011) aim at creating an emotional impact on users. Both approaches require dealing with user needs and influence the whole product development process, in particular the early stages.

However, UX needs to be realized in real development projects by real designers and engineers, mostly within a team without psychologists. We suggest that most of the approaches and models are unlikely, if not impossible to be included in highly interrelated, inflexible and long-lasting development processes for complex products. No doubt: UX demands a profound psychological consideration and could have the highest impact, if the whole development process was organized accordingly. Nevertheless, we could not discover a successful implementation of UX synthesis support in real industrial projects so far. (von Saucken et al., 2013a)

1.3. Solution

In this paper, we present a pragmatic tool for UX synthesis which is applicable throughout the whole development process without any deeper psychological knowledge: we developed a guideline consisting of one pager UX principles. We derived these principles by paraphrasing real customers' product reviews which we analyzed using the Customer Experience Interaction Model (von Saucken et al., 2012). With these principles developers shall be motivated to consider different UX-related problems, opportunities and goals. The principles are enriched with real examples and reviewer quotes to clarify the UX issue and to inspire new solutions.

We have investigated and analyzed 57 reviews from various sources and derived 20 UX principles. The scientific basis for our analysis is the Customer Experience Interaction Model (CEIM) described in section 2.2. It helps analyzing real customers' product reviews which is shown in section 2.3. The method for deriving UX principles from these reviews is discussed in section 2.4, the resulting principles in section 3.1 and a form sheet for illustrating them in section 3.2.

2. RESEARCH METHOD

2.1. Overview

To clarify the proceeding in this paper, we show three exemplary extracts from product reviews which we analyze by paraphrasing and demonstrate the derivation of a UX principle. The three examples describe bad experiences with a smartwatch, a Wi-Fi router and a convertible laptop:

- **Galaxy Gear**. *(…) The Galaxy Gear gently vibrates to let you know when something comes in through these channels, but upon checking the notification, the smartwatch displays a message that tells you to look at the contents through your mobile device. The experience is akin to a waiter telling you that your food is ready, but that you have to go get it from the kitchen if you want to eat. Thankfully, there are third-party apps that can provide this type of functionality, but it's a shame Samsung couldn't do it itself, especially since the Gear can be set up to receive notifications from these specific services right out of the box (…).* (IGN Entertainment Inc., 2013)
- **Linksys Wi-Fi Router.** *(…) Other than that the router has no new features at all. In fact it has exactly the same as what the EA6500 has to offer, including the shortcomings. For example its Guest Access feature is still available only on the 2.4GHz band, and you can't change the name of this guest network. (…)* (CBS Interactive Inc., 2013)
- **Toshiba Satellite Click.** *(…) Second battery issue aside, the device's performance simply can't keep up with competing Intel-powered devices, which really don't cost that much more. (…) Port selection isn't great from a laptop. On the right edge of the upper tablet section, there's a volume rocker, headphone jack, a Micro HDMI port and a micro SD card slot. On the left edge sits a power jack and the power button. (…)* (Digital Trends, 2014)



Figure 2: Exemplary product reviews, © by Samsung, Linksys, Toshiba

All of the statements above have in common, that the reviewer expects a certain feature whereas the product misses that specific recognizable technological advance or benefit. We will now paraphrase (cp. Mayring, 2003) the respective part in order to develop a better understanding:

- **Galaxy Gear Paraphrasing.** The reviewer is annoyed because Galaxy Gear does not completely display messages although the technological preconditions are met.
- **Linksys Wireless Router Paraphrasing.** The Linksys Wi-Fi router has no new features compared to another router.
- **Toshiba Satellite Click Paraphrasing.** Laptops usually have a better performance and more ports than the Toshiba Satellite Click.

The three reviewed products apparently have a lack of technological advance, either because expected and technologically feasible features are not implemented or because the state of the art usually offers better technical standards. Thus, we can derive the principle «ensure technological advance» from these three reviews. The associated form sheet is illustrated in section 3.2.

2.2. Customer Experience Interaction Model (CEIM)

We take the Customer Experience Interaction Model (CEIM) as the scientific basis for our review analysis. CEIM is a cross-disciplinary model to illustrate causal connections in user product interactions relevant for UX. It incorporates relevant perspectives from the disciplines of industrial design, engineering, ergonomics and psychology. It supports the communication of developers by creating a shared understanding and a common terminology. CEIM consists of five elements (see figure 3): the surrounding environment, in which the user performs a usage with the development object causing an effect. Apart from the environment each element consists of detailed segments. Arrows illustrate the interrelations between these elements. (von Saucken et al., 2012)

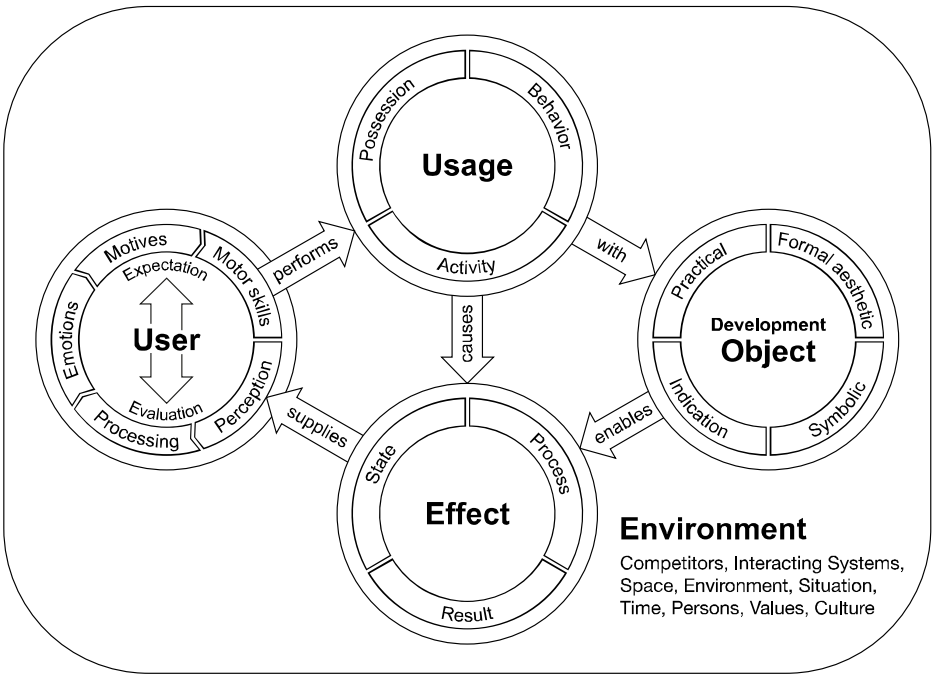

Figure 3: Customer Experience Interaction Model (von Saucken et al., 2012)

CEIM is based on the block diagram of human machine system by Schmidtke (1993) which represents a classic ergonomics perspective with the goal to optimize the working performance. As the UX view requires a stronger consideration of the human perception and processing, CEIM details the user element by adding triggered emotions and user motives. Furthermore, CEIM enlarges the functional understanding of the development object (product, service or combination) by indication, aesthetic and symbolic aspects according to Steffen (2000).

Another UX-relevant consideration is involved in the element behavior (Rasmussen, 1983): UX highly depends on the user's level of training. The experience of driving a car for the first time is very intensive and completely different from the driving experience of an expert driver. Both users need to be considered in the UX design perspective. Finally, we added the consideration of ownership in the possession element, as this highly influences the subjective experience of a user.

The different aspects of CEIM help analyzing an observable experience holistically: By matching quotes from reviews to the corresponding elements we could get a deeper understanding what reviewers like or dislike about their product. Our three exemplary statements show different UX aspects: the reviewers of the router and the laptop describe a bad experience as they compare the practical function of their product with competitors. The smartwatch reviewer complains the deficit indication in combination with an interacting system (mobile device) compared with competitors.

2.3. Analysis of Product Reviews

In preparation of deriving principles, we analyzed a variety of reviews using CEIM – both products and services – and user comments from diversified sources. This section addresses the specification of review sources and the breakdown of product and service categories that have been analyzed. While consumer-testing magazines usually focus on features (Norman, 2001) and often lack the consideration of emotional aspects, user-generated content provides a suitable source for the underlying task.

A similar approach has been presented using positive experiences to deduce UX principles (von Saucken et al., 2013b). In this paper we focus on negative experiences, in which the authors of reviews and comments were frustrated or bored. The Cone Online Influence Trend Tracker (Cone Communications, 2011) found out that 4-out-of-5 consumers reverse their purchase decisions based on negative online reviews, therefore representing a significant source for deriving design principles.

Although online shops such as Amazon or Ciao already offer an enormous database of customer reviews we wanted to diversify the analysis and additionally examined reviews from forums (e.g. Yahoo, ebay user forum…), blogs (e.g. CNET, Digitaltrends…), online magazines (e.g. Spiegel.de, Chip.de…), information portals (e.g. IMDB, Jameda…) and social media (e.g. Twitter, Instagram…). Figure 4 (left) shows the balanced breakdown of the sources for the in total 57 reviews.

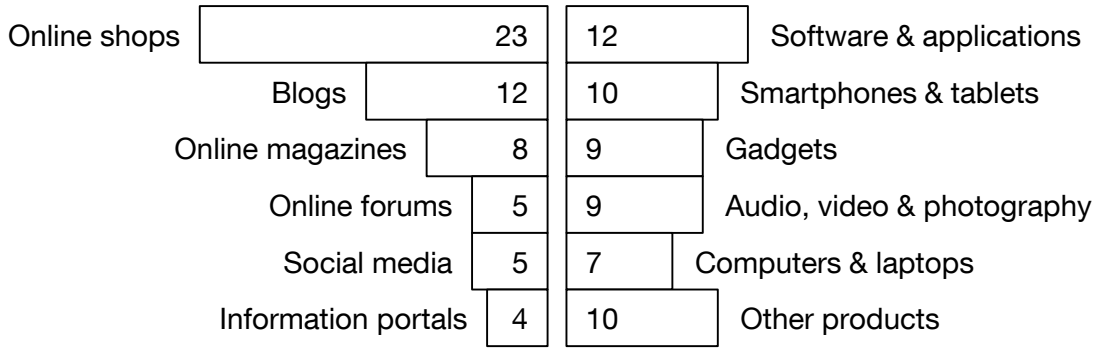

Figure 4: Sources (left) and product categories (right) of the 57 surveyed reviews

In the course of this paper we also looked at several different products and services, in which we set a focus on digital technologies. Figure 4 (right) illustrates the range of different products and services that build the foundation of the derivation process.

Besides classic digital technologies such as smartphones (e.g. iPhone 5s), tablets (e.g. Kindle Paperwhite), computers (e.g. Mac Pro, Xbox One), and laptops (e.g. Toshiba Satellite Click) we analyzed reviews for audio, video or photography products, for example a digital single-lens reflex camera (Canon 6D) or a LCD TV (Sony KD), as well as small equipment and gadgets, for example fitness wristbands (Fitbit, Jawbone, Nike Fuelband) or a navigation system (Tom Tom Go 500).

In addition to that, among the 57 analyzed reports there were several software or application products, for example a review of the Yahoo Mail interface or of the OS X Mavericks. Finally, reviews from non-digital products, such as a coffee pad machine or a battery-operated drill, and web-based experience reviews of services like a movie review, a hotel evaluation and a visit to the doctor round off the types of products and services that have been analyzed.

2.4. Derivation of UX Principles

The procedure of deriving UX principles is based on the qualitative content analysis, i.e. structuring content analysis, according to Mayring (2003). The goal of this type of content analysis is to find commonalities within any type of recorded communication and to draw conclusions regarding specific characteristics of this communication (Mayring, 2003). Figure 5 illustrates the process of the derivation of UX principles using a structuring content analysis.

The structuring content analysis contains several steps: Firstly, a category system to structure and summarize different statements from the product and service reviews has to be developed. In this case, we took the categories and sub-categories from CEIM as it provides a holistic and application-oriented description of a user's experience and has already been tested in other student projects.

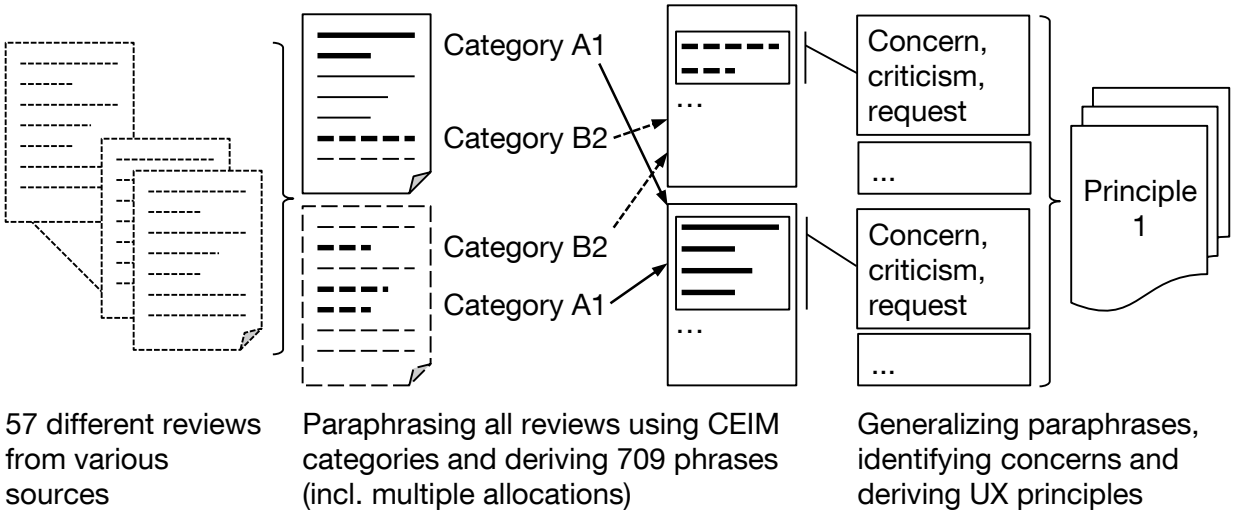

Figure 5: Process of deriving UX principles

All of the reviews have been analyzed due to statements that correspond to the sub-categories of the CEIM. Thus, 709 allocations have been extracted from the 57 reviews and structured according to the CEIM categories, using the spreadsheet software Excel. As sentences included statements that fit into several categories, for example when a user writes about a missing feature in a specific situation, some proposition have been listed in more than one sub-category. This is consistent with the content analysis according to Mayring (2003).

Having structured and summarized the allocated statements from every sub-category, we were able to expediently look for commonalities within each sub-category. Therefore, each sub-category has been analyzed individually and the related statements were translated into simplified phrases, describing the underlying concern, criticism or request of the respective statement.

The next step consisted of matching the commonalities from one sub-category with the concerns from other sub-categories of the associated main-category. Finally, assisted by this classification it was possible to cluster bad experiences caused by similar concerns and formulate general principles. By means of this approach, it was possible to derive 20 UX principles from 57 reviews, based on 709 categorized paraphrases.

3. RESULT

3.1. UX Principles

In the following we provide further information for each of the 20 UX principles that we were able to derive from the reviews and comments based on negative experiences. The principles will be described by explaining the respective characteristics that built the foundation for the particular principle. Real examples from the analyzed reviews thereby enrich the description in order to enhance the comprehension of the principles:

1. **Prevent a bad first impression.** The first impression of a product or service has a substantial impact on the user's attitude and relation towards the product. Thus, from the packaging over the user manual to potential installation processes the first usage has to be a pleasant process. In our review, some users complained about the manual that did not provide the appropriate assistance for the product setup. Another user was frustrated that he was not able to use his camera straight away but had to install an additional firmware first.
2. **Avoid the feeling of inability.** If a user has the feeling that he is not capable of using the product properly, there is no chance to create a sufficient UX. The user of a ticket machine for example felt unqualified for using the machine because the menu navigation was too complicated. Products have to be self-explanatory to avoid such feelings.
3. **Avoid forced interruptions.** I our reviews, forced interruptions due to an unexpected fast draining battery of a fitness wristband, overheating of a video projector or the frequently required recharging of an electric car's battery pack lead to a bad experience. The duration of constant usage has to be enlarged in order to satisfy the users' needs.
4. **Enable a natural handling.** Users want to enjoy a straightforward, natural usage without complex, illogical or inconsistent features. An Xbox One user complained about the complex menu setup that is apparently made for everything but gaming, while in the review of a video recorder the user was confused that volume controlling differs for regular and HD channels.
5. **Prevent inertial functions.** In general, the analyzed reviews gave the impressions that users desire fast and smooth function fulfillment. On the one hand, a user of OS X Mavericks was upset because of the long duration of a video upload. On the other hand, the review of a video recorder criticized the fact that the sound was delayed in relation to the video.
6. **Enhance controlled information provision.** People want to get information and feedback about their usage behavior. However, it is important not to provide too much or unstructured information. In an opera review, the author wrote that he was negatively overwhelmed by the amount of information on stage whereas the user of the fitness wristband did mention the lack of a status bar in order to receive system information.
7. **Realize a natural usage for everyday life.** To avoid a bad experience, products and services have to be comfortably used in everyday life. This is highly influenced by the product's geometry and the way users interact with the system. A user's blog comment mentioned that his smartphone is too big to be comfortably stored in a trouser pocket. Moreover, a Google Glass review described that it is awkward to activate the glasses by throwing the head in the neck.
8. **Minimize necessary user operations.** A navigation system review complained about many confirmation screens before starting the navigation. A smart watch user was annoyed by the fact that due to the idle state he always had to interact with the watch just to read off the time. In general, people expect an interaction to be processed quickly and easily. Hence, users are annoyed when they have to complete a lot of steps to cause the desired effect.
9. **Enable individualization.** It is impossible to create a product that fits perfectly to everybody's need. Consequently, it is important to enable the possibility to individualize or personalize a product or service according the user's habits. Several reviewers demanded more control and configuration options.

10. **Support controlled socializing features.** In a film review it was clearly recognizable that the reviewer wants to socialize, mentioning the lack of memorable quotes or sayings that can be used for conversations. The Xbox One reviewer however was upset that you obligatory get logged into your Skype account and other present persons can see your private messages.
11. **Prevent the feeling of insecurity.** Expressing security via your product or service can lead to a positive experience; the contrary will definitely lead to a bad experience. Besides data and software security whereof some reviews were dealing with, the user of a drill mentioned the missing GS-sign for tested safety (Germany) that made him feel less secure.
12. **Avoid limited compatibility to the system's environment.** If it is a game console where you can play only a limited number of games, a music box of which the sound is only satisfying for a few music genres or a fitness wristband that is only compatible with the iPhone – these restrictions limit the utilization and consequently the UX.
13. **Exclude incompatibility of different versions.** The user of a text-processing program was frustrated that he could not use any of his documents with the new version of the program. Other reviews described a bad experience with new versions or updates of their products and services that missed general features they were used to use. It is important to enable the user to compensate the lack of common features if they are not integrated in the new version.
14. **Fulfill expected fundamental functions.** Sophisticated features, materials or design may lead to a distinctive joy-of-use, but only if basic functions are fulfilled. Among others, a reviewer of a smart watch came to exactly this conclusion as he missed basic features he expected a wearable companion device to have.
15. **Ensure technological advance.** From photo-editing software over a smart watch and a video camera to a review of a visit to the doctor, several reviewers mentioned missing features as shortcomings or even compared their product or service with competing solutions. As the mentioned reviewers missed a recognizable technological advance or benefit, they were dissatisfied and sometimes even thought they would have been better of buying the competing product.
16. **Orientate the product impression towards the context of use.** Design is a very important influence factor affecting a user's experience. Characteristics such as geometry, material or color have a recognizable impact on the reviewer's judgment. In our reviews it could be seen that users associate the design of products or services with the context it is used in. The reviewer of a fitness wristband complained that the wristband doesn't look sportive, as it is very rigid.
17. **Minimize design-related complexity.** Design-related characteristics do not only influence the look and feel but also the usage of objects and services. In a TV review, the miniaturization of control elements was criticized, making it difficult to control the product. A coffee pad machine was hard to use because the complex geometry of the pad drawer did not allow a trouble-free usage. Reduction in complexity is crucial to avoid a bad experience.
18. **Realize a product-service system.** Nowadays, when users buy a product they expect to simultaneously buy the belonging customer service. In our reviews, products from six out of the seven product categories included a comment, describing a bad customer service.
19. **Convey a holistic experience.** A product or service on its own can be as pleasing as possible, when accompanying accessories are either obligatory or are of low quality the overall experience suffers. One of our reviews, evaluating an MP3 Player, criticized the ear buds that seemed to be sub-standard.
20. **Avoid a bad price-performance ratio.** Several reviews, where users were unsatisfied with the experience of the product or service, established a connection between the quality and the price. The user of a fitness wristband missed several features he or she expected due to the associated price segment whereas the reviewer of a hotel evaluation complained about the poor quality for the given fare.

3.2. UX Principle Form Sheet

Since a simple listing, as shown in section 3.1, of the derived UX principles will hardly support a designer during the development process, it is of fundamental importance to provide a structured guidance with multiple examples. For this reason we developed a UX guideline with detailed information for each principle in the form of a one pager. This section addresses the structure and layout of the one-sided principle form, which is illustrated in figure 6.

The form is divided into three parts. The upper section gives a brief introduction into the principle, explaining why or in which contexts the principle is relevant. On the basis of this objective or explanation, the principle is named and fully described by the associated design parameters. From our perspective it is important to include the principle attributes that we can derive from our analysis but also enrich the description with our own expertise. This means that we include parameters that are part of the principle but have not been a subject of our selected reviews. Consequently, we ensure a holistic consideration and completeness. An Icon for each relevant characteristic enhances the perception of the particular characteristic.

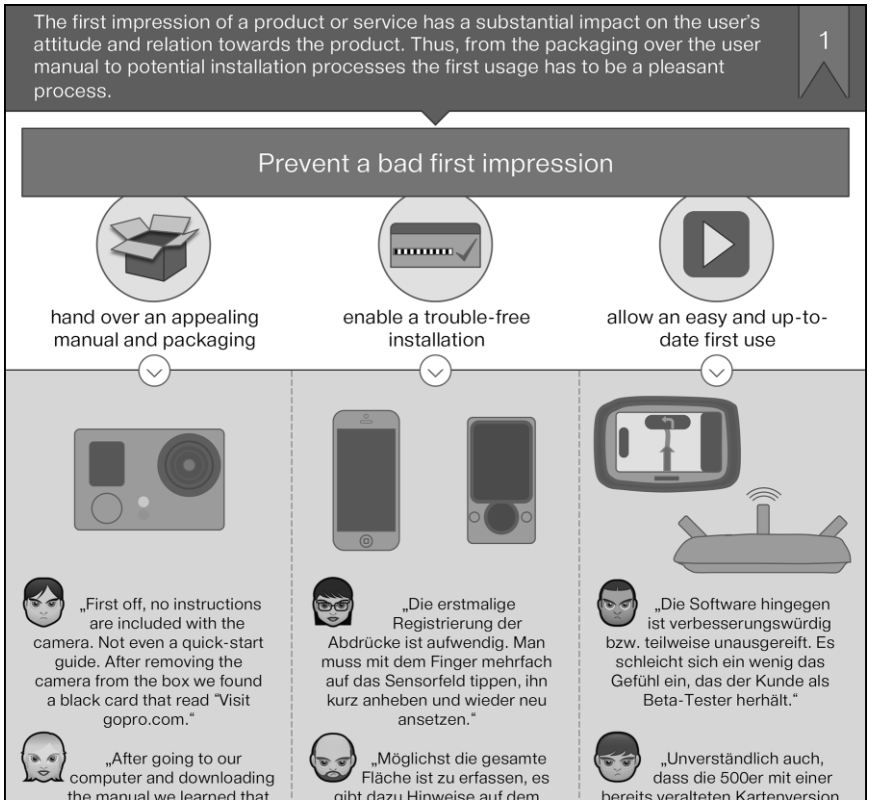

Figure 6: Form sheet for the first UX principle

The second part illustrates the principle by representing a descriptive example. Firstly, a picture or sketching of a product or service that does not realize the respective principle will be shown on the left side. Based on this counter example we show a second picture or sketching where the principle is applied. Thus, this illustration helps the designer to understand how the principle can be applied in a certain context and is encouraged to adopt the UX principle.

The third part finally states several related comments from the reviews we have selected for our analysis. Storytelling, i.e. incorporating real comments, is a way to guarantee a comprehensible and memorable assistance for designers during the development process, as it can demonstrate new opportunities for experience (McCarthy & Wright, 2004).

4. CONCLUSION

4.1. Summary

We showed the Customer Experience Interaction Model which combines different perspectives and aspects of UX and thereby helps analyzing observable experiences. Furthermore, we presented our synthesis approach to support developers in UX design. We gathered and analyzed negative product reviews and experience descriptions, mostly taken from internet sources. These reviews were classified by CEIM elements, paraphrased according to the proceeding from Mayring (2003) which finally allowed us to derive UX principles from them.

These principles were illustrated as one pager with a standard from sheet. These one pagers consist of a principle description and give extracts from the investigated product reviews as quotes enriched with pictures. With these UX principles, inexperienced developers can be supported in considering UX aspects and be given concrete hints with examples taken from other products.

We ran a first evaluation in the context of a Bachelor Thesis. The student could apply the principles in a use case triggering new UX-related ideas. The evaluation showed that even without previous knowledge concerning UX, the approach helps in asking the right questions and getting hints for appropriate solutions. Other approaches like the need-driven one by Kim et al. (2011) can be included in terms of an own principle.

4.2. Outlook

The presented principles, mostly based on student's works, were derived only from a few examples. Many more reviews from different sources need to be included to get more principles to inspire concrete ideas. We plan to expand the investigated reviews by looking at other branches besides physical product development like entertainment, sports, gaming, cinema, theatre etc. We suggest that product developers can profit from being inspired by looking at other disciplines that aim at creating experiences.

Our evaluation within a student's project showed first good results but the student had a deeper previous knowledge about UX including the inner motivation to deal with this topic. As our goal is to support inexperienced designers within real industrial development projects, we will run several evaluation loops in this context to prove the benefit of our approach.

Furthermore, we see a high potential for improving the illustration of principles. So far we only created and applied paper-based one pagers; this can become confusing with a higher number of principles. Based on the one pager design a web-based solution could help finding the appropriate principles and examples easily to support understanding by use of icons and images. Moreover, potential connections between different principles could be easily linked within a web-based solution. Furthermore, a more detailed storytelling approach would also help in clarifying the principles and application examples.

Finally, the approach should be enriched by more existing UX theories, approaches and corresponding literature sources. Developers should be enabled to deepen their knowledge about a specific UX principle and underlying scientific basics – our framework serves no more than a top-level overview on various UX perspectives.

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BIOGRAPHY

Constantin von Saucken is scientific assistant at the Institute of Product Development (Prof. Dr.-Ing. Udo Lindemann) from the Technische Universität München (TUM) in Germany since 2010. Before, he passed his diploma degree in Mechanical Engineering at TUM with the specialization in systematic product development and human factors and after that a master degree in Industrial Design at TUM. His research interest is the systematic development of User Experience.

A Kansei Design Collaboration Platform in Taiwan

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Abstract:

Taiwanese researchers began research on Kansei design in 1999. Until now, there was no comprehensive study regarding the industrial needs for Kansei design. The first part of this paper summarizes the survey results from 86 companies, including design studios and domestic product manufacturers. These companies need support from Taiwan's research organizations in the following fields: trend and lifestyle research, design and market databases, rapid prototyping services, design talents, business matchmaking, etc.

Industrial Technology Research Institute (ITRI), a major non-profit research organization in Taiwan, established the ITRI Emotional Design Office (EDO) in 2013 at its new campus in Central Taiwan. EDO started their emotional design program to develop advanced emotional design methodologies and to provide assistance and services to companies in central Taiwan. It provides an open lab and functions as a collaboration platform that fosters collaboration between academia and industry. The second part of this paper covers the strategy plan to support industry.

Keywords: Kansei design, emotional design, industrial survey, collaboration platform

1. INTRODUCTION

Industry in Taiwan grew fast during the early 1970s. It was a period of export-oriented industrialization. Many manufacturing industries benefited from OEM and ODM business. Taiwan's industry gradually upgraded itself by advancing high-quality manufacturing technologies and lowering costs to enhance competitiveness and profitability [1]. With the growing threat of low-cost manufacturing and labor from Southeast Asia and China, it is necessary for Taiwan's companies to develop competitive products and to transform their business model from OEM, ODM to OBM. This transformation is challenging because manufacturers are used to the OEM model in which the focus is to drive costs down and to satisfy their clients' requirements. End-users' needs and requirements were not normally considered in their product development process.

As time moved on, customer's product expectations of also changed. In the experience economy stage, price is no longer the main concern. Expectation expanded to include branding, product

appearance, usability, and value. Consequently, understanding culture, lifestyle, user behavior, and addressing end-user's needs became more important for product development. Companies that shifted from the OEM to the ODM or OBM business models are gradually changing their product design strategy from manufacturing-driven to user-driven. Although manufacturing companies normally contract design studios for product appearance type of design, many of them formed in-house design teams [2] that adopted the emotional design concept and incorporated emotional design into their product development. As for design studios, the majority of the services provided are small scale, low budget types of product appearance design [3]. The types of design works and the opportunities for personal career growth are limited in design studios. This is why new graduates from design schools prefer working in manufacturing companies.

According to the ITRI's Industrial Economics & Knowledge Center (IEK), most design service companies in Taiwan are small-scale firms with around 10 employees. Insufficient human resources and lacking business opportunities from manufacturing companies created obstacles for them to develop new design skills and provide new services such as research on users and user behavior, ergonomic surveys, physiological and psychology measurements for industrial needs [4].

ITRI established their emotional design office (EDO) at its new central Taiwan campus aiming at upgrading the design capabilities and competitiveness for both manufacturing and design service companies. EDO started their emotional design program to develop advanced emotional design methodologies. It provides an open lab and functions as a collaboration platform that fosters collaboration between academia, industry and non-profit research organizations.

The purpose of the research stated in this paper was to investigate the needs of manufacturing and design service companies, and to develop strategic plans for the emotional design program to help industrial transformation.

2. INVESTIGATIONS OF CENTRAL TAIWAN MANUFACTURING COMPANIES AND DESIGN SCHOOLS

2.1. Subjects

In order to understand the needs of central Taiwan manufacturing, design service companies and academic resources, 86 companies and organizations were interviewed, including 70 manufacturing companies, nine design studios and seven design schools. The following is the type of the industry and the number of companies in these industries.

- Toy industry: three companies
- Healthcare industry (assistive technology): 23 companies
- Bicycle and accessories industry: 20 companies
- LED general lighting industry: 10 companies
- Automotive and accessories industry: 10 companies
- Other: four companies

Companies' needs for support are compiled into seven categories, namely: "Market and Industry Trends", "Equipment Services", "New Technology Information", "Emotional Design Database", "Design Methods and Tools", "Marketing and Channel", and "Talent Training".

2.2. Needs from Manufacturing Companies

Figure 1 shows the survey results for the needs from the 70 central Taiwan manufacturers. It

shows that the largest needs are in “New Technology Information” at 29% of which 84% are related to new technology integration. “Emotional Design Database” at 20% and “Design Methods and Tools” at 22% show there are strong demands for support related to designs. The total percentages of other needs are less in 30%: “Marketing and Channel” is 4%, “Equipment Service” 8% and “Talent Training” is 4%.

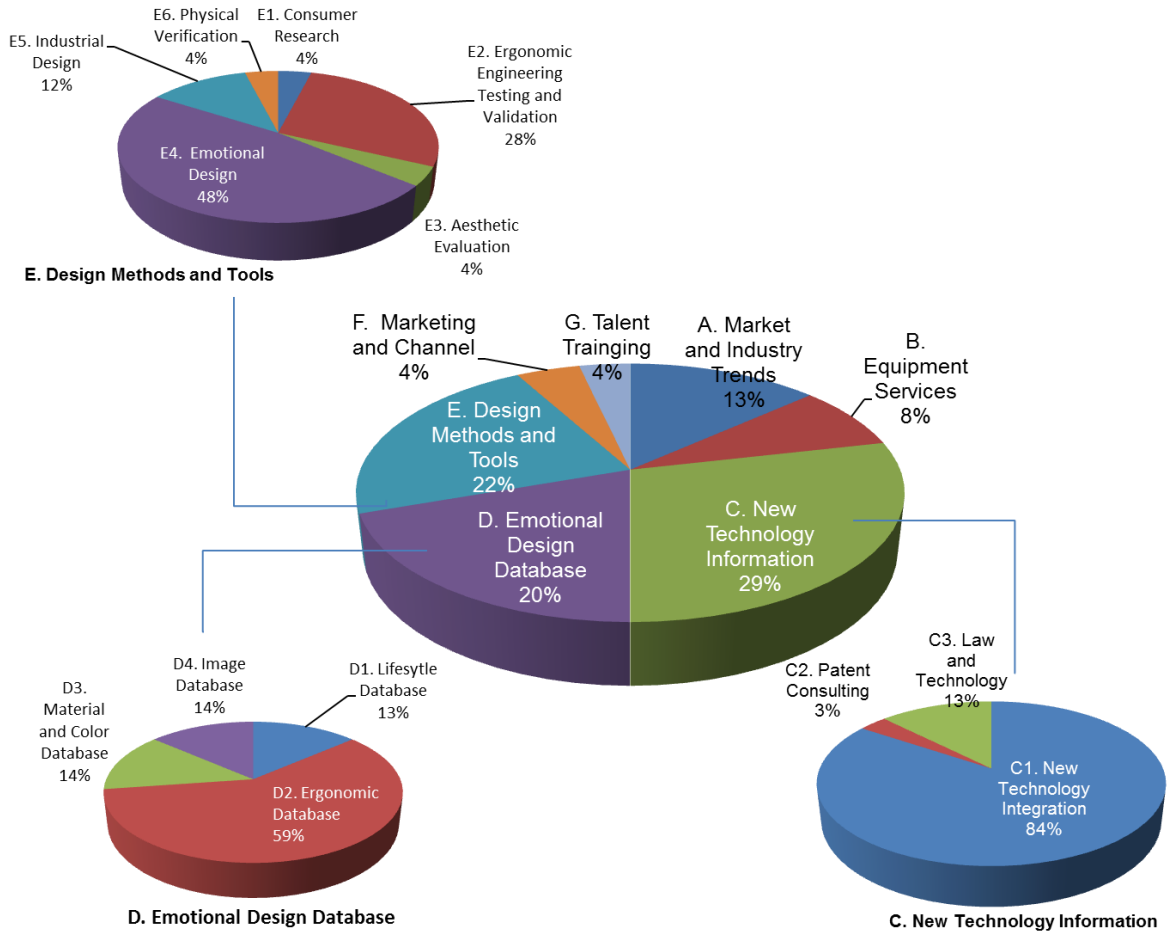

Figure 1: Desired services from ITRI EDO reported from manufacturing companies

The following further describes the needs in each category:

Market and Industry Trends (13%): Healthcare, bicycle and toy companies need the latest industry trends and international design information to set business strategies and to set directions for new product development.

Equipment Services (8%): Although only 8% of the needs are in this category, but the areas of interests are clearly identified. For example, the healthcare and bicycle companies like to have rapid prototyping (RP) services. Similarly, LED general lighting companies also need high-precision RP machines for lens development using transparent materials. They specifically asked for 3D optical simulation software and design software.

New Technology Information (29%): Integrating new technologies into new product design is very important for product’s competitiveness. The companies have expressed

interest to know where to find this information and wish ITRI can provide them the technologies. Bicycle manufacturers wish to have new bicycle mechanism and new materials to improve the seat cushion for a more comfortable ride. Both bicycle and healthcare companies expressed the need for making lightweight products. Healthcare companies need advanced technologies for body-signal sensing and controlling, medical engineering, material science and electrical and mechanical engineering. Automotive companies need analytical methods and tools to test hydromechanics and applied mechanics. The toy, automotive and healthcare companies all expressed the need for safety verification.

Emotional Design Database (20%): Bicycle companies emphasized their need for an ergonomic study database relating to riding posture, especially in different countries. Healthcare companies are interested in an ergonomics database for walking aids and wheelchairs. For the toy companies, they needed lifestyle studies in different countries. Additionally, many companies showed strong desire for a good materials database.

Design Methods and Tools (22%): Bicycle manufacturers are looking for usability testing tools. The LED general lighting manufacturers want to know the relationship between human emotions and lighting. Vehicle lighting companies in the automotive industry want to understand the relationship between human emotions and optical pattern switching. In short, these companies are interested in ergonomic testing and validation services. Although emotional design is quite new to the surveyed companies, these companies are interested in knowing whether it can help in product design and product development strategies. As a result, the need for “Emotional Design” takes up 48% in this category.

Marketing and Channel (4%): Companies need a platform to expand into different industries, and to connect with resources for technical support and marketing consultation.

Talent Training (6%): Brain drain, or human capital flight, has been an increasing problem in many Taiwan companies. Companies face the problem of maintaining and recruiting talented people, and/or developing talents within the companies. They expect R&D organizations such as ITRI-EDO to provide training courses to bridge the gaps between the schools and industries.

2.3. Needs from Design Service IndustryCompanies

Taiwan’s Ministry of Economic Affairs in response to the changing trends in product design, encouraged the industrial design service providers to upgrade from primarily color and shape design to incorporate new materials, service design and take into account of business strategies in their design process [2]. There are four types of design service providers in Taiwan. The primary business of most of the companies is concept and industrial design. Only a small portion of them do user research because such research demands high man power and cost. Another type of design service firms focus on user experience research. They provide their customers with business and product development strategies based on in-depth studies on user behavior. The third type of design companies provides services to companies that have their own brands. The forth type targets specific industries, for example, transportation companies.

Figure 2 shows the needs from the design service companies. Comparing to the results in Figure 1, some obvious differences should be noticed. The needs for emotional design database from design service firms are 36%. It is a 16% increase compared to the manufacturing companies. It

shows the design service industry has greater needs for a design database. On the other hand, design service firms are familiar with design technologies, therefore their needs for “Design Methods and Tools” is relatively low at 5%, a big drop from 22% from the manufacturing companies. Their needs in “New Technology Information” also dropped from 29% to 21%. “Market and Industry Trends” in Figure 1 and Figure 2 are the same. Demands for support in the “Marketing and Channel” are 5%. Both manufacturing companies and design service companies have less demand for support in the “Marketing and Channel” (5%). The survey also shows that “Talent Training” and “Equipment Services” are more important for design service companies than manufacturing companies.

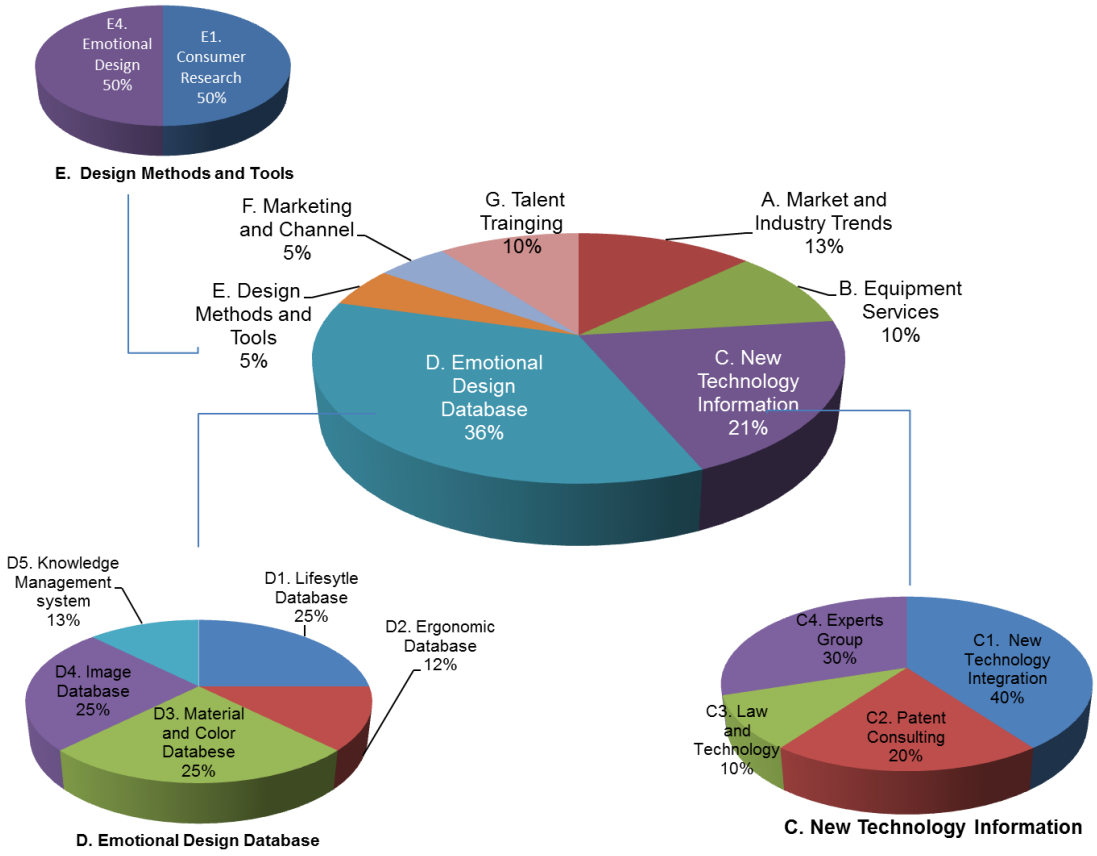

Figure 2: Needs of design service companies

Market and Industry Trends (13%): Because most of the design service companies are small scale, they don’t have enough resources to link with global industries. Therefore, they requested global market and industry information of several industries.

Equipment Services (10%): For most design service companies, the need for high level 3D printers with professional technicians is the main requirement in equipment services.

New Technology Information (21%): They asked ITRI-EDO to build a platform to gather new technology resources and experts in various fields. Patent consulting services are also important in the design process; it helps understand technology trends and to develop their patent portfolio. It is also beneficial to know product regulations in advance to save time and

costs.

Emotional Design Database (36%): As mentioned earlier, this service is the most important for design service companies. The five types of requests mentioned were: lifestyle database, image database, materials database, ergonomics database, and knowledge management system. Designers have to consider lifestyle and user behaviors in different countries. Currently, some information is obtained from the client, and some from the internet. However, the information is interpreted by the designer's subjective experience. A lifestyle database can shorten the design process and fill the gap between designer and client. Designers also get ergonomic information from international papers. It is difficult for them to investigate the information in a new design project. The ergonomic database should include transnational human factors for various products. This database is also expected to include an image library of different cultures.

Changing the color and materials gives a different feeling. There was a strong need for a material database that includes diverse color pallets and material samples. Having access to the latest new material information and samples are important to many companies. Knowledge management system can help design companies train new designers.

Design Methods and Tools (5%): The need for design methods and tools is not as high as other needs. That is because design service companies are more concern about the extensive time needed for Kansei engineering process. ITRI-EDO's contribution for these companies is to provide more efficient methods and design verification tools to help them reduce the design process time and costs.

Marketing and Channel (5%): Only five percent of the needs are in this category. This is because design companies dedicated to serve the brand name companies generally have established good marketing and channeling by themselves.

Talent Training (10%): It takes about one year to train a new designer before they can work on a design project independently. Young designers often quit their job because they felt they were not getting the proper training to develop their potential. Consequently, the return on investment for training is low, which in return reduces companies' incentive to train new designers. For some companies, this situation leads to a downward spiral. Quickly bring up the skills of new designers is a very important task for many design service companies.

2.4. Design Schools Needs

Emotional design engineering has been studied in Taiwan's for many years. Seven universities with emotional design engineering curriculum were interviewed. ITRI-EDO initiated a forum with The Taiwan Institute of Kansei in 2013. All participants agreed that the study of Kansei engineering and its applications should not be limited to industrial design. Many other fields can also benefit from Kansei design engineering. Besides, most design schools are interested in long-term joint research programs using emotional design engineering for specific types of products. ITRI-EDO can assist academia to promote Kansei design.

3. EMOTIONAL DESIGN PROGRAM STRATEGIC PLANNING

To better serve industries in central Taiwan, ITRI-EDO's Emotional Design Systematic Platform (EDSP) will function as a collaboration platform where the design service industry, academia and

manufacturers work and contribute together through the open lab operation and get support from EDO.

3.1. Emotional Design Systematic Platform (EDSP)

Figure 3 shows the Emotional Design Systematic Platform (EDSP) structure. There are five service segments: Data Tank, Technology Discovery, Test & Validation, Tools & Methodology, and Consulting & Branding. ITRI-EDO will provide services and linkage with industry and academia based on these five modules.

Data Tank focuses on research and data analysis on lifestyle, consumer behavior, industry trends and market. Technology Discovery helps build three to five year technology roadmaps for industry and products. Testing and Validation establishes an open lab operation for product and usability testing. The Tools and Methodology module will construct general and customized emotional design tools and methodologies. The Consulting and Branding module will help industry define their business strategies.

Based on the survey results and the program resources, Data Tank, Testing & Validation, and Tools & Methodology are the top three priorities to be established.

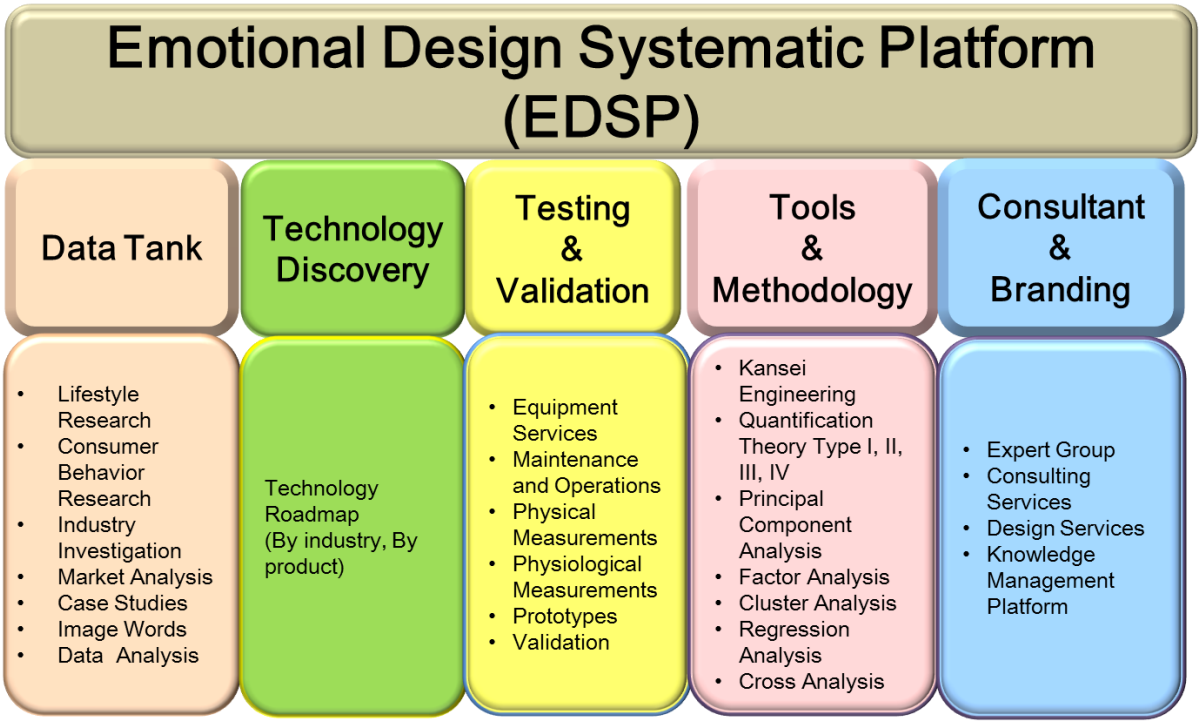

Figure 3: Emotional design systematic platform structure

3.2. Rapid Prototyping Center

There is a great demand for rapid prototyping service. The ITRI-EDO's rapid prototyping center has three laboratories: (1) User Research Laboratory provides facilities and support for user research. Eye-tracking, motion capture, tactile pressure measurement and behavior observation rooms will be established in this laboratory. (2) Prototype Making and Analysis Laboratories are

intended for making models, testing and validation. There will be two 3D RP machines, 3D Scanners and commercial design software in this laboratory. (3) The Material Laboratory establishes a linkage between new materials, especially those developed by other ITRI-R&D programs.

3.3. Taiwan Emotional Design User Alliance

Through The Taiwan Emotional Design User Alliance, manufacturers, design academia, design studios, non-profit R&D organizations, and ITRI itself network together. ITRI-EDO provides its members the technological and marketing information for emotional design. It will initiate a facility and equipment sharing program to assist the members in developing their products.

Connecting with international organizations is very important. ITRI-EDO welcomes the opportunity to work with international organizations and companies in countries with different cultural, lifestyles, user behaviors, and advanced design technologies.

3.4. Industrial Cluster and Living Lab Establishment

ITRI-EDO plans to build a design cluster in central Taiwan and bring local manufacturers, design service industries, academia, and R&D organizations closer to ITRI-EDO. A living lab will be built to experience and share the emotional design accomplishments.

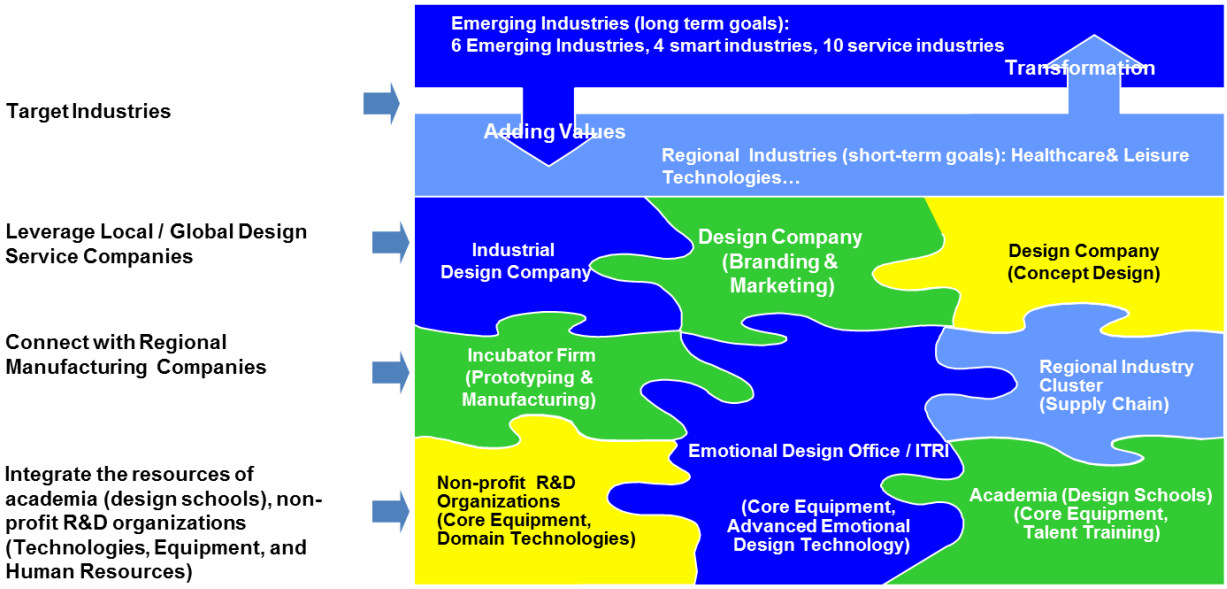

Figure 4: Model for creative and technology industrial cluster in central Taiwan

4. CONCLUSION

The research surveyed 86 companies and organizations to investigate their needs for emotional design. Based on the survey results, EDO-ITRI introduced a strategic plan and initiated an emotional design program in which an emotional design systematic platform is proposed which includes five major segments: Data Tank, Technology Discovery, Test & Validation, Tools & Methodology, and Consulting & Branding. EDO-ITRI will promote collaboration with industry and

academia and establish a creativity and technology industrial cluster. The aim of this program is to assist manufacturing companies and design service companies in central Taiwan to find product differentiations, create business opportunities for new product development, and to establish competitive design-driven innovation strengths for next generation products and industrial transformation.

ACKNOWLEDGMENTS

This research is supported by the Ministry of Economic Affairs, Taiwan, R.O.C. (Project number: 103-EC-17-A-21-1242).

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BIOGRAPHY

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An Emotional Study for Urbancage from the View of Experience Design

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Abstract: In nowadays, urban living gradually can't live without technologies and automobiles, which accompany people for 24 hours just like two soul mates or pets. People hope to interact with others closer via Internet; however, the convenience of technology condenses the genuineness and cares from humans. In the past, there are two purpose of having The Cage, one is for admiring-use, to show the elegant movements and the sound of birds; the other is the symbol of society, representing the social level by having a delicate Cage. Deep inside their mind is their reliable consistency. This research was presented a design project "Urbancage" that was tries to aroused an experience from peoples innocent imagination. Compare with the social phenomenon in nowadays that over-using mobile phone and the behavior of raising birds in the past. Those unite the cage and the mobile phone by penetrating the action of holding and placing the cage, so we can metaphor the automobiles to the birds in cage. Therefore, user would connect the icon of electronically bird with human being via the technology of the application, creating a new life style and habit by that. Finally, this paper would discuss its discover for record of "Urbancage" that presented at exhibition of Tokyo Designer Week and exhibition of PRODUCT DESIGN MADRID2. Those were analysis the act of interaction between audients and product, and make suggestions for regarding the social interaction design.

Keywords: experience, emotion, readymade, communication, product design.

1. Introduction

Ideas of people constitute of memories and experiences, and are the drive for people to look for the experience of happiness; and if we examine carefully, we will find that happiness comes from true feelings. Probably, through interactive design, the true feelings hidden in the deep heart can be awakened. Pratt & Nunes (2012) indicated that from the Internet to cell phones, the interactive design in various forms including structures and services is used to attract the public for further communication when some life experiences are implanted to users; they are also encouraged to use skills and strategies to respond and interact. Their study guided us to understand the importance of design for "people". We need to understand who they are, what they want, and finally, what their unsatisfied needs are. It requires the designers, however, to look for the potential needs and product affordance to present the levels of interactive media and experiences. Desmet (2010) pointed out that product emotion is constructed by "stimulation" and "concern." In recent years, information products launched have changed the public cognition and provided high convenience and progress, but they also cause some social concerns. Traditional values are left behind for the pursuit of new changes and fewer interactions among people occur. We are less

familiar with the natural environment and new stress issues are triggered. Hence, the industrial design field also responds to the environmental change thereby reflecting the focus shift from functional development to humanitarian consideration or the restoration of traditional cultures with the aim to convey trans-functional meanings behind products via the interaction details between users and objects. It is also through a pure emotional connection between people and nature, that people are able to find a sincere living attitude in the confusing environment and feel touched again. The link to the fun brought by toys and fairy tales probably can be applied to products with emotional traits. Innocence experiences can be presented via the form of toys or can be linked to past cultural behavior with the inclusion of use experience of information products. As a result, this study uses bird café-bird-cell phone (radio) connection to examine how “innocence experience” can be guided into creation procedure to present the thinking process that create the interaction with products.

2. Thinking Points of the Application of Innocence Experience to Product Design

“Innocence” means pureness, truth, sincerity, and beauty; and in Chinese, innocence associates with pureness, the simple, direct, and joyful response from the deep heart. Innocence is hidden in the past and present experiences and the direct innocence experience transcends ethnicity and ages and impresses us deeply and affects our perceptions. As we get older, we will find the world to be more complicated and on the contrary, innocence is proven to be more valuable.

Demirbliek (2003) used to discuss the pleasurable elements in product design from the perspective of human factors engineering. The research believed that products shall transmit positive emotions from their specific characteristics. Also, through these characteristics the corresponding emotions will be aroused. Toys are made to enable people to generate positive and joyful perceptions. Johnson and Yawkey (1992) argued that toys are the miniature objects designed according to psychological and social environment of children to make gaming experience more joyful. Hsu (2005) classified function features of toys into three types: (1) basic function, (2) dependent function, and (3) object format. In terms of fairy tales, Li (2002) mentioned that “story, justice, and aesthetics functions of fairy tales can please children and make them feel happy, and bring them spiritual entertainment and enjoyment.” The fun to link toys and fairy tales can be applied to products that focus on emotional features. But innocence experience can be presented in the format of toys and associate with past cultural behaviors. Teng, C.K. & Chuang, M.C. (2011) proposed a design method by having the designer observe local characteristics before integrating cultural background and emotional characteristics into conceiving design. It mention that "simile" and "metaphor" were used as differential methods to convert the analyzed cultural emotions into product. Gorp & Adams(2012) proposed the attract, converse, and transact (A.C.T.) Model based on the perspective of emotional design. In the model, attraction is aesthetics-oriented that triggers the desire; conversing is interaction oriented with the core of usable features; and transacting is function oriented with the focus of usefulness. Thus, this study based on “innocence experience” of creation examines the association between characteristics of experiential elements and modern life behaviors. The attempt is to preserve valuable emotional memories via creation to present emotional and life characteristics of people in modern time with the in-depth discussion on the association between product design and users as well as the effectiveness brought by the final application to high-tech product design. Hence, the comparative transfer of source elements of experience and comparative behaviors will be redefined.

In order to clarify the impacts of product design on the innocence experience as well as the guidance by emotional memories to the interaction between users and objects, this section focuses on the correlation among innocence experience, products, and users.

2.1 The Influence of Innocence Experience on Products and Users

Innocence experience refers to the true feelings that are generated from past joyful experiences and the interaction with environmental objects that will enhance the emotional depth behind stories and the value of overall design concept. The inclusion of good experience in product design gives more human touches to the objects. In addition to the provision of external display, the emotions of users are better satisfied. For users, elements of innocence experience are opportunities to activate past memory experience of users that have been lost in the environmental society and even for users that are not familiar with the elements; at various age groups and with different

backgrounds they are able to feel the fantasy like children brought by innocence experience elements.

2.2 The Influence of Products on Innocence Experience and Users

Products themselves contain multiple meanings such as functions, shapes, materials, and cultural contents and for innocence experience. If the relevant innocence experience according to different product contents is re-constructed, then the past emotional experiences can be represented. Through comparative transfer of experiential elements with design method, the whole new feelings based on old memories are developed. For users, products are objects that satisfy the needs and solve problems. Through the mechanism or hint provided by products, users operate. The satisfaction levels can be divided into functional and psychological ones and the methods to satisfy involve the transmission and receiving of information of sub-consciousness and the results also differ according to social environment of users.

2.3 The Influence of Users on Innocence Experience and Products

For innocence experience, users are the containers that help to keep memories and the completeness and depth of memories also differ according to users. As a result, different users will perceive with different strength towards experiential elementsbut experiential characteristics of memories are in common and with more common memories, users can be felt by users with various cultural backgrounds. For products, users are containers that accept information and respond and products according to semantics cues of various shapes, colors, and house requirement, users are guided to operation. The interaction between the middleman and the object is full of interpretation and response to information. This study classifies interaction into two types: interaction of external function that aims to produce information receiving and response based on functional demands as well as interaction of internal memory that focuses on the production of information receiving and response due to emotional memories.

Thus, three types of correlations from different perspectives are shown as in Fig. 1.

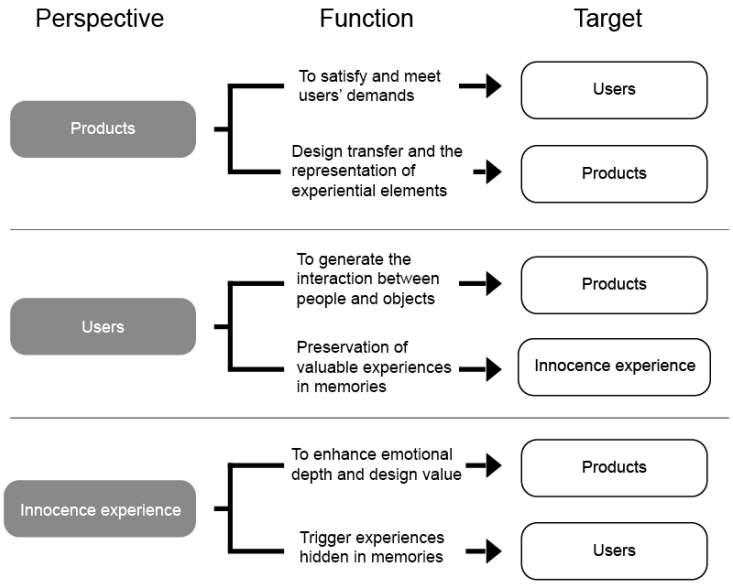


Figure 1: Three types of correlation from different perspectives

3. Creation Process and Method

3.1 Phase 1: Design Observation and Analysis

(1) Observation of life behavior: Scattered observations are conducted on surrounding objects, human behaviors, social environment, and small and big events.

(2) Analysis of innocence experience: The causes and effects of the theme targets are examined to link up with innocence experience and analyzed for more design details.

3.2 Phase 2: Integration of Innocence Experience and Design

(1) Initiation of theme concept: Objects observed or causes and effects of behavioral model and innocence experience are understood through initial analysis to transfer analytical elements to design concept to inspire the thoughts of design theme.

(2) Comparative transfer of product details and innocence experience: Deep design transfer is conducted for conceptual theme for comparative and design transfer of detail product elements and corresponding innocence experience. A three-layer axis design based on innocence experience is discussed.

3.3 Phase 3: Design Practice Phase (the implementation of design details)

When the design process enters the practice phase, we make decision on appearance image design, manufacturing process, functional material and details, scenarios and styles. Through tests and adjustment such as 3D, draft simulation, and functional assumption, we actually transfer the concept into a complete object.

3.4 Phase 4: Result Presentation and Feedback Phase:

Products are launched externally through different ways and according to product features and items, presentations and contests are organized to acquire opinion feedbacks from people in and out design field to explore for more possibilities about the theme. The whole process is shown as in Fig. 2.

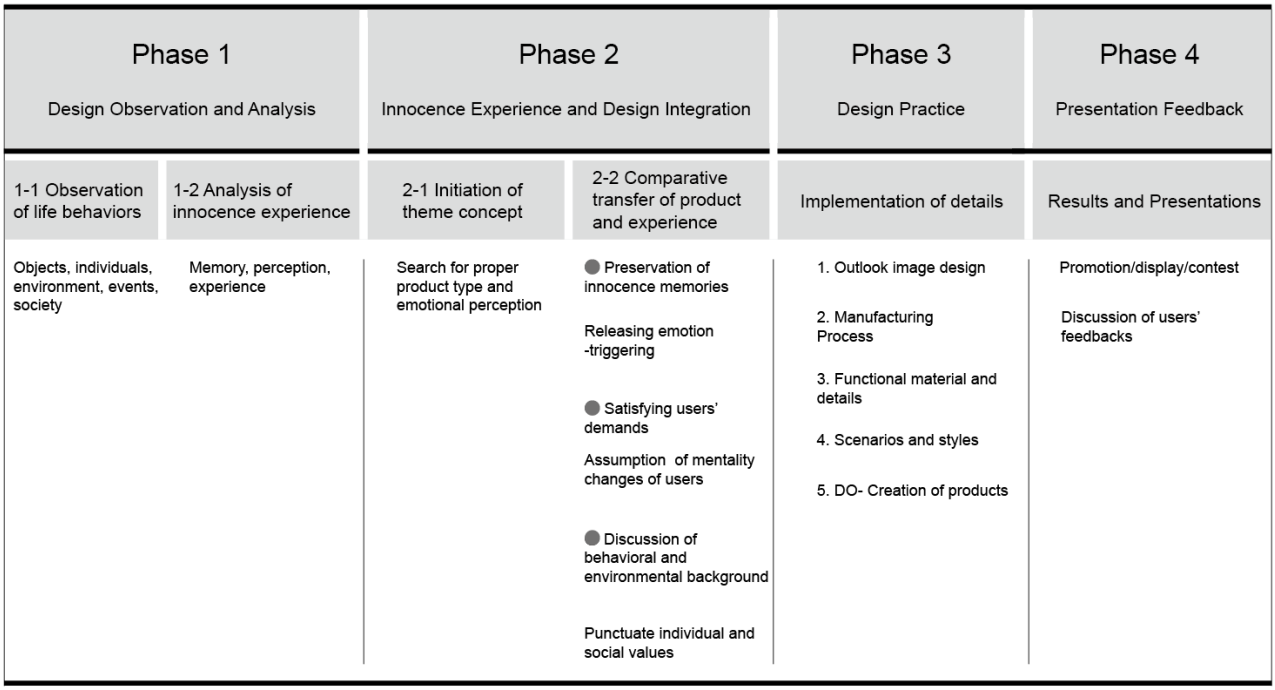


Figure 2: Creation Process and Method（by the authors）

4. Creation Discussion - Urbancage

4.1 Phase 1: Design Observation and Analysis

4.1.1 Observation of Life Behaviors – The Overwhelming number of Cell Phones and Tablet Computers

Opinions and spiritual communication are critical reasons for human civilization and smart phones and tablet computers have gradually changed the traditional communication habits in society. The quick and convenient communication way enables people to quickly communicate without barriers but technologies, at the same time, shorten the distance of the heart although the caring behaviors are lost the warmth during the process of message and digital symbol communication. The intangible technology barriers, thus, appear in our surrounding environment and sometimes, misunderstandings and stress occur.

4.1.2 Analysis of Innocence Experience- Cultural Experience of Birdcages

Birdcages house birds from the wild nature in a limited and small space; people, through the narrow gaps of a birdcage, are able to view the livid life and enjoy the bird. Birdcages can be found in every culture around the world. From the up the River During Qingming painted by the artist Chang Tse-Tuan in the North Song Dynasty, we are able to see people in the ancient time often talked their walk with birdcages. The rich Bannermen in the Qing Dynasty collected designers' birdcages that have been viewed as the presentation of social status. The owners of birds cared about everything of the birdcages from materials, sculpture details, to feeding devices and different types of birdcages were designed for different types of birds (as in Fig. 3). Nowadays, due to the concern of infection diseases (for example, avian flu), bird raising is not encouraged and the number of shops that sell birds in Taiwan has decreased quickly. The new generation has gradually become less familiar with this traditional culture.



Figure 3: Taiwan's Traditional Birdcage (photographed by author)

4.2 Phase 2: Integration of Innocence Experience and Design

4.2.1 Initiation of Theme Concept

In the past, people raised birds to live with the wild life, and through birdcages, birds were housed but with the care, special emotional connection had been created. Now, people live with cell phones and tablet computers and are dominated by them, too. And in the distant urban environment, the public contacts the outside world with cell phones. At the same time, they are limited in the frame to look for the special dependence and emotional sustenance. What birdcages to bird is like what charging stereos of cell phones and tablet computers to us and with this link, the thought of product design examines the association between past innocence experience and urban life of people as shown in Fig. 4.

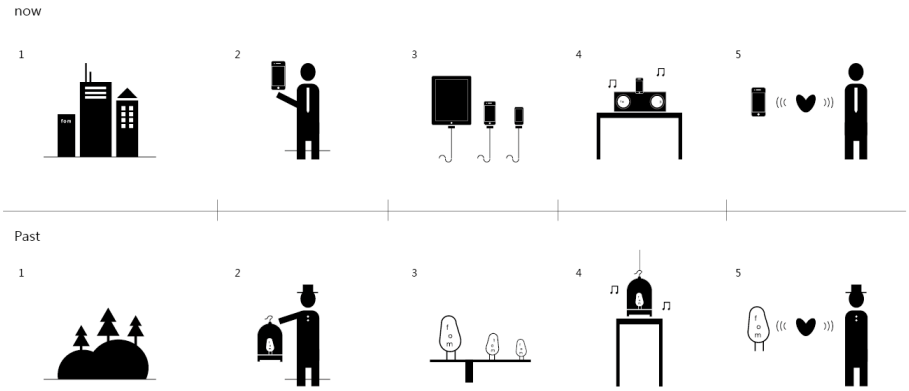


Figure 4: Design elements（by author）

4.2.2 Comparative Transfer of Product Details and Innocence Experience

(1) Preservation of the Experience of Innocence Memories

A. Comparison of Three Elements of Products and Innocence Experience

a. Object elements: This study compares different models of tablet computers and cell phones of Apple to various sizes of birds; the cell phones are equipped with amplifiers that can have vivid sound like the birds do. Birdcages for birds are safe shelters that provide warmth and safety like the houses of people, while we are in the house, we will place our cell phones on charging stereos to amplify music effects. For cell phones, the charging stereos are similar to sheltering objects. Inside traditional birdcages, there are food slots and fruit holders to supply birds' food; the charging stereos provide cell phones the electricity power that can prolong the use of cell phones, a similar function provided by birdcages.

b. Emotional elements: Birds are small in size and easy to be frightened, and during bird raising, the owners need to maintain good living conditions for birds. During the process, special emotions and connection are created like what we have for families and good friends. In the past, beautifully sculptured birdcages and special bird species presented the fantasy of freedom as well as social status. Sometimes, they are the objects to show off one's wealth. People in modern times use cell phones excessively and smart tablet computers, like our families and good friends, often stay with us around the clock. People via cell phones and the Internet look for communication channel to contact with the outside world and gradually become dependency in smart tablets.

c. Environmental elements: Birdcages can be found in most of the parts of the world. For Chinese culture, they present long historical culture and memories. Traditionally, birdcages were handmade but in Taiwan, the birdcage tradition has gradually lost. For the new generation, it is a gradually lost cultural memory. The cell phone market in the world has been led by the launching of new models and the purchase of expensive cell phones now has been the symbol of fashion in society. The life experience of the new generation is all about smart tablets, the new generation memories that replace the traditional ones.

B. Releasing Emotions and Triggering Imagination

It is the use process that integrates the impression experience of the wildlife and cultural tradition in modern products. With the traditional image of birdcages including the hanging and holding method, bamboo material, standing position of bird, attraction to viewers or the imaginary space during use, new experience is introduced to the product to re-awake good ecological environmental experience and to promote emotional interaction between users and the product.

(2) To satisfy the internal and external demands of users

A. Assumption of demand satisfaction

External demands: At the bottom of the birdcage, there is stereo speaker with the equipment of bamboo made power and sound source buttons in the front end. With the built-in charging batteries, the connector is placed in the middle of the birdcage. At the right bottom, there is a USB slot that allows one to connect it with an external power source.

Potential demands: As the feeling of hanging the birdcages, three types of stereo system with the shape of birdcage are designed and the hook on the top allows people to hang the system as the position of birds standing on the top of tree. The charging port presents the standing position of a bird inside the birdcage.

B. Assumption of Users' Mentality Change

b-1 Experience of innocence experience triggered by product appearance: The smaller size matches with the dimension of birdcage where the user can place the cell phone at the center that gives the traditional impression of birdcage to the majority of people. The rectangular model punctuates the interaction of two birds living in the same birdcage; on the top, the arch implies the activeness and lightness of a swing. The large size model presents the traditional birdcage for large size bird; IPAD can be viewed as the birdcage stereo system designed based on large size birds.

b-2 Link to innocence experience triggered by operating process: Compared to traditional models, the small stereo system is lighter, so it is more suitable to be hung in the air or carried indoors like birdcages in the air, and it is a joy to walk with a birdcage. The long model of the stereo system can accommodate two birdcages and the top gives the space for a new cell phone where the sound source is only supplied. At the bottom, the old cell phone can be placed in the opposite direction that allows the user to feel the interaction of two birds during placement. The

new cell phone is placed on the top while the lower part, the old cell phone is placed in an opposite direction implying the pursuit of novelty in the cell phone market. The large size model punctuates the weight of big bird and the placement of tablet is designed directly on the speaker representing that the bird is too heavy to stand on the top.

b-3 The link to innocence experience with the reflection on product semantics: Through the product use, the users will feel the use of traditional birdcages. When the Urbancage is placed in the same living space with a user, the scenario is like those who collect antique and raise birds. The overlapping imaginary and reality scenarios creates unique link to the new experience and further trigger the user to think the behavioral model that relies on technologies and the impacts on the biological environment.

（3）Discussion on Human Behavior and Environmental Background

A. Innocent Experience that Punctuates Individual and Social Behaviors

Starting from the reliance of people on smart tablets in the technology life of people, this study examines the environmental phenomena via the user behavior of birdcage stereo system. The Urbancage is not only the positive comparison of a birdcage and cell phone experience, but in some aspects, it criticizes the expansive connection between these two. For example, the placement arrangement of the long model birdcage that can have two cell phones, new and old, placed in opposition directions, showing the careful thought of this study. It is aimed to compile the analysis of innocence experiential elements into new design language and then transfer it into product semantics that punctuates the behavioral causes of people and the social environment behind.

B. Special Value of Design

The special value of design lies in the observation in different aspects and analyses of themes via various types of media. It is hoped that in this study, material approach distinct from other product designs can examine more deeply about the new interactive experience between users and products. Therefore, this series of “Urbancage” products are combined with interactive APP animation to discuss the interaction of products and innocence experience of reality and virtual imagination and how they impact the thought and emotional experience of users as shown in Fig. 5.

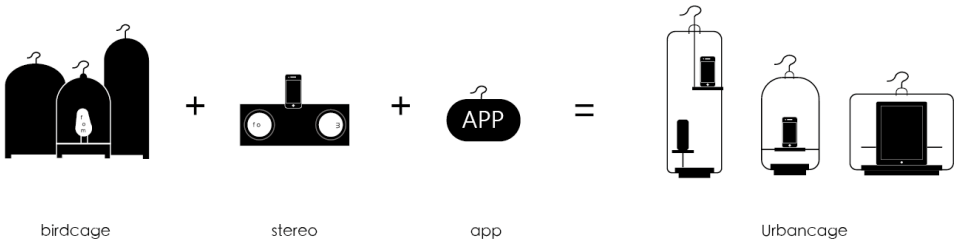


Figure 5: Design elements（by author）

4.3 Phase 3: Design Practice Phase

In appearance image, in order to trigger the imagination of innocence experience, the overall contour of the stereo is designed on the base of old birdcage in the design strategy by using modern and simple frame line to support the overall visual structure of products that incorporates with the edges of internal cell phones and tablets. The proportion is adjusted with 3D software and paper tests (as shown in Fig. 6) before manufacturing. In order to enhance structural strength of the Urbancage stereo, stainless steel is used. The old birdcages often use “bamboo” as the material and we preserve “emotional memories of birdcage” with the color, smell, and touch feeling of bamboo and therefore, power supply button, volume button, and the upper and lower covers of speaker use bamboo material. Stereo chip is placed at the bottom. A user can operate the stereo either by holding or hanging it to feel the joy of taking a walk by carrying a birdcage (Fig. 7).



Figure 6: From Contour Drawing to Model Making (photographed by the researchers)



Figure 7: Fun Operations of the Stereo (designed by Yi-Ting Chen)

4.3.1 Interactive APP Design of Urbancage

The combination of interactive APP with Urbancage stereo aims to bring users and viewers more in-depth memory triggers and responsive feedback with the overlapped virtual and reality memory elements in order to explore the potential possibility of the application of innocence experiential elements to product design. The overall interactive structure in this study consists of “physical products” and “virtual APP,” but virtual APP transcends the professional field of products and in order to look for the optimal effectiveness of creative study, we asked for the help of three partners. The bird illustrations are the work of Hsing-Wen Yeh, the animation was produced by Chao-Hau Yang, and APP was done by Hung-Chi Li.

(1) Frame of birdcage stereo: The Urbancage stereo allows users to place the cell phone at the center and the cell phone, like the bird housed in the cage, implies the public behavior in society controlled by high-tech products.

(2) Frame of virtual world: The cell phone has an electronic screen and visual sensing lens and after the smart tablet connects to the Internet and the cell phone is placed on the birdcage stereo after the interactive program is installed, the bird animation is shown on the cell phone in the cage when the music is played. When a person gets closer to the birdcage stereo, the sensing lens in the front of cell phone will receive the message. The virtual electronic bird on the screen will then react like a real frightened bird flying to another smart tablet via the Internet connection (Fig. 8). After a while, it automatically flies back to the original electronic tablet. The whole interactive process presents the innocence experience of people and birds. With the virtual presentation, the actual interactive behavior is shown to trigger emotional experience of people with the natural life.

(3) Innocence experience triggered by interaction: Users via the virtual interactive experience feel the desire and curiosity of the previous generation towards free lives. At the moment when the virtual bird flies away from the screen, there is some regret and expectation and when it appears on another tablet, users often feel surprised and joyful. Users can also feel the intangible frame when the virtual bird flies back to the original screen and it implies users as the cell phone, tablet, and the electronic bird in the cage are limited by the social system. Through the presentation of innocence experiential elements, behavior features and symbols of people in the modern time are shown (different proportion arrangement in Fig. 9). Thus user would feel an interaction experience from “Urbancage” that was combine two types feeling from real frame and virtual frame, it were integrated with links by App and transferred through Wi-fi. (The interactive scene was shown as Fig.10)



Figure 8: Flying of Virtual Bird that Transcends the Frame (photographed by the author)



Figure 9: Frame Scenario at Different Proportions (designed by Yi-Ting Chen)

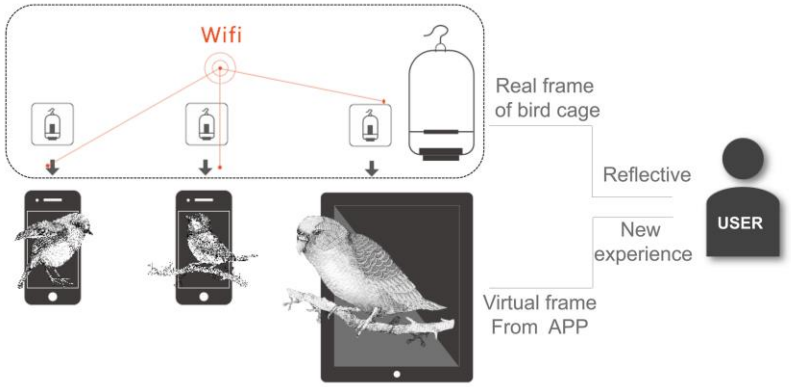
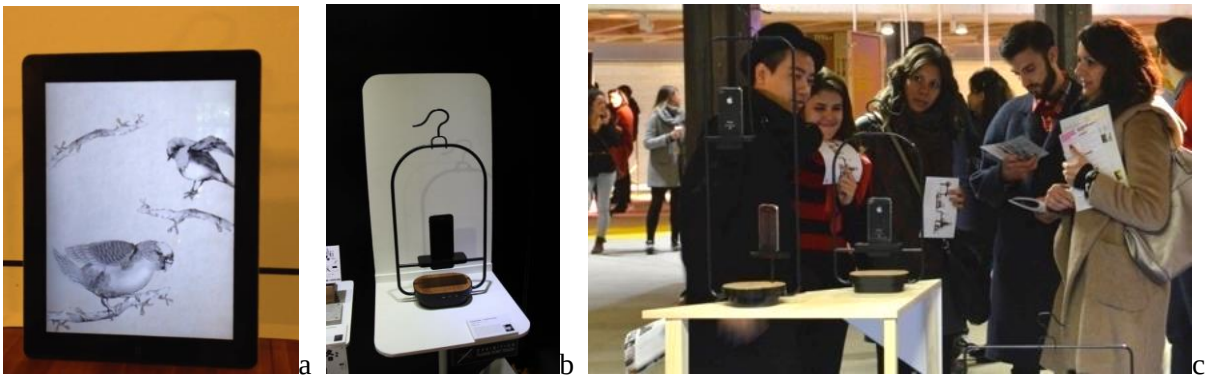


Figure 10: The experience combine from real frame and virtual frame by App & Wifi.

4.4 Phase 4: Presentation and Results

The creation Urbancage of this study has been presented in “2013 Taiwan Design X Taipei Design & City,” “Tokyo Designers Week 2013,” and “Product Design Exhibition Madrid 2013” (shown as Fig. 11 a-c) and it was also awarded as the excellence works in “2013 Taiwan Design & Taipei Design & City.”



a b c

Figure 11: Interactions at the Three Exhibitions of world (photographed by author）

5. Conclusion: The Circular Relationship between Innocence Experience, Products, and Users

This study combines interactive design and emotional design in observations and initially, the applications of innocence experience to products are analyzed to identify different effects generated from the different sources of cognitive experiences and the integration with product

types as well as the impacts on external and internal demand aspects of users. Next, after studying experiential elements and contents that need to pay attention to at different design levels, we introduced innocence experience for creation process and thinking points to product design. Then, according to creation process and thinking points, the past formats and user behaviors of birdcages are compiled to link to the association with the use and innocence experience of high-tech products such as cell phones and PAD to help people to know cell phones are birds that have been raised in the modern life. In the end, a discussion on details are conducted through the design transfer to innocence experience during creation and creation results are examined with the application of innocence experience as well as the potential effectiveness and possibility to apply innocence experience to product design and interactive design.

This study examines the correlation of innocence experience, products, and users and finds the bi-directional special circular chain.（a）In anti-clock direction, products provide functions to satisfy the demands of users and during the operating process of satisfaction, users generate innocence experience. Therefore, users become the intangible vehicle to preserve experiential elements and after the integration of innocence experience in products, new values can be created to satisfy external and internal demands of users through the operation of products. (b) In clockwise direction, the integration of innocence experience in products can preserve the tangible vehicle of experiential elements. When users view or use the products, the past memories are triggered to overlap with the imaginary space of existing experience and their stress is released and a joyful feeling is generated. At the same time, the interactive interdependent relationship between users and products is built to enhance attractiveness between people and the objects (as in Fig. 12).

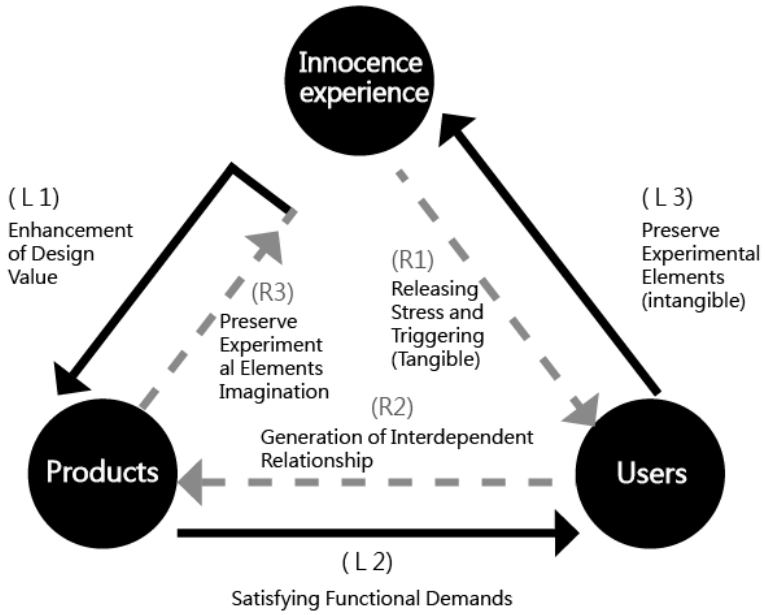


Figure 12: Bi-Directional Circular Relationship of Innocence Experience, Products, and Users (by the author)

This study initially proposes thinking points for “the transfer of innocence experience to product design” to explore the in-depth cognitive message hidden in the memories and convey the product messages to users. It is hoped that through this study, more designers are inspired to think of the incorporation features of interactive contents and their vehicles that will help users to see the more diversified world with appropriate emotions and rich product use experiences provided by the designers.

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Potential of Objective Preference Evaluation in a Creative Process

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Abstract: Nowadays, many researches on the objective and logical evaluations of created objects are conducted in *Kansei* design field. However, there are not many studies on the relationship between creator's own creativity and the evaluation on their work in fine art field like glass art. Many students in the fine art field conduct creative work with their limited favorite styles although they have not developed their own expressive characteristics yet. It simply means they need to introspect and cultivate their own *Kansei*. With this background in mind, the purpose of this study is to provide students in the field of glass art with new perspectives so that they can introspect their own *Kansei* and develop characteristics of their creative work. Thus not only Kansei as a source of creativity but also *Kansei* as an evaluation on perceived stimulus from outside are addressed in this study. As a result, the relationship between student's preference in a creative work and others' *Kansei* evaluation on it was analyzed by multivariate analysis. All students were able to introspect their own *Kansei* as a source of creativity based on the others' objective evaluation. The result means each student can understand one's characteristics of creative work. That is instrumental in trying various expressions in their creative work. Moreover, they can convey their creative work to others objectively and logically by using the results of analysis.

Keywords: Creativity, Preference, Introspection, *Kansei* evaluation, Fine Art

1. INTRODUCTION

Nowadays, many researches on the objective and logical evaluations of created objects are conducted in *Kansei* design field. However, there are not many studies on the relationship between creator's own creativity and the introspection and evaluation on their own art work in fine art field like glass art. According to *Harada*'s research (Harada, 1998), *Kansei* is defined as "mental function creating images" and "beauty and comfort, ability of reacting and evaluating symbolically and intuitively". According to Lee's research (Lee, 1998), *Kansei* information such as 'Images'

helps the creative process. Creator's internal factor (=*Kansei*) and external factor such as information from an outside are involved with the process of creating a new idea (Kiyokawa, 2010). These results from previous researches mean a designer, a fine artist or a craftsman creates something using their own *Kansei*.

Many students in the fine art field conduct creative work with their limited favorite styles although they have not developed their own expressive characteristics yet. It means they have to develop their own expressive characteristics through generating trying new various ideas and trying to use unlimited expressive styles, and they have to refine one's expressive style continuously also. Moreover, they have to introspect and reflect one's expressive style based on others' opinion and evaluation on their style, and they have to convey the value of their creation works to others logically. Because, it is pointed out that almost artist cannot convey the value of their creation works logically to others although they created the great works. If that is the case, how can the students in art school have the experience to introspect their own creation style in art works, and to convey the value of their creation works more logically to others?

There is Evaluation Grid Method to construct one's evaluation structure of an object (Morita and Kanade, 2005). In general, we evaluate an object generally using sensitive understanding (Middle layer in Fig.1). The sensitive understanding needs some objective reasons (Bottom layer in Fig.1). And the abstractive judgment value is extracted based on the sensitive understand (Upper layer in Fig.1). The Evaluation Grid Method helps to convey some information logically using the visualized evaluation structure. It means the Evaluation Grid Method may help to convey the value of their creation works more logically to others.

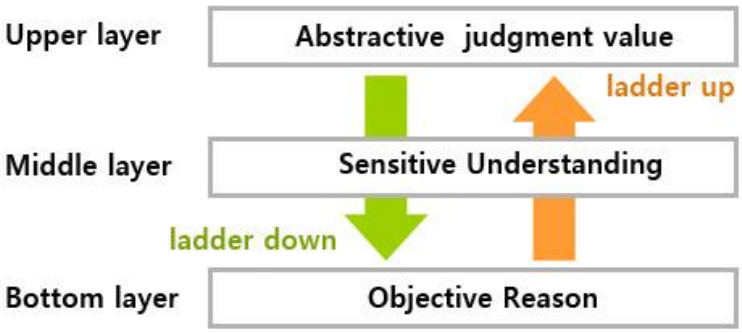

Figure 1: The concept of Evaluation Grid Method

With these backgrounds, the purpose of this study is to provide a special experience to students in a glass art field with new perspectives based on the viewpoints of *Kansei* Science research field so that they can introspect their own *Kansei* and develop characteristics of their creative work. Moreover, to suggest a new experience which they can convey the value of one's creation work to others logically using the results of objective analysis is the purpose of this research also. Thus not only *Kansei* as a source of creativity but also *Kansei* as an evaluation on perceived stimulus from outside are addressed in this study.

2. METHOD

2.1. Workshop “Beyond Creativity”

As the previous descriptions, the purpose of this study is to provide a special experience that students in the glass art field with new perspectives so that they can introspect their own *Kansei* and develop characteristics of their creative work. Therefore, the workshop, named “Beyond Creativity”, was conducted with 14 students in glass art (glass art) course in Southern Illinois University (SIU) on 18th Feb. and 20th Feb. 2013. Especially, the educating position of glass art course in SIU is nearer to fine an art field than a craft or a design field. In fine art, a value of aesthetic is highly estimated. On the contrary to this, the value of function is more estimated in design or craft field than fine art field. Therefore, the purpose of this workshop “Beyond Creativity” is to help the students of glass art to introspect their own *Kansei* and convey the value of their own creation work logically to others.



Figure 2: The participants of workshop “Beyond Creativity”

2.2. Method

This workshop “Beyond Creativity” was composed with the following four steps:

1) As a warming-up process, the each participant brings a preference item in daily, and they conduct presentation freely why they selected the item.

2) The each participant selects a preference glass art work (glass work) from the magazine named “Glass Quarterly”, and constructs each one’s evaluation structure using adjectives with Evaluation Grid method (Left in Fig.2).

3) The each participant is separated with five groups, and the each participant constructs the others’ (in same group) evaluation structure using adjectives with Evaluation Grid method. After that, all participants conduct interim presentation why they selected the glass work as a favorite art work using the results of Evaluation Grid Method (Right in Fig.2).

4) All participants evaluate all of the selected each one’s art work by using SD method. In that time, the cited adjectives in step 3 are used. (The results of SD method were analyzed with Factor analysis).

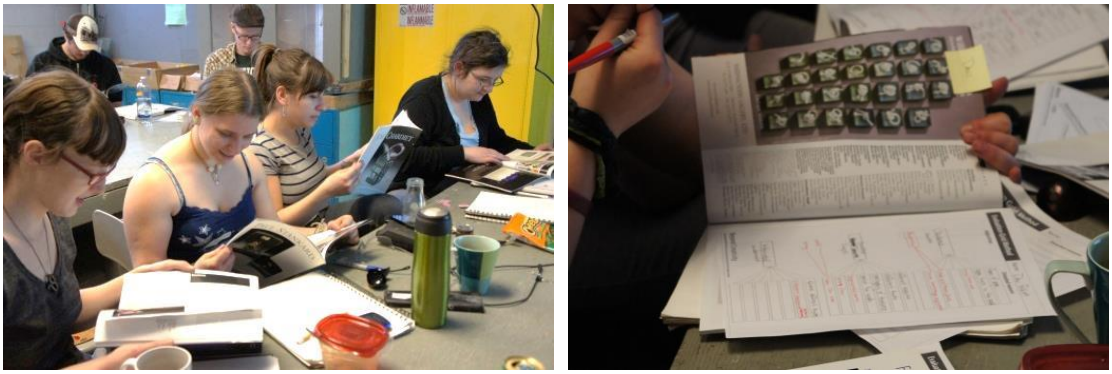

Figure 3: The scenes of second and third step

3. RESULTS

3.1. Results of Evaluation Method

The first, they conducted a presentation why they selected the preference item in daily. In that time, almost participants presented using shot sentences with some common key works such as “cool” and “easy to use”. The almost of all presentations had finished for about only1-2 minutes.

In the next step, each Participant selected a glass work freely based on each one’s preference from the magazine named “Glass Quarterly”. Figure 4 shows the results. Each participant evaluated some glass works as each stimulus and selected their own favorite glass work using each one’s *Kansei*. That is why the selected glass works are different with individual.



Figure 4: The selected art glass works

In the third step, the other participant in the same group added the adjective words and the definite reasons to the each one's selected glass work on other's sheet of Evaluation Grid Method. The Figure 5 illustrates the results a sample of a participant's evaluation construction with Evaluation Method. The black words in the figure means the extracted each participant own adjective words and definite reasons to the one's selected glass work, the red words means the extracted other participants' adjective words and definite reasons to the same glass work. In this step, each participant was needed to extract adjective words as a middle layer as many as possible. In this step, 57 adjective (Ave. 4.75 per person) words and 195 definite reasons (Ave. 16.25 per person) were extracted in Evaluation Grid Method.

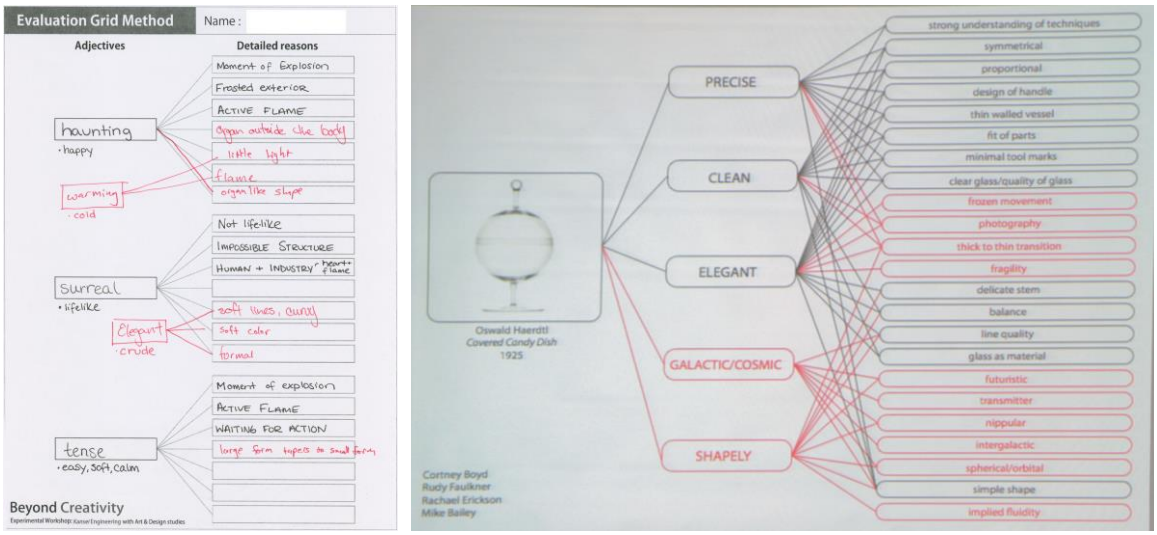

Figure 5: Examples of the constructed evaluation of the selected art glass work

Through these second and third steps, each participant could get the visualized evaluation construction using Evaluation Grid Method with the causal-and-effect relations. From the visualized structure, they could realize not only the each one's evaluation construction of the selected favorite glass work logically but also the others' evaluation construction of the selected one. This result conflicts with the result of warming-up task in first step. Using Evaluation Method in this step, participants could obtain more various and objective information why they selected the glass work as a favorite one than in the first step.

3.2. Results of SD method and Factor analysis

From the second and the third steps, total 57 adjective words were extracted from all participants. The 57 adjective words were arranged to 27 adjective words for SD Method with 3 persons including a Native American.

In the final step, 10 participants had evaluated the selected each 10 glass works with the 27 adjective words as the standard of SD method (Fig.6). (Only 10 participants attended in the final step.) The Factor Analysis was conducted with the all results of SD Method. The table 1 shows the results of Factor Analysis.



Figure 6: The scene of fourth stept

Table 1: Results of Factor Analysis

		Factor		
		1	2	3
Boring	Interesting	−0.767	−0.267	−0.160
Haunting	Forgettable	0.699	0.047	0.092
Static	Dynamic	−0.683	0.103	−0.003
Expressive	Impassive	0.641	−0.055	0.130
Complex	Simple	0.600	−0.042	−0.191
Unexpected	Predictable	0.587	0.049	0.292
Strong	Weark	0.510	0.086	−0.102
Monochromatic	Colorful	−0.492	0.311	−0.050
Dull	Bright	−0.486	0.028	−0.150
Textual	Flat	0.473	−0.286	−0.101
Uninformative	Informative	−0.467	−0.073	0.108
Tense	Calm	0.445	−0.396	−0.094
Fitting	Contrasting	−0.409	0.224	0.017
Elegant	Messy	0.049	0.846	0.091
Clean	Dirty	0.008	0.748	0.020
Smooth	Rough	−0.291	0.605	0.333
Clumsy	Skillful	−0.348	−0.550	0.225
Useful	Useless	−0.026	0.513	−0.110
Vague	Precise	−0.221	−0.451	0.415
Surreal	Realistic	0.359	−0.399	0.378
Sensual	Chaste	0.129	0.250	0.675
Fluid	Solid	0.048	0.104	0.459

From Factor Analysis, the following three principal factors were interpreted: 1) Originality of expression of glass work, 2) Abstractness of expression of glass work, and 3) Conservativeness of expression in glass work.

Table 2: Result of the Interpreted three principal Factor

Adjective word	Elgenvalue	Factor interpretation
Boring, Forgettable, Static, Impassive, Simple, Predictable, Weark, Monochromative, Dull, Flat, Uniformative, Calm, Fitting	4.695	**Originality of expression** (Conventional-Original)
Messy, Dirty, Rough, Clumsy, Useless, Vague,Surreal	3.332	**Abstractness of expression** (Abstractive-Objective)
Chaste, Solid	1.731	**Conservativeness of expression** (Conservative-Raunchy)

The following Figure 7 shows the position of the selected each glass work based on the extracted 3 factor.

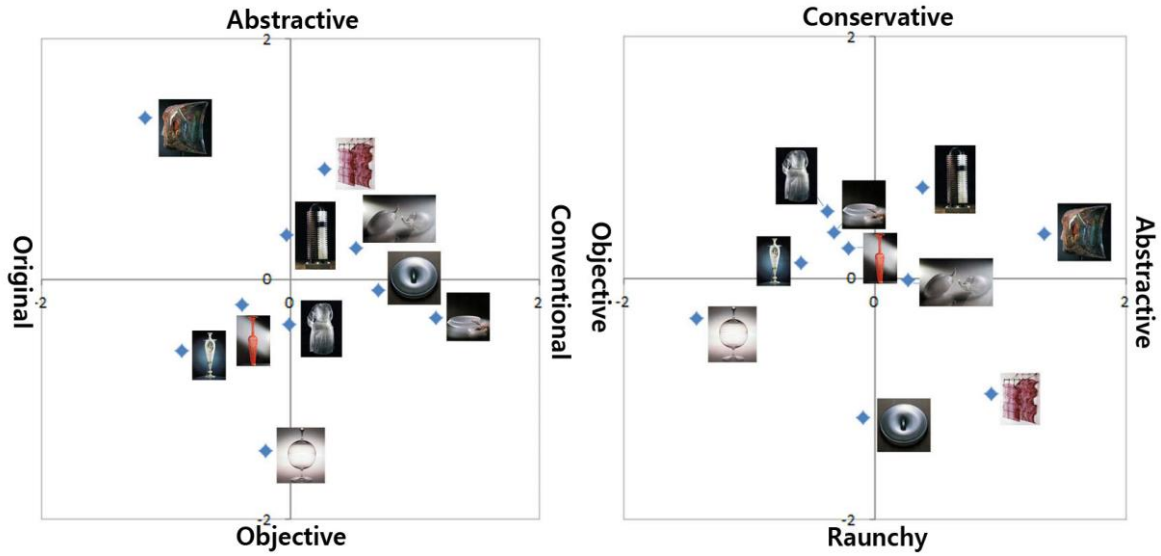

Figure 7: The position of each selected art glass work with three Factors

From the results, it was revealed that “Originality factor”, “Abstractness factor”, and “Conservativeness factor” were used to evaluate the favorite glass work of glass course in SIU. Each participant could identify the selected glass work based on their own preference. From the result, each participant could introspect their own preference in creative glass work from the visualized the figure. Moreover, each participant could verify each other’s preference from the figure also. This result means that we can grasp a position and a situation of preference in a creative process and an evaluation process of various fields by using this method.

3.3. Creating a drinking vessel for other student as a clinet

Each participant could understand not only one’s preference in creative work process but also the other’s preference. Each participant created a drinking vessel for the other participant as a client based on the understanding not only one’s situation preference in creative process but also the other’s preference. Figure 8 shows the some idea results from the final step.

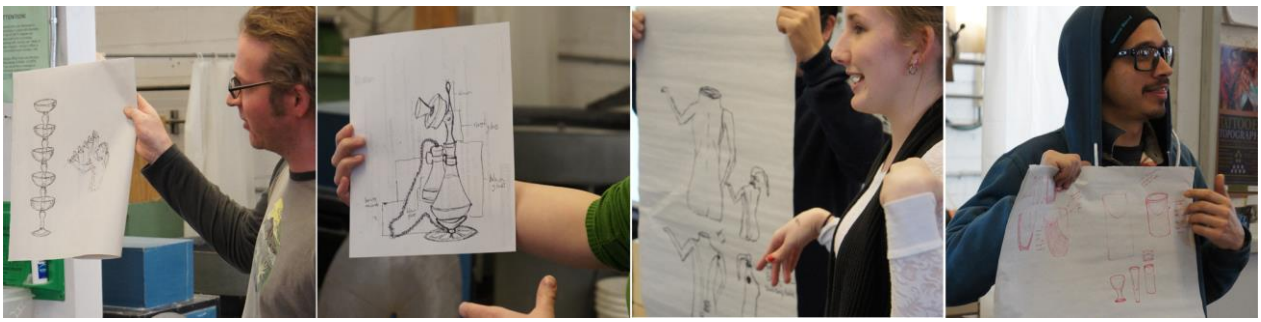

Figure 8: The examples of created water base bottle

4. CONCLUTION

The purpose of this study is to provide students in the field of glass art with new perspectives so that they can introspect their own *Kansei* and develop characteristics of their creative work. Thus not only *Kansei* as a source of creativity but also *Kansei* as an evaluation on perceived stimulus from outside are addressed in this study. Therefore, the workshop “Beyond Creativity” was conducted with the students of glass course in SIU.

As a result, the relationship between student’s preferences in a creative work was visualized, and not only each one’s evaluation but also others’ evaluation on the preferences in the creative work were analyzed by Evaluated Grid Method and Factor Analysis. From the results, all students were able to introspect their own *Kansei* as a source of creativity based on the others’ objective evaluation. The result means each student can understand one’s characteristics of creative work. That is instrumental in trying various expressions in their creative work. And, they could convey a value of creative work to others more objectively and logically by using the results of these analyses. Moreover, they could understand the position of their favorite glass work more objectively using the result of these analyses. These processes helped each participant introspect their own *Kansei* and develop characteristics of their creative work.

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BIOGRAPHY

Kang had studied a product design at Hong-ik Univ. of South Korea. And Kang had completed his Ph.D. in *Kansei* Science at Tsukuba Univ. of Japan. Now, Kang is associate professor at Future University Hakodate of Japan.

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The Impact of Narrative Methods on Deriving User-Centered Product Requirements from Individual Knowledge

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Abstract: Industrial design education and practice often sits on the fence between rational approaches as established in engineering design on the one side and free-spirited approaches familiar to fine arts on the other. Especially when in interdisciplinary contexts, this may cause some issues since industrial designers and their methods may be perceived as either too narrow-minded or too chaotic. One example of reoccurring surprise is the use of narrative methods such as personas and use case scenarios in systematic product development processes. Usually, collaborating engineering designers are sceptic in the beginning but later on accept the methods as means of communication and collaboration. However, narrative methods are not only means of team work and presenting concepts or solutions, but also help analysing the task, defining requirements and evaluating design proposals. This paper describes a study that aims at proving the impact of narrative methods in industrial design on an empirical basis.

Keywords: individual design knowledge, narrative methods, user-centered product requirements

1. THEORETICAL UNDERPINNINGS

1.1. Specifics and acquisition of design knowledge

Based on his general definition of design knowledge as “as simply knowledge that can be used to produce designs” (2005: 387), van Aken provides the categories object knowledge, realization knowledge and process knowledge, which can be further classified into prescriptive and descriptive design knowledge. In reference to van Aken’s categorisation, this paper focuses on prescriptive object knowledge.

Prescriptive design knowledge is needed to be able to work on the design task. Individual prescriptive process knowledge may grow from project to project, being applied mostly unconsciously. In contrast, large parts of prescriptive object knowledge must be acquired

specifically for the projects. Consequently, design projects usually start with the designers' individual acquisition of knowledge. Especially to novices, it may be rather complicated to make this knowledge individually available although it is principally and individually already there (Schön, 1983; Goel, 1995). The action regulation theory (e. g., Hacker, 2005) brings forward an explanation model according to which the lack of an anticipatable goal as the crucial foundation of action can be the problem. Before the design goal – in industrial design this is human experiencing (Schifferstein & Hekkert, 2008) – can be anticipated together with the design concept at an abstract level, the designer must be enabled to act during the acquisition of relevant design knowledge by giving further intermediate goals, e.g., as methodical instructions. It is vital that these intermediate goals are defined independently of the task but specifically for the discipline and interact with the other foundations of action, such as motivation.

When methods are selected and adjusted for setting and fulfilling such intermediate goals by the acquisition of individually available design knowledge (in the sense of van Aken's [2005] prescriptive object knowledge), it is vital to take into account its specific characteristics. This knowledge can be described as non-knowledge (e. g. Lawson, 2006, along with uncertainty), previous and experiential knowledge (e. g. Jones, 1963; Cross, 2004), factual and episodic knowledge (Visser, 1995; Lawson, 2004), sociocultural and technical knowledge (Strickfaden, 2006), everyday (e. g. Visser, 2006; Krippendorff, 2006), and expert knowledge (cf. Cross, 2004), tacit and explicit knowledge (Schön, 1992; van Aken, 2005 and many others) and also as objective, subjective and emotional knowledge (e. g. Lawson, 2004; Eckert & Clarkson, 2005). When compared to design knowledge in e. g. engineering design, the focus of design knowledge in experience-oriented design domains is particularly shifted towards socio-cultural, implicit and subjective knowledge, factual and purely professional knowledge play a minor part, on the whole (Wölfel, 2008).

Only few of the methods established in the product development disciplines take full account of these characteristics of design knowledge and hence can assist designers in design knowledge acquisition. Visual, verbal and narrative methods can significantly contribute to the utilisation of portions of unconscious knowledge, the visual methods in particular being already utilised both extensively and intensively in industrial design. As a rule, verbal methods are, even if seldom explicitly perceived as such, also widely used. These methods include sales talks, personnel dialogues, team discussions and presentations, however in a wider sense also brainstorming, brainwriting and less widely used checklists and lists of questions. Narrative methods have been less common in industrial design, yet have gained a certain distribution and acknowledgement in related fields, e.g., in interaction design (Cooper et al., 2007, Pruitt & Adlin, 2006 et al.).

1.2. Narrative methods

In this paper, the focus is on the applicable, however rather labour-intensive narrative methods persona and narrative normative scenarios. The said narrative methods define anticipatable intermediate goals and allow a holistic understanding of the product experience context. This paper aims at discussing the function of narrative methods and at providing proof that these methods actually support industrial design processes.

Storytelling is the oldest and most natural form of knowledge generation (sense making). Storytelling is part of everyday life and an intuitive aspect of vocational practice, it has also been explicitly introduced in some spheres as narrative methods and adapted to actual problems at hand. Moreover, narrative methods are increasingly used as exploration tools in social sciences (Jonassen & Hernandez-Serrano 2002) in particular when experience and meaning are of interest

(Bruner, 1990).

Storytelling is a worthwhile narrative method in business management (e. g. Gabriel, 2000) and is sometimes also used in product development, e.g., for requirements analysis (Gruen, 2000). Using the method of the Grounded Theory (Strauss & Corbin, 2003) knowledge is retrieved through storytelling and can later be verified. The approach is quite intuitive: knowledge and experiences are told as narrations, taken down or represented in a suitable form. That means that stories can describe the objectives and experience of potential users (Gruen et al., 2002). A certain ability and motivation for writing stories is required of course. As Norman (2011) sees it, it professionals in the experience-oriented design disciplines necessarily must have the ability of developing stories in general.

Thomas (2003) points out that experience narratives and also personal stories are only partly suited as a scientific research method to derive generalizable knowledge. For him the key advantage of experience narratives as a research method is their potential to show the unique-ness of individual existences and at the same time the similarities between the existences in different conditions. Stories allow the readers to share the thoughts and feelings of others in situations they would otherwise never experience.

Storytelling is an individual activity and can be done without any particular learning. A proto-col is automatically produced, either as an audio recording or in writing. Although the method can be used by novices, it is expected that it will be employed more successfully with growing experience. It is also possible to use stories in a collaborative process to create, for example, (fictional) environments, situations and artefacts (Dindler & Iversen, 2007). Dubberly (2009) presents the alternation between stories and models as a circular process that has parallels with the principle of hands-on designing. In this process, stories are »verbal artefacts« that are externalised and communicable and that exist explicitly (and have implicit components), while internalisation creates and alters mental models which in turn have an effect on the stories, on the one hand, but also combine implicit and explicit knowledge that can be used for the ongoing design process.

A recent study by Goldschmidt & Sever (2011) provides evidence of the positive effect of texts integrated in the task on the originality of the design of children’s chairs and desk clocks (but not on their feasibility). The authors compare stimulation by texts with visual stimuli and recommend the application in design processes, in particular in the context of training. In the study, texts were given that were both close to the content of the task and also those straying far from the topic at hand; both types of texts generated the same positive effects on the originality of the designs.

Miaskiewicz & Kozar (2011) established the benefits of personas from the angle of practitioners in a multi-level expert panel and had their role evaluated. According to practitioners, the most important benefit of personas is the chance to raise to life potential users and to make their needs and objectives the focus of design processes (instead of self-referential design). Furthermore, the potential of personas to support the ascertainment and prioritisation of product requirements, is very highly valued. This can be regarded as a type of acquisition of design knowledge.

2. RESEARCH APPROACH

2.1. Analysis of the effect of narrative methods on the design process

On the basis of the above specific characteristics of individually available (prescriptive object) design knowledge and also of the suitability of certain individual methods for the acquisition of such

types of knowledge we developed a two-day workshop that aims at supporting knowledge acquisition at the beginning of the design process. This workshop offers an opportunity to develop and analyse narrative scenarios in which personas as prototypical target group representatives are using the products that are being designed. The workshop is herein-after referred to as narrative scenario. The essential components of the workshop are brain-writing, storytelling, certain (narrative) scenario methods such as user stories or a-day-in-a-life, the persona method and visualisation (e. g., *ad-hoc* mood boards). The participants create three ad-hoc personas in both individual and group work and develop a narrative scenario for a typical day of the primary persona without using external data sources and product usage being in the focus of the process. Subsequently, expressions are derived and images are chosen from a provided set of photographs that represent an abstract definition of objectives in simple form (Figure 1).



Figure 1: Derived expressions and selected images as a preliminary stage to the design concept (example)

It is necessary to define measurable criteria to undertake a systematic analysis of the support capacity of narrative scenarios. The aim was to cover not only should self-disclosures made by the users of the method since this has been already investigated (e. g. by Miaskiewicz & Kozar, 2011). Beyond that, relevant variables of the early design stages are of interest. It is hardly possible or even impossible to measure the quality of the design solutions, though this stands to reason, and there are also too many uncontrollable variables. Consequently, the relevant measurements in this study were made in the first design stages including requirements analysis and concept creation. The variables measured there (described in more detail in the paragraphs below) stand in a more direct relation with the intervention, however, they allow conclusions to be drawn about the effect on the whole design process.

The study was conducted *post-ex-facto* in a test-control group setting. A total of 23 students of Industrial Design Engineering participated in the study. As an intervention, the test group took part in the workshop described above as part of the students' first design project. At the time of the study, the participants had already completed four semesters of basic engineering studies and also a course in design theory and basic design courses in freehand drawing and graphic design. Thus

the participants may be viewed as semi-experts in the field of engineering sciences (in particular in mechanical engineering) and as open-minded novices in the field of industrial design.

As part of the design project, students work on an individually set design task on the subjects *gluing* (test group) and *waste* (control group). The structure of the two tasks was the same: a problem space was given within which an actual product for private or commercial use should be designed. The procedure of the semester project was identical except for the intervention.

Students worked on the design task for one semester and went through clarification and analysis, design concept, overall design solution and detailed design. Students not only produce the design and the pertaining illustrative aids, such as models, drawings and renderings, they also write documentations to represent the design task, the design process and the design result. In a cooperative effort students used brainstorming and similar methods to prepare the individual design task and continued this work individually under the supervision of teaching staff. At the beginning of the design project, the intervention group conducted the above described two-day, supervised workshop for the development and assessment of *ad-hoc* personas and narrative, normative *ad-hoc* scenarios in the form of *user stories* as typical daily routines of the primary personas. After the study was complete, the control group was made familiar with the narrative scenarios in another design project.

The participants of the two groups could not be randomly distributed. It was impossible to take into account personal characteristics of the participants and their potential effect on the result. For this reason, the study should be viewed as *ex-post-facto* and the results should be assessed accordingly. As regards the effect of the narrative scenarios, the type and number of the derived requirements and also the completeness level of the created design concepts as *dependent variables* has been determined based on content analysis. Experienced support, certainty of action, objectives and other »soft criteria« were assessed in a standardised questionnaire. The documentations for the design projects were evaluated using qualitative content analysis according to Mayring (2007). For the purpose of measuring the influence of the narrative methods on the acquisition of knowledge in oneself, the requirements made on the design objects and represented in the documentations, were grouped and quantified in a category system.

For the assessment of the completeness of the design concepts we used qualitative content analysis to check if they include crucial components focussing on human experiencing, technical function and specific solution approaches. The concept representations of the design documentations were analysed and grouped according to the three components. Subsequently an assessment was made whether the design goal was sufficiently or completely anticipated at the particular components. On this basis, the design concepts were classified as *missing*, *marginal*, *incomplete*, *effective* and *complete*.

3. STUDY RESULTS

3.1. Impact on ascertained requirements

Figure 2 illustrates the average quantity of requirements identified in the above categories in a graphic representation. The statistical hypothesis test (independent two-sample, two-sided *t*-test) was employed to evaluate the differences. The test shows that the participants of the test group represented highly significantly more requirements in the category *human-subjective* (p=.008) and in the category *technical-functional* highly significantly less requirements (p=.002). No significant differences were measured in the other categories. The total number of the represented

requirements is almost the same (and again no significant difference). The effect size was estimated using Cohen's d. Accordingly, a mean effect size (d=-.558) has been identified for the category *technical-functional* and for the other statistically significant requirement categories a small effect size only.

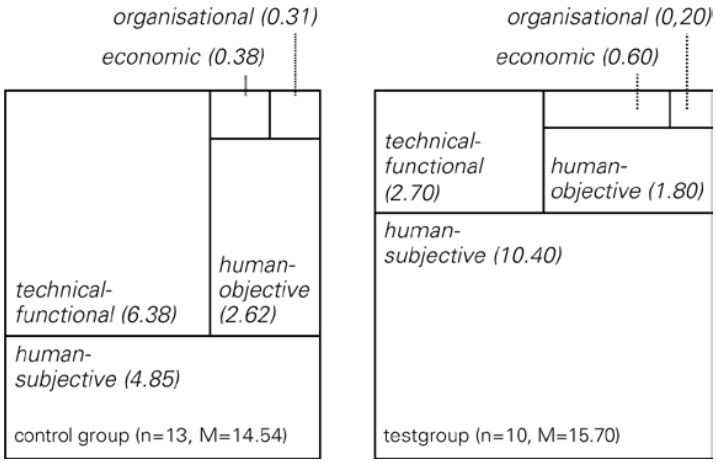

Figure 2: Graphic representation of the mean values of the numbers of obtained requirements per category in the control and intervention group

Figure 3 illustrates the differences in the description of the intended product character in the documentations both of the control and the test group. Beside the larger quantity (variety and frequency of mention of terms) in the test group it can be noted that the participants used more experience-related terms like *confidence*, but also *cheerful* or *calm*, while the control group predominantly used objective target criteria like *small* and *inexpensive*.



Figure 3: Graphic representation of the terms used by the control group (left) and the intervention group (right) to describe the product character in the documentations.
Quantitative representation: size indicates frequency of mention.

3.2. Impact on completeness of the design concepts

The design concepts presented in the documentations were assessed for their completeness. The following figures show examples of concept posters that the participants created as part of the design project and the reviewed documentations. Figure 4 shows the normative description of the product character as a *mood board* that was supplemented with word marks, while the concept poster in Figure 5 rather illustrates the use case since it is influenced by the narrative methods.



Figure 4: »concept poster« for a gluing device (Anonymous 1)



Figure 5: »concept poster« for a gluing device (Anonymous 2)

As can be seen in Figure 6, the share of complete design concepts is only slightly higher in the test group than in the control group. What is even more significant is the clearly smaller number of *missing* design concepts in the test group. The difference in the completeness of the design concepts is – according to a test using the Wilcoxon rank sum test – *statistically significant* (Z=-2.188; p=.029), i. e. the positive effect of the narrative methods on the design concepts is proven.

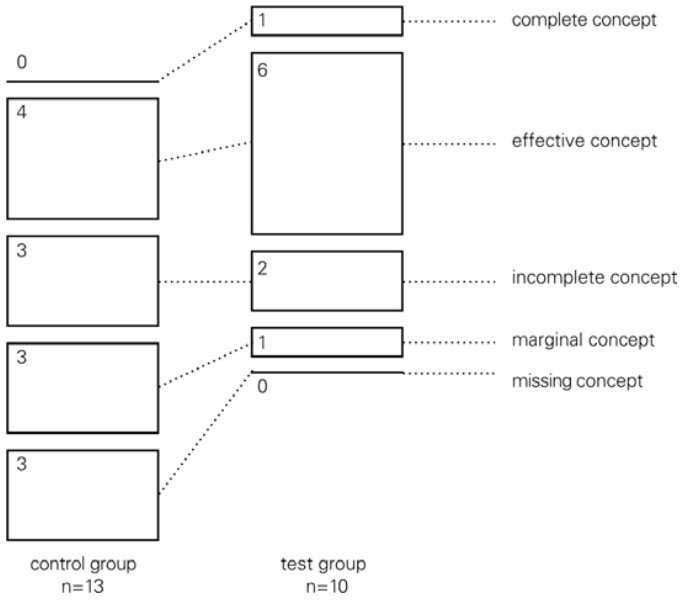

Figure 6: Differences between intervention and control group relating to the completeness of the design concepts

3.3. Support received

During the workshop at nine instants of time, e.g., at the milestones *design concept* and *hypothetical overall design* and also at the end of the design project measurements in terms of lived support, perceived capacity to act etc. were conducted in the intervention group using a standardised questionnaire. All participants in the intervention group tend to evaluate the support function positively (mean ranging between 4.1 and 5.3 on a scale from 0=no support to 6=huge support). *Objective* and *perceived capacity to act* improved during the workshop, which can be

explained by more acquired knowledge and the resulting idea of the design goal.

4. DISCUSSION

The test group ascertained a highly significantly greater number of requirements in the experience-relevant *human-subjective* category. While the control group presented slightly more requirements in the category *technical-functional* than in the category *human-subjective*, the focus of the test group was clearly on experience-relevant requirements. Obviously, this effect was accompanied by a lower number of represented requirements in the category *technical-functional*. The merely small or medium effect size restricts the persuasiveness of the statistical evidence. If we consider the essentially halved or doubled average values, we can assume to have a practical relevance of the differences; however, the relatively large –variance of the measured data reduces the measure of the effect size (Cohen's d). A greater number of participants could bring about a homogenous variance that would conduce to the effect size and could render clearer evidence of the actual effect.

It was also possible to confirm the hypothesis that assumes a relationship between the narrative methods and the completeness of the design concepts despite the small random sample. This serves to confirm the findings of Krzywinski (2012) as well, who identified the elements product character, persona and scenario as constituent elements of design concepts in the slightly different context of transportation design. The Wilcoxon rank sum test, which we employed for testing the hypothesis, has a relatively high robustness to wide data scattering, which has a beneficial effect in this case. In a preliminary analysis using the Median test, a statistical relationship could not be found. A possible reason may be the considerably greater statistical power of the Wilcoxon rank sum test than that of the Median test, because it completely utilises the rank information in the data (Bortz & Lienert 2008).

The restrictions of the quasi-experimental research design and also the small measured effect sizes cannot be taken as »hard facts« that could be used as an argument in favour of using narrative methods or the workshop developed from them. Another analysis under controlled conditions and with a more representative random sample is vital to reliably preclude alternative explanatory approaches for the measured and described differences. It should be examined whether it is possible to qualitatively understand the output of persona and narrative scenario methods, how they influence the design process and how they can be identified in the major stages of the design process.

One of our findings is that the narrative methods *persona* and *scenario* or *user story,* respectively, can be used beneficially in industrial design and are valued by students. Thus it can be stated that both function and effect of the methods can be transferred from interaction design to industrial design. The methods are well accepted as training tools both by the teaching staff and students: almost all students used personas and scenarios in follow-up projects – to varying degrees – without being asked to do so. This complements the findings Krzywinski (2012) made in explorative studies in training programmes in *transportation design* where he identified persona and scenario as effective tools for the creation of experience-based design concepts.

There is evidence that the acquisition of design-relevant knowledge by novice students of design engineering can be improved by employing narrative methods. The study did not cover whether the methods served to improve specific types of knowledge – e.g., episodic or tacit knowledge. This would at least in part be a tautological conclusion since the methods were chosen and employed

just because of their particular suitability to support the acquisition of these types of knowledge.

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BIOGRAPHY

Christian Wölfel studied industrial design at Technische Universität Dresden and Burg Giebichenstein University of Art and Design. He completed his PhD thesis in 2011. Since 2005, he is research associate at the Center for Industrial Design at Technische Universität Dresden, he is also visiting lecturer at OTH Regensburg. He teaches and researches in design fundamentals and design theory. In applied research, he specializes in industrial goods and medical devices.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Electronic Product Development with Kansei Engineering / Kansei Ergonomics

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Abstract: Successful products cannot be made with only ergonomic considerations, and Kansei engineering provides eloquent answers to the problems that arise. In this paper, we report Kansei ergonomics process of electronic products, shaver and washer-dryer from SANYO electronics. Both of the cases have ergonomic researches into detailed Kansei domain. New prototype of electric shaver has 80 degree bent head and shaped to pen grip. Electromyogram of fore arm and pressure to skin are both significantly lower. Washer-dryer has evaluated with subjective Kansei, working posture analysis and kinematic model. Control panel was also examined and improved. Research results of both projects have commercialized, and have got successes.

Keywords: Kansei Ergonomics, Product Development, Electronic Products, Measurements

1. INTRODUCTION

Along with the spread of the Kasei engineering applications, different approaches have been required to new aspects. From the last 1990s and during the first 10 years of the 21st century, novel measurement and analysis methods have been developed and used in Kansei engineering field. The major approaches are in below lines. 1. Novel analysis methods of non-linearity (Ishihara et al., 2007a, 2007b), discreet (combination) optimization analyses (Nishino et al., 2005,2006a,2006b, Tsuchiya et al., 2007), 2. Statistical analysis of shapes (Ishihara et al., 2008), 3. Brain wave measurement and analysis: Yoshida theory (Yoshida & Iwaki, 2000), 4. 3D measurement, computer graphics and virtual reality, 5. Kansei Ergonomics. In this paper, we show methods and applications on Kansei Ergonomics, which have been applied to different commercial products. Cases of SANYO electronics are shown.

2. KANSEI ERGONOMICS

Research results produced during the early era of Kansei engineering, from the 1970s to the mid-1990s, were presented primarily in ergonomics societies. Since the end of the 1990s, we have been involved in the development of many more products, and have recognized that Kansei engineering and ergonomics are inseparable. Successful products cannot be made with only ergonomic considerations, and Kansei engineering provides eloquent answers to the problems that arise. We are fully convinced of the need for Kansei Ergonomics. Two cases are shown here.

2.1. Electric Shaver

Home electrical appliances are changing from low-price mass-produced items to higher-price higher-function items. One of main challenges for appliance manufacturers is continuously presenting innovative functionality.

The mechanism of a typical electric shaver involves an inner blade, which moves inside of the mesh outer blade. Thus, when more pressure is added to the face, the load is added to the inner blade and shaving becomes poorer. The conventional stick-shaped shaver tends to force users to add pressure to their faces. SANYO Electronics engineers thought that bending the shaver head and grasping it with a pen-grip, like a T-shape razor, would address this problem. We have verified the idea with experiments and measurements.

We examined two types of shavers: a conventional stick and a prototype of a new pen-grip shaver. These two shavers had the same grip part; thus, their grip length and diameter were identical. The stick shaver had its head at 15° from the grip and the pen grip prototype had its head at 80°.



Figure 1: Stick shaver (left) and pen grip prototype (right)

2.1.1. Electromyogram (EMG) measurements and Pressure measurements

EMG measurements: The factor in this experiment was the difference in EMG between the NS1 (existing stick shaver) and the pen-grip prototype (based on the NS1). Electrodes were attached on the flexor digitorum superficialis and on the flexor digitorum profundus, with bipolar derivation. Measurements were conducted with two channels and the earth was taken on the elbow joint bone. The measurement device was a Biopac MP30 (Biopac Inc.) with a sampling rate of 500 Hz.

Pressure measurements: A piezo pressure sensor was attached behind the blade of the shaver. The factor in this experiment was the difference in pressure to the face between the stick shaver and the pen-grip prototype. Measurements were also made with the Biopac MP30.

Instruction to the participants: An instruction sheet with directions applying to the face and shaving direction was given to the participants. The task was to move the shaver three times at seven different sites: the middle under the chin, right and left of it, on the chin, under the nose, right cheek, left cheek. The subjects were seven men in their 20s.

2.1.2. EMG and pressure results

As shown in Fig.2, the pen-grip prototype had smaller EMG voltages. EMG integral values (mV×sec / 500 (Hz)) of the two shavers (sum of the seven sites) were compared using measurements from the seven participants. The ratios between the pen-grip prototype and stick (average between subjects) were 0.60 at the flexor digitorum superficialis, 0.95 at the flexor digitorum profundus, and 0.78 combining both muscles. Thus, a 22% EMG reduction was observed with the pen-grip prototype.

The statistical distribution of differences between pen-grip and the stick was not a standard distribution, according to the Shapiro-Wilk W test. These were paired data, because the same subject used both shavers. Thus, we used the Wilcoxon signed-rank test, a non-parametric test of paired data. Using this test, the difference in EMG integral value between two shavers was statistically significant ($p < 0.0001$).

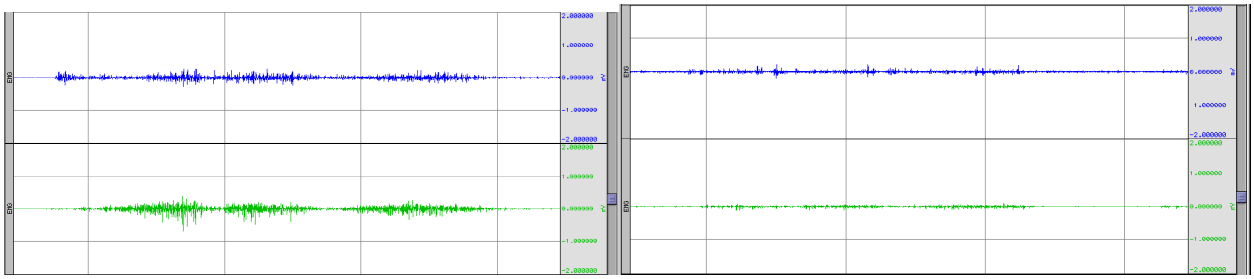


Figure 2: EMG examples in the middle, under the chin. The left panel shows stick shaver data and the right panel shows pen-grip prototype data for the same subject. The upper row corresponds to the flexor digitorum superficialis; the lower row corresponds to the flexor digitorum profundus. One tick on the *y*-axis is 1 mV; one tick on the *x*-axis is 2 s.

Pressure to face measurement results: As shown in Fig.3, the pen-grip prototype had a lower pressure. The pressure integral values (mV × sec/500(Hz)) of the two shavers (sum of seven sites) were compared in measurements from the seven participants. The ratio between the pen-grip prototype and the stick (average between subjects) was 0.15. Thus, an 85% pressure reduction was demonstrated using the pen-grip prototype.

The statistical distribution of differences between the pen-grip and stick shavers was a standard distribution. Thus, we used the paired t-test; the difference in pressure integral value between two shavers was statistically significant ($p < 0.0001$).

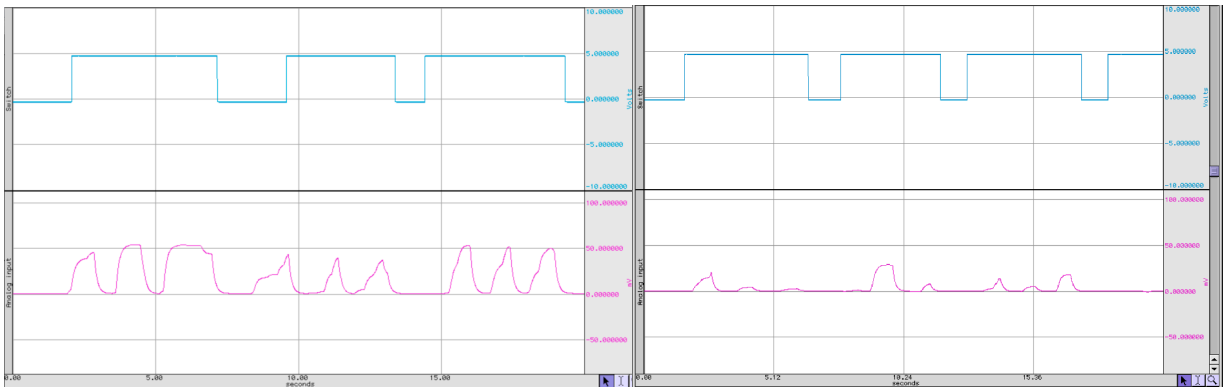


Figure 3: Example of pressure to the face; middle, right, and left under the chin. The upper row shows the moving period and the lower row shows the pressure. The left panel shows stick shaver data and the right panel shows pen-grip prototype data for the same subject. One tick on the *y*-axis is 50 mV.

2.1.3. Shaver results and product launch

From the experiment, the pen grip prototype reduced 22% of the forearm EMG and provided an 85% reduction in pressure to the face. Statistical tests demonstrated the significance of these reductions. As a result, the pen-grip shaver was developed and launched in March 2008, and has generated large sales at a fairly high price (around 9500JPY, 100USD) than before. Recently, two derived variations were added to a line-up.



Figure 4: Commercial realization of the pen-grip shaver (SANYO SV-GS1)

2.2. Washer-Dryer machine

Washer-dryer machines with slanted drums have recently become popular in Japan. Japanese washing machines have traditionally had vertical drums, and these are still quite common. The users of vertical-drum washers must bend their backs and stretch their arms to insert and remove laundry. In Europe, on the other hand, horizontal-drum washing machines have long been popular. This type of machine requires the user to crouch to insert and remove laundry because of its lower height.

The new washer-dryer combo machines have horizontal or slanted rotational drum axis. This has resulted in a significant change in shape, and the door position was changed to make loading and unloading easier.

This research compared the physical loads and usability of the new generation of washer-dryer with traditional Japanese and European washing machines. This comparison was performed using subjective evaluations, three-dimensional (3D) motion captures, and estimates of the load on certain body parts using a human kinetics computer model.

2.2.1. Subjective Kansei evaluation

A subjective evaluation was carried out by asking the participants a set of questions each time they completed the task of removing laundry from a machine. Five questions were related to fatigue, five were related to usability, and one final question was related to the general usability of the washing machine. Table 1 lists the questions asked. Each question was answered on a five-point scale.

We used a one-way analysis of variance (ANOVA) to examine whether differences existed between the evaluations of the different washers. For post-hoc pair-wise comparisons, we used the Tukey-Kramer Honestly Significantly Different (HSD) test. Table 2 shows the results; washers are aligned by evaluations in rows. The slanted-drum machine received the highest evaluations for all questions.

Results show that 7 of the 11 questions were significant and that the European-type machine was statistically significantly inferior in terms of user fatigue and ease of use. The results also showed that the vertical-drum machine, which has been widely used in Japan until recently, was not suited for removing laundry from the drum (Q10). We next investigated the relationship between these results and the user's working posture using motion capture.

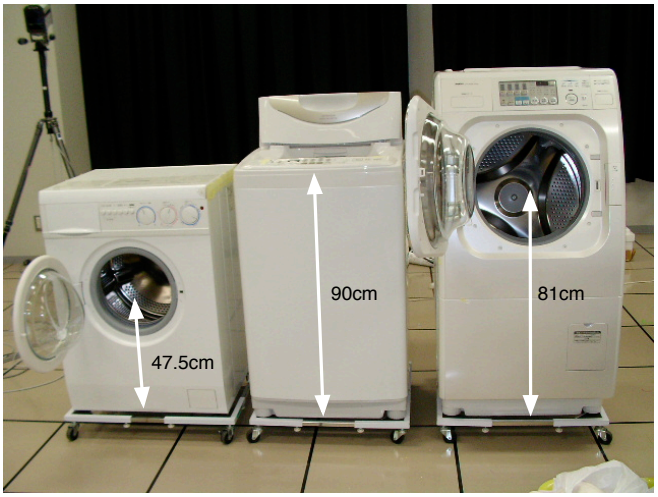


Figure 5: Laundry machines: European-type AWD-500 9 (left), vertical-drum washer ASW-800 (center), and slanted-drum washer-dryer AQ-1. The measurements on each machine are the heights to the center of the opening.

Table 1: Questions for Subjective Evaluation (left) and one-way ANOVA and Post-hoc Test Results (right)

1. How tired does your entire body feel?
2. How tired are your neck and shoulders?
3. How tired are your upper arms?
4. How tired is your low back?
5. How tired are your knees?
6. How easy was it to push the door open button?
7. How easy was to open and close the door?
8. How easy was it to check inside the drum?
9. How easy was it to insert your hand or arm inside the drum?
10. How easy was it to remove the laundry?
11. How easy was the machine to use?

Question	1way ANOVA significance	Good <--> NoGood, post-hoc test significance(*)
Q1	√	* * slanted-drum, vertical-drum, European-type
Q2	√	same
Q7	√	same
Q8	√	same
Q11	√	same
Q10	√	* slanted-drum, European-type, vertical-drum
Q6	√	* slanted-drum, European-type

2.2.2. Working posture measurements using motion capture and analysis of joint angles

Slanted drum machine has excellent Kansei evaluations. We should know why these evaluations have achieved, and what the relations between body loads. Then, we have working posture analysis with motion capture system.

Figure 6 shows the posture of a participant with a height of 158 cm (the average for twenties to thirties Japanese women) during maximum bending of the body when removing a towel from the bottom of the drum. Using data from the motion capture, we measured and analyzed the angle formed by the knee, greater-trochanter, and shoulder. This angle was 110° (average of all participants) for the slanted drum, 114° for the vertical drum, and 64° for the European-type horizontal drum. Because standing posture is close to 180°, the larger angles are better. Slanted

drum has better (larger) angle than European type, but not the best. Single angle data is not enough for explaining the better Kansei evaluations on slanted drum.

We showed that the vertical drum required an unbalanced posture. The entire body load in such a position cannot be estimated on the basis of coordinates and angle data obtained through motion capture alone. The load on the lumbar vertebra that cannot be directly measured is also an important factor. Thus, to give due consideration to the mass of the various parts of the body, we attempted to estimate such loads using a kinematic model.

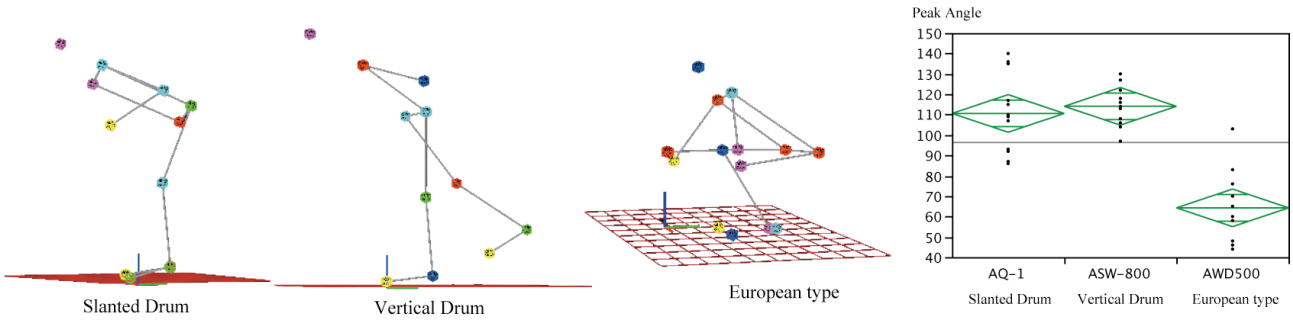


Figure 6: Posture during maximum bending of body (young 158-cm female) and graph of angles formed by the knee, greater-trochanter and shoulder for different machines

2.2.3. Static load estimates using a kinematic model

We estimated the load on various parts of the body using a kinematic model. To perform these calculations, we used the 3D Static Strength Prediction Program (3D SSPP) developed by a team lead by Prof. Don Chaffin at the University of Michigan. As shown in Figure 3(left), the Chaffin model features a human body with a basic structure consisting of seven links. These links are the forearm, upper arm, torso (shoulder to lumbar vertebra), sacral vertebra to pelvis, femoral head to knee, shank, and foot.

Using this model, we estimated the pressure (N) on the disk between the fourth and fifth lumbar vertebra and the maximum voluntary contraction (%MVC) for the muscles involved in the elbow, hip, knee, and ankle joints for the posture corresponding to maximum bending of the body for a 158-cm, 53-kg participant. The participant is most close to average height and weight of twenties to thirties Japanese women. Marker coordinates and the participant's height and weight were used for the parameters of load estimation.

Table 2 and Figure 7 (right) show that the slanted drum required less overall muscle strength, except for the hips. For the vertical drum, the pressure on the intervertebral disk was less than that of the other two machines, because the back was not bent as much. On the other hand, laundry cannot readily be removed from the bottom of a vertical drum without raising one foot, so that the load on the ankle of the other foot exceeded 100%. The load on the hip and knee was also high.

Summing individual %MVCs and comparing the overall %MVC for the different machines revealed that the slanted drum had the smallest value, with a muscle load about 60% less than that of the vertical drum. The European-type machine placed a smaller load on the hip than the slanted drum, but required 2.36 times the load on the knee because of the squatting posture required. These results demonstrate that the slanted drum permitted improved posture.

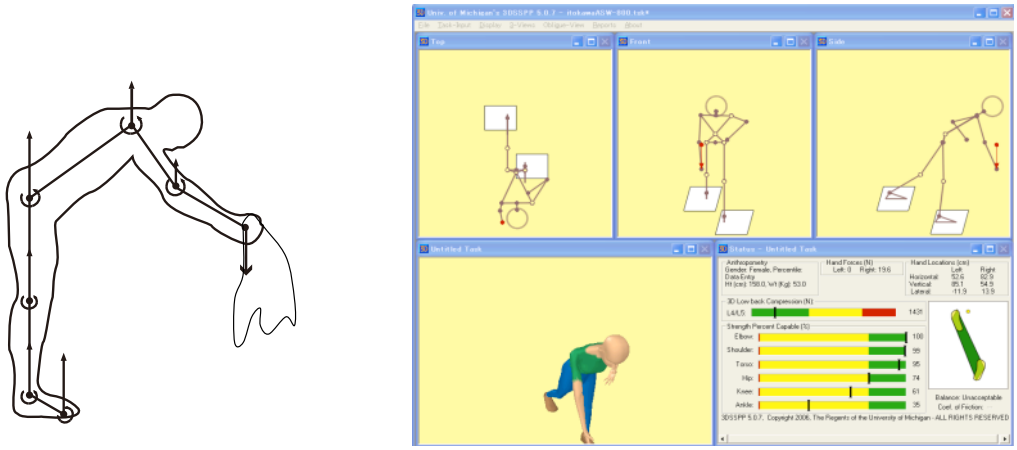


Figure 7: Body links (entire body) and SSPP calculation screen for the vertical drum (158-cm young female)

Table 2: Values estimated by the model (158-cm female)

Participant: 158 cm 53 kg	L4/L5 Comp (N)	Elbow (%MVC)	Hip (%MVC)	Knee (%MVC)	Ankle (%MVC)	Sum (%MVC)	Sum (%MVC)/ 400
Slanted drum	1732	12	54	25	25	116	0.29
European- type	1801	17	31	59	26	133	0.33
Vertical drum	1431	8	75	91	110	284	0.71

2.2.4. Control panel improvement

After the working posture measurement and evaluation, we began a project to improve control panel of next generation of washer-dryer.

We compared the control panels of the existing model washer (SANYO AWD-AQ2000) and the proposed model prototype (AWD-AQ3000) that included a modified layout and a control knob. The both panels were implemented as two simulator programs.

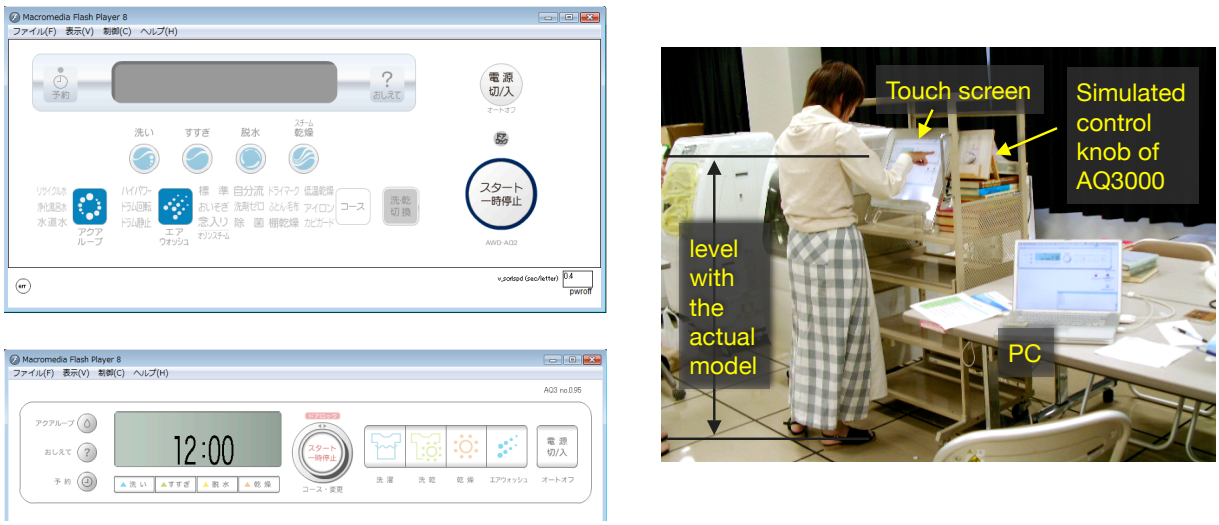


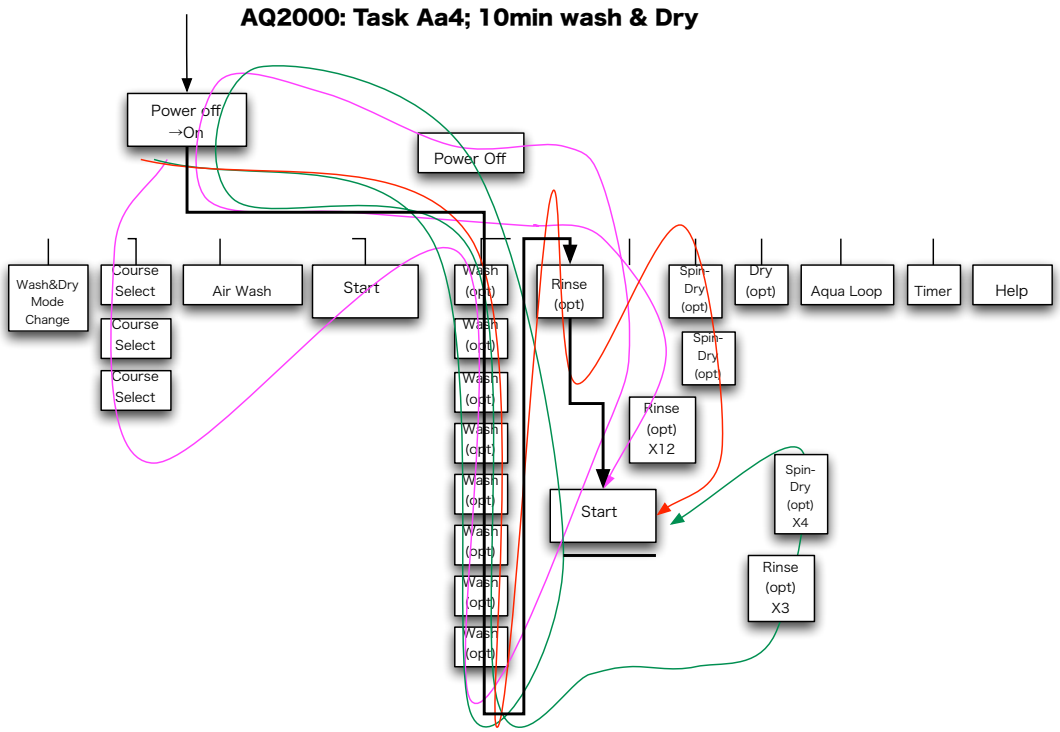
Figure 8: Control panels of the washer-dryers used in the usability experiment
Upper Left: Simulated panel of AWD-AQ2000, Upper Left: AQ-3000, Right: Experimental setup

Figure 8 shows screen copies of the two simulated panels and an overall view of the experimental setup. The participants in the experiment were seven women all over the age of 30 who were accustomed to using automatic washing machines.

The required tasks were the following: turn on the power, select the wash or wash-dry mode, change the washing courses, adjust the wash settings, set the timer, set water-saving mode, and set the “air-washing” function. The instructions given to the participants were, for example, “Set to the machine to wash the wool sweater and then end without drying it” or “deodorize the leather shoes.”

The participants were asked to set the designated washing tasks by using two simulator panels. The time and the number of steps to complete each task were measured. Each turn of the control knob of the AQ3000 was counted as one step. The level of irritation on a five-point scale was reported by each participant. All steps were recorded on video tapes.

Hierarchical task analysis (HTA) (Stanton & Young, 1999) was performed (Figure 9) to find the erroneous steps of the tasks we conducted. The current alternatives were laid out horizontally and the participants’ actual operations were followed vertically. This permitted easy identification of the points where our participants became lost by comparison with the intended (optimal) operating sequence.



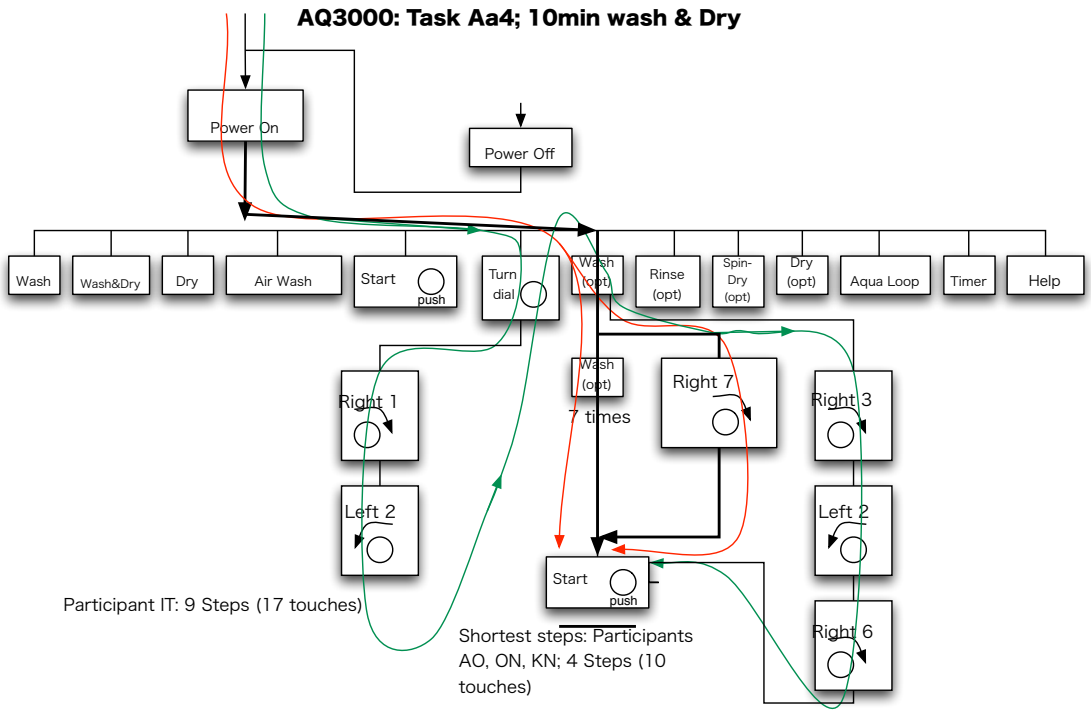


Figure 9: HTA example of a trial of "10 min wash and dry" task on AQ2000 and AQ3000 (simulator). Choice buttons and control knobs (AQ3000) are drawn as connected boxes. The shortest procedure and the sequence that the participant actually performed are indicated.

2.2.5. Improvement of the AQ3000

Based on these resuls, we propsed to adopt the control knob and to isolate the mode-selection (wash-and-dry / wash / dry) buttons from the other buttons. The locations of the "Start" button and control knob were also changed. The "Power" button was placed at the right end and the "Start/Stop" button was placed just to its left.

The courses were differentiated from the program options. The courses were appeared in sequence when rotating the control knob. The detailed options were appeared when rotating the knob after pressing one of "Wash options," "Rinse options," "Spin-dry options" or "Dry options". The control knob was also knurled to increase user control.

2.2.6. Final verification with prototype models

Fifteen male and female washing machine users, aged 30-61, and 25 users about 20 years old participated in the usability experiment. They were asked to operate to the actual hardware of the conventional model (AQ2000) and the improved hardware prototype model of (AQ3000) to perform six of the seven washing tasks.

There was no significant difference in the total completion times for the two models, but the total number of steps and the total level of irritation were significantly reduced with the new model. We then focused on the performance of the participants 30 years and older, because they most closely represent our target market. We found that all measurements were significantly reduced for the new model. In particular, the change in layout and control knob facilitated the task of using the "Air-wash" function (disinfects and deodorizes using ozone instead of water), reducing the average completion time to 34.5% that of the conventional model.



Figure 10: Usability experiment with the hardware prototype models.

2.2.7. Improvements and results of Washer-dryer

Measurement of working posture showed the evidences of superiority of slanted drum design over the conventional vertical or horizontal drum machines. In our control panel study, small problems found during the experiment were fixed in the final production model. The colored line on the start button was changed so that it would be easily discriminated from the power button. The final design is shown in Figure 11. The improved new model AQ-3000 was released in February 2008 and became a success in the marketplace.



Figure 11: Production model of the SANYO AQUA AWD-AQ3000.

ACKNOWLEDGMENTS

Authors thank for Dr. Yoshihisa Fujiwara at Panahome, Co.Ltd., for his collaborations and coordinates during his researches at Sanyo Electric, Co.Ltd.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Evaluation of the Effect on Viewer Recognition of Viewing at an Angle a Sign with Arrow Markings

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Abstract: This paper presents an evaluation of the effect on viewer recognition of viewing at an angle a sign with arrow markings. Focusing on the case in which a sign at an intersection is marked with an arrow pointing in the direction of a given destination, this paper (a) investigates, using linear transformation, how to represent such an arrow in a manner which ensures that drivers follow the proper direction, even when the arrow is viewed from different angles, and (b) proposes a specific approach to representing such an arrow. It has been shown that the direction and magnification of a given arrow marking are important factors in the recognition of the proper direction on the part of observers.

Keywords: Evaluation, viewer recognition, sign, arrow marking.

1. INTRODUCTION

The presence of signs plays an important role in all commercial activities, as illustrated by the fact that we constantly encounter them in daily life [1-3]. One key role of a sign is to make us aware of the presence of something we may be looking for, and to guide us in reaching it.

Focusing on the case in which a sign at an intersection is marked with an arrow pointing in the direction of a given destination, this paper (a) investigates, using linear transformation, how to represent such an arrow in a manner which ensures that drivers follow the proper direction, even when the arrow is viewed from different angles, and (b) proposes a specific approach to representing such an arrow. It has been shown that the direction and magnification of a given

arrow marking are important factors in the recognition of the proper direction on the part of observers.

2. EFFECT OF VIEWING A SIGN AT AN ANGLE

We do not always view a sign straight on. When a sign is viewed at an angle, as shown in Figure 1, factors leading to recognition error naturally increase; and when a sign includes an arrow pointing in the direction of a location shown on the sign, and the sign is viewed at an angle, the recognition error rate is likely to further increase.

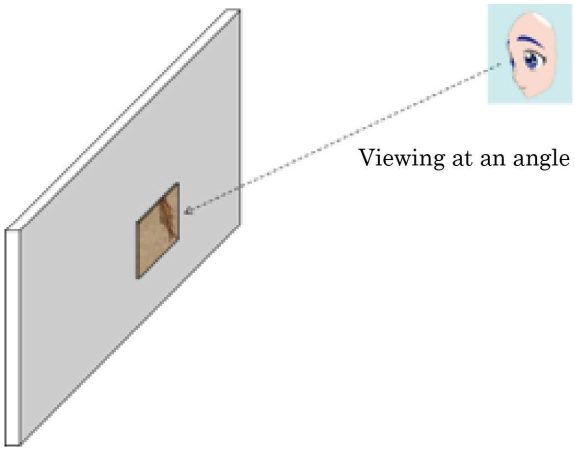


Figure 1: Viewing a sign at an angle

The factors leading to recognition error, which arise when a sign is viewed at an angle, can be explained by Figure 2. When we look at Sign A from angle α, we are actually perceiving the Acosα (or Asinβ) image of the sign, rather than the sign itself. Naturally, the letters and arrow on the sign appear distorted. In this study, we focus on the arrow marking on such a sign, and propose a transformation drawing approach using a linear transformation of the distorted image of the sign, based on the nature of a linear transformation matrix, which enables viewers to determine the proper direction indicated by the arrow. When we follow the direction of an arrow on a sign, we may assign an incorrect path to the given destination; thus, here we evaluate the role of representing a transformed arrow in reducing such recognition error.

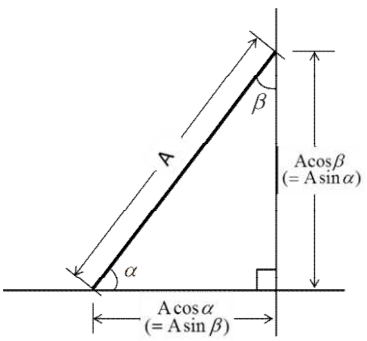


Figure 2: Effect of viewing Sign A at an angle

Imagine that Sign A, for example, as shown in Figure 2, is located at one of the four corners of an intersection. A driver can choose ‘straight,’ ‘left’ or ‘right.’ How should the arrow be drawn, in order to properly guide drivers, coming from any direction, to their destination? In fact, this is a difficulty commonly faced by road-sign manufacturers.

3. LINEAR TRANSFORMATION

Generally, to map point onto point by linear mapping, the linear transformation matrix is given by

$$\begin{bmatrix} x_2 \\ y_2 \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \end{bmatrix} \tag{1}$$

Solving Equation (1), we obtain the following equation:

$$\begin{bmatrix} x_1 \\ y_1 \end{bmatrix} = \frac{1}{ad - bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix} \begin{bmatrix} x_2 \\ y_2 \end{bmatrix}. \tag{2}$$

This linear transformation has the following characteristics.

(1) The origin does not move.

(2) The original straight line is transformed to a straight line.

(3) The ratio of the segment lengths of the original straight line is retained.

Characteristic (1) means that the origin is transformed to an origin, and (2) and (3) ensure linearity. This is why a given shape remains essentially unchanged when it collapses or rotates. A shape may completely collapse in a transformation. The determinant of a coefficient transformation matrix is expressed as

$$\Delta = \begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc$$

(1) The shape faces right if $\Delta > 0$.

(2) The shape faces left if $\Delta < 0$.

(3) The shape collapses into a line if $\Delta = 0$.

(4) The value of |ad-bc| shows the magnification factor of a parallelogram.

As shown above, this transformation equation determines how a line drawing collapses in a transformation, based on the value of the determinant Δ. Table 1 shows four typical linear transformations.

A combination of linear transformations may be obtained by performing two transformations in succession. For example, transformation matrices A and B are combined as follows:

$$\begin{bmatrix} x_2 \\ y_2 \end{bmatrix} = \overset{\text{B}}{\begin{bmatrix} e & f \\ g & h \end{bmatrix}} \overset{\text{A}}{\begin{bmatrix} a & b \\ c & d \end{bmatrix}} \begin{bmatrix} x_1 \\ y_1 \end{bmatrix}$$

$$= \begin{bmatrix} ae+cf & be+df \\ ag+ch & bg+dh \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \end{bmatrix}$$

This may be calculated as a product of matrices, no matter how many transformations are performed in succession. Using these linear transformations, we may investigate a basic method for properly interpreting an arrow marking at an intersection.

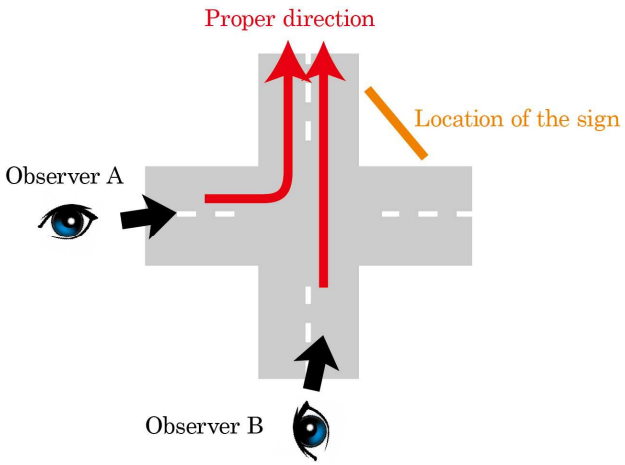
Table 1: Four typical linear transformations

Method of Transformation	Examples of Transformations	
Zoom in/zoom out (Similarity transformation)	Magnification by a factor of *k* in the *x* direction $\begin{bmatrix} k & 0 \\ 0 & 1 \end{bmatrix}$	Magnification by a factor of *k* in the *y* direction $\begin{bmatrix} 1 & 0 \\ 0 & k \end{bmatrix}$
Symmetrical displacement (*x*-axis, *y*-axis)	Displacement symmetrical to the *x*-axis $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$	Displacement symmetrical to the *y*-axis $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$
Rotational displacement	A rotation of θ about the origin in the forward direction $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$	
Shift	A shift of k in the direction of the x-axis $\begin{bmatrix} 1 & k \\ 0 & 1 \end{bmatrix}$	A shift of k in the direction of the y-axis $\begin{bmatrix} 1 & 0 \\ k & 1 \end{bmatrix}$

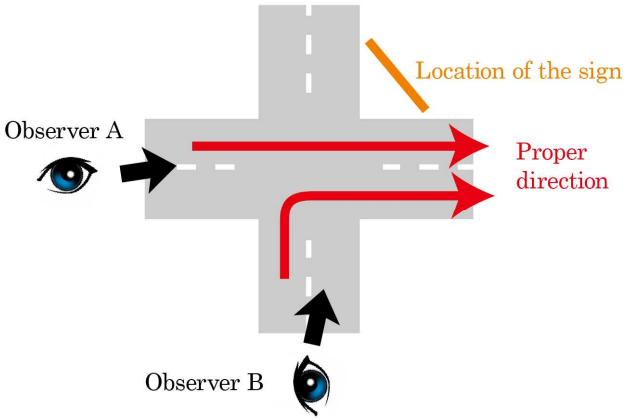
4. RECOGNITION OF THE PROPER DIRECTION INDICATED BY AN ARROW MARKING AT AN INTERSECTION

We here consider the case of signs located as in Fig. 3 (Observers A and B wish to go in the same direction).

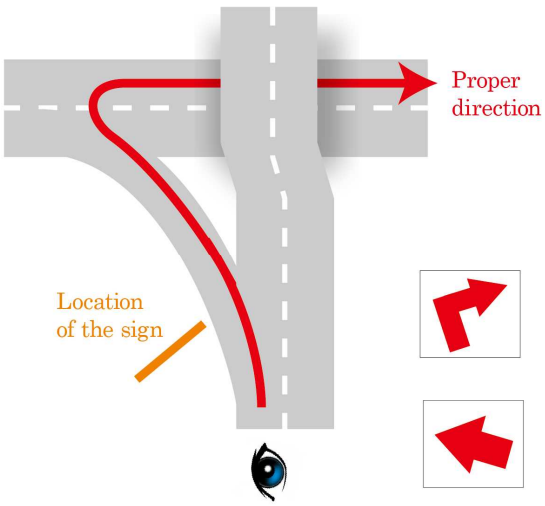
First, we examine the case of Figure 3(a). Observer A wishes to turn left at the intersection, and will definitely turn left if the sign has the arrow shown in Figure 4(a). However, Observer B too will recognize it as indicating ‘turn left.’ In this case, how should the arrow appear, in order for Observer B to recognize it as indicating ‘go straight’? When the arrow is linearly transformed into a shape slightly tilted to the left, as shown in Figure 4(b), we understand that it means ‘turn left’ for Observer A and ‘go straight’ for Observer B.



(a) Observer A turns left and observer B goes straight.

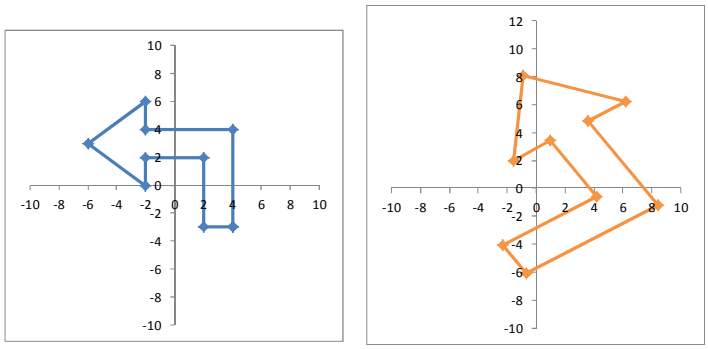


(b) Observer A goes straight and observer B turns right.



(c) Arrows at a crossing with an overpass (a right turn).

Figure 3: Location of signs at intersections, and corresponding arrow markings



(a) (b)

Figure 4: Proper arrow orientation to ensure that drivers coming from different directions can recognize 'turn left' and 'go straight', respectively: (a) Both Observer A and Observer B will recognize the arrow as indicating 'turn left; (b) Observer A will recognize the arrow as indicating 'turn left' and Observer B will recognize it as indicating 'go straight.

The following transformation matrix was used for the transformation from Figure 4(a) to 4(b):

$$\begin{bmatrix} 0.8 & 1.3 \\ -1 & 0.7 \end{bmatrix}$$

Figure 3(b) shows a case in which Observer A goes straight and Observer B turns right. The arrow shown in Figure 5(b) is generated for this case.

The transformation matrix is given by

$$\begin{bmatrix} 1 & -0.5 \\ 0.5 & 1 \end{bmatrix}$$

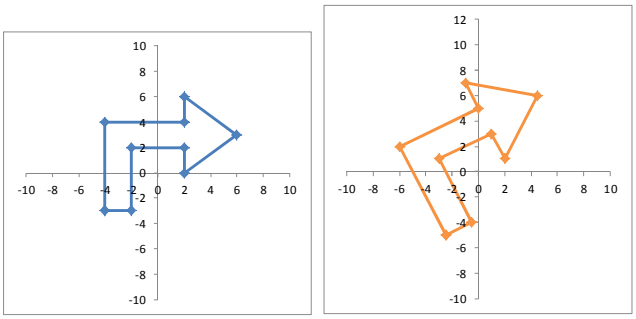


Figure 5: Proper arrow orientation to ensure that drivers coming from different directions can recognize 'go straight' and 'turn right,' respectively: (a)Both Observer A and Observer B will recognize the arrow as indicating 'turn right'; (b) Observer A will recognize the arrow as indicating 'go straight,' and Observer B will recognize it as indicating 'turn right.'

5. EXPERIMENTAL METHOD

We considered a typical suburban intersection, as shown in Figure 6. In the experiment, to guide

observers to the right (in Figure 6), we placed a roadside sign, with an arrow at a 45° angle from the direction of travel, at one corner of the intersection. We presented 24 subjects with signs with different arrow angles and information. The road consists of 3-m lanes, with two opposing lanes and a dedicated 40-m right-turn lane. When each observer recognizes the arrow on the sign as indicating 'turn right', and changes to the right-turn lane 40 m before the intersection, the viewing angle on the sign is 36.6° for Observer A, and 34.1° for Observer B. Six different arrow markings commonly employed on roadside signs (Figure 7) were used. The following three-dimensional transformation matrix was used to ensure that the respective arrow markings would appear as perceived by Observers A and B:

$$\begin{bmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{bmatrix}$$

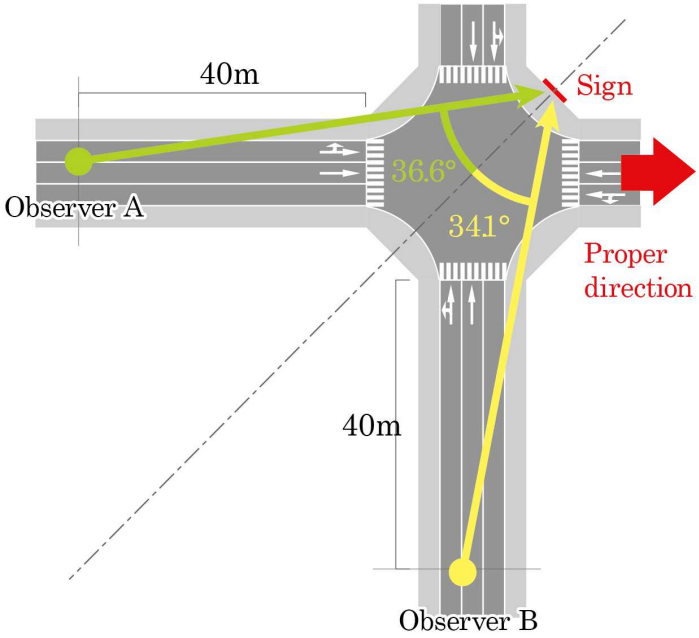


Figure 6: Configuration of the intersection

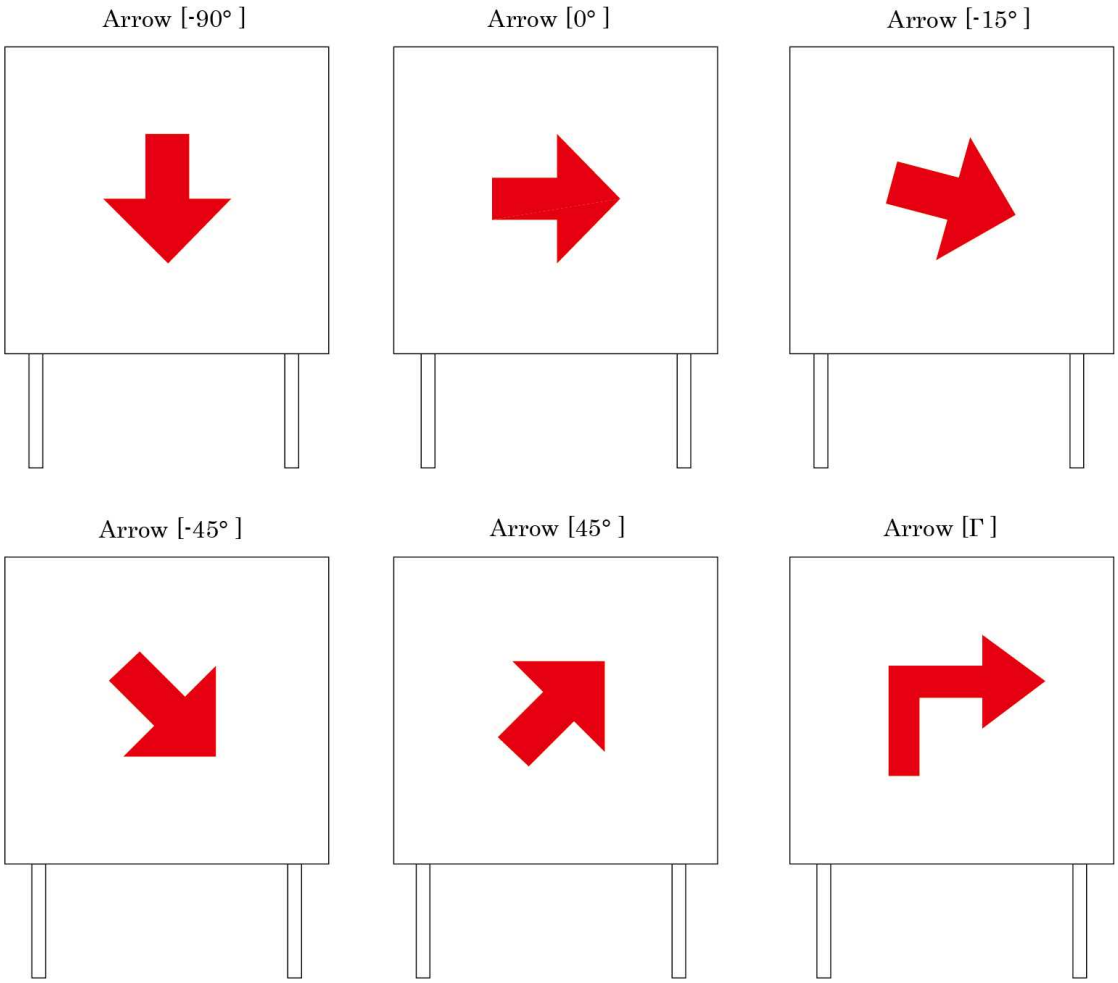


Figure 7: Six different arrow markings used in the experiment.

In the experiment, images of the intersection were generated such that the arrow markings would appear as perceived by Observers A and B, respectively. These images were presented to the subjects, and a questionnaire survey was conducted, in which they were asked to select a direction (forward/reverse and left/right turn) (Figure 8).

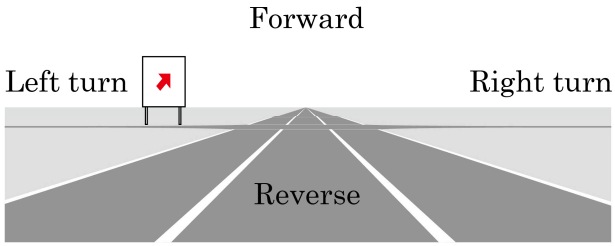


Figure 8: Example of a sign presentation (45°-angle arrow as viewed by Observer A)

6. RESULTS

The results are tabulated in Figure 9.

(1)

Arrow marking	Correct answer rate for both observers
	4%
	0%
	4%
	25%
	38%
	54%

(2)

Arrow marking	Observer vantage point	Correct answer rate
	A	25%
	B	71%
	A	4%
	B	21%
	A	29%
	B	71%
	A	46%
	B	92%
	A	4%
	B	100%
	A	96%
	B	58%

Fig. 9 Correct answer rate for different arrow markings

(1) To perform its function, a roadside sign must guide both observers A and B in the proper direction. As shown in Figure 9(1), the arrows were not designed such that the observers were guided in the proper direction with 100% accuracy. Of the candidate arrows, the 45°-angle arrow had the highest overall correct answer rate, of 54%. The correct answer rate can be increased by providing additional character-based information on the sign.

(2) If there is a large volume of traffic in one lane at the intersection, it may be especially desirable for the correct answer rate of one of the observers to be high. With this in mind, we calculated the correct answer rate for each observer. When the angle of the arrow was set at 45°, to increase the correct answer rate of Observer A, the respective rate increased to up to 96%. When the angle of the arrow was reduced to 0°, to increase the correct answer rate of Observer B, the rate was 100% for Observer B, and very low for Observer A, at 4%. When a sign with an arrow angled at -15° was presented, the correct answer rate was 46% for Observer A and 92% for Observer B, indicating that a sign with this arrow orientation is relatively effective.

7. DISCUSSIONS

In this experiment, a variety of arrow markings were selected from those in common use. Angled arrows were found to be relatively effective; however, the design of the arrow must be improved to achieve a nearly 100% correct answer rate for both observers. For example, we must investigate how to represent an arrow rotated parallel to the surface of the sign, as shown in Figures 4 and 5, as well as an arrow with a map, and an arrow designed to look three-dimensional. In future studies, we will pursue this investigation into approaches to more effective representation of arrows.

In the next stages, more generic and practical studies are needed, which employ as parameters the width of the road, the installation angle of the respective sign, and the length of the right-turn lane. In addition, we will investigate which arrow marking is most effective for a left turn.

In this experiment, in order to represent how a given arrow marking appears to respective observers, we represented how the given arrow appears at an intersection, approximated by a linear transformation of rotation about one directional axis. Given our three-dimensional perception, the arrow is actually viewed in perspective. However, this approximation is considered adequate for representing an arrow on a sign more than 40 m ahead, and is confidently expected to be applicable to practical sign design.

As a potential extension of this study, the approach to representing signs in buildings may be reconsidered. Arrows on signs in buildings, such as train stations or public facilities, are typically viewed in a complex context and from a shorter distance than in the case of roadside signs. Therefore, such arrows are often viewed in perspective, and the perception of the arrow will be more complex.

The use of linear transformation in this study made it possible to conduct a presentation experiment which takes into account sign representation nearer in appearance to that which is actually perceived. Many signs are forms of advertising media involving a number of external factors. Sign manufacturing requires craftsmanship and experience that takes into account these external factors, and has traditionally been a subject about which it is difficult to generalize. The linear transformation-based representation approach makes it possible to achieve results that take into account the installation location of a sign as an external factor.

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BIOGRAPHY

Masaaki Koyama: He is a President of Aiwa Advertisement Co., Ltd., who has been worked for many advertisements and signs, and also lectured his ideas about new advertisement and sign art and technology.

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A study of the attractive factors for the kidult furniture

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Abstract: With the changing times, people not only concern about the functions of a product but also focus on the emotional connection with a product. Taking furniture, for example, it is a part of our life because we use and rely on it every day. When people interact with it, an emotional connection is then built up. As a result, it is particularly important that new furniture design can satisfy the emerging needs in emotion. In this study, the authors would catch the idea of "kidult", which combines the two words ‘kid’ and ‘adult’. It means a person who continues to participate in and enjoy youth culture (McFedries, 2002). Nowadays, the "kidult furniture" already exists in the market, whereas the definition and the features of this kind of furniture are not clear. Therefore, in this study, the authors used “Evaluation Grid Method” to explore the attractive factors of kidult furniture. Then the factors were justified by the discussion of the existing design projects. As a result, this study proposed some important abstract and concrete features for kidult furniture which can be categorized into four categories, i.e. shape, material, multifunction, and interaction. In the future, this finding would help designers to design kidult furniture better.

Keywords: Emotion, Furniture, Kidult, Evaluation Grid Method, Miryoku Engineering.

1. INTRODUCTION

People are emotional, and they would have several feelings with many things. The authors think that people would have particularly strong feelings with their furniture because they use furniture every day, and most of the furniture can be used for such a long time. People rely on furniture, for example, if they feel sad, they want to find a shelter to hide inside; if they feel happy, they want to just lie on furniture comfortably and freely. Gradually, furniture becomes people's friends, and they accompany with us. Since that people rely on furniture, it is particularly important to think about how to design furniture to let the emotional connection can be built up much easily. In addition, the form

of consumption has developed from "subsistence" to "culture", so people would put more emphasis on the extra emotion of the products rather than only on the function of the products.

During the process of human civilization, people create a lot of vocabulary to describe different kinds of group, such as Bobo, Kidults, freeters, metrosexual and so on, and each of the group has its own habit or special ideas. In this study, the authors choose one of the groups, kidult, to have more discussion, in spite of that there is few literature about this. In terms of the kidult group, the authors believe that everyone has childlike innocence to some extent. Therefore, the authors want to explore everyone's thinking of kidult furniture. One feature of childlike innocent people is that they want to be themselves. Just like children who do not need to think too much. This idea also corresponds to that kidult people want to use furniture freely. Therefore, it is possible to add this idea to the furniture design. With doing this, the user might feel freer and closer when they use kidult furniture. Although this kind of furniture has already existed in the market, it is lack of clear definition. So the purpose of this research is to explore this field more and give it an appropriate definition.

Consequently, this study discusses the background of kidult and its influence on design first. Following that, the authors use the perspective of emotional design to analyze the elements of kidult furniture. Subsequently, the authors use "Evaluation Grid Method" to catch the attractive factors of kidult furniture.

2. BACKGROUND

2.1. The origin of kidult

The term "Kidult", which combines the two words ‘kid’ and ‘adult’, was firstly proposed by Peter Martin in 1985 in the *New York Times.* It is defined as a middle-aged person who continues to participate in and enjoy youth culture (McFedries, 2002). People who have this perspective seem to have mature adult appearances, but actually possess a child's mind and behavior. Initially, kidult is just an external feature, but it gradually becomes an inner spirit (Pan, 2004).

2.2. Evaluation Grid Method (EGM)

In Miryoku Engineering, Evaluation Grid Method (EGM) is one of the important research methods. It originated from the category of psychology, was adapted from Repertory Grid Method (RGM), and was created by Sanui in 1997, who was a Japanese scholar. The RGM was proposed by Kelly (1955). Kelly caught the idea of personal cognition and arranged it into grid chart. Through the personal interview, discussing the difference and the resemblance of two objects with the participants to get the consecutively sorted personality (Kelly 1955). In this study, by using ”Evaluation Grid Method”, the authors need to interview a group of people who are interested in kidult furniture. Then, the focus group will come up with the original concepts of kidult furniture. Based on the original evaluation item, the participants will be asked to try to link the ladder-up evaluation item and the ladder-down evaluation item to their original evaluation item. Finally, the authors will integrate the information and make a network of attractive factors.

3. METHODOLOGY

In this research, the authors interview with participations according to the Evaluation Grid Method first, and then the authors collate the data and analyze them to extract the attractive factors of kidult furniture.

3.1. Preparation for interview

The preparation includes collating the pictures of kidult furniture, filtering some of them, printing

out the remained ones, and finding the suitable participations.

3.1.1. Collection and filter of pictures

First, the authors need to collect the clear pictures of kidult furniture extensively, and the total number of collection is 100. Second, in order to make sure that all the pictures meet the standard of the research, the authors find an expert designer of kidult furniture to filter some of them, and the standards of filter are that if this furniture does not belong to kidult furniture, if it is just a concept, and if there is a similar one in the pictures. Finally, there are 52 pictures remained.

3.1.2. The process of making out the cards

In order to let the participations can see and compare the cards more easily in the interview, the authors need to remove the background of the pictures to remain the furniture itself, for example figure 1.

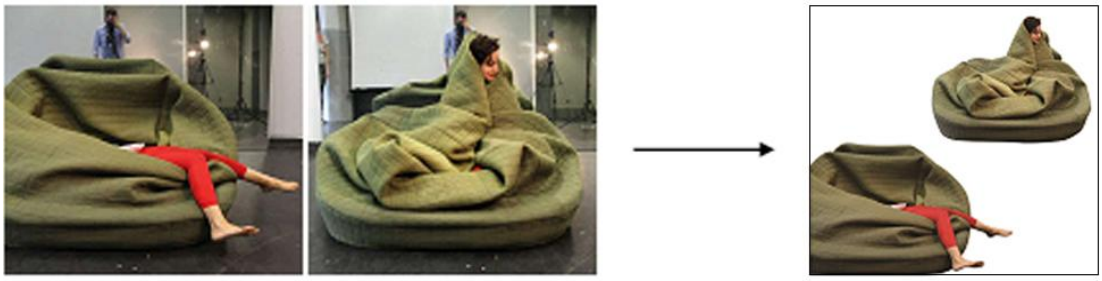


Figure 1: Remaining the furniture itself

After removing the background of the pictures, the authors make each pictures to become 12cm x 10cm cards, for example figure 2.



Figure 2: Part of the cards for interview

3.1.3. Participants and tools

In the research, the author invites three male and tree female participants, who studied industrial design for more than four years, and had the relative work experience. Despite of that, all of them are financially independent. The form of the interview is one-to-one, and each person has about one hour. As for the tools, which may be needed in this research, are the cards of kidult furniture, log sheets, pens, and a camera.

3.2. Interviews

In this section, the authors would introduce the process of interviews and the method of analysis.

- The process of interviews

1. Invite the participants to have interviews.
2. Let the participants separate the 52 cards to two groups, one of the group they like and the other one they do not like, for example figure 3.
3. Let the participants group the cards which they like again, according to the different reasons they like, for example figure 3.



Figure 3: Grouping cards

4. Let the participants explain the reasons for the grouping to make the original evaluation items (original reasons), for example: cocoon chair, bionic, and so on.
5. According to the original evaluation items (original reasons) the participants said, the authors would ask more about the abstract feelings (ladder up) and concrete conditions (ladder down) as shown in figure 4.

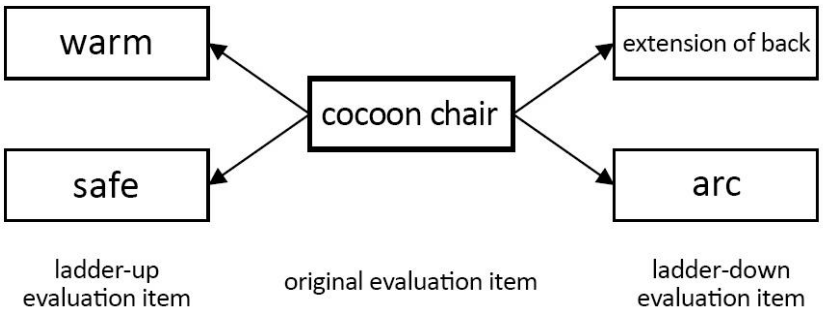


Figure 4: The example of asking ladder-up and ladder-down evaluation item

6. Make out the Evaluation Grid Chart.

4. RESULT OF THE EVALUATION GRID CHART

4.1. Catch of the attractive factor

According to the evaluation items the authors get from the interview, the authors can make out each participant's Evaluation Grid Chart, for example figure 5 is participant A's Evaluation Grid Chart. Through the Evaluation Grid Chart, the authors can see much clearly about the different attractive factors from different people.



Figure 5: Participation A's Evaluation Grid Chart

4.2. Category of the attractive factor

After collating all of the original evaluation items (original reasons), the authors separate them to four categories, which are "shape", "material", "multifunction", and "interaction", and mark them with different colors, which are blue, pink, purple, and yellow respectively; the participant A's classified Evaluation Grid Chart is shown in figure 6.

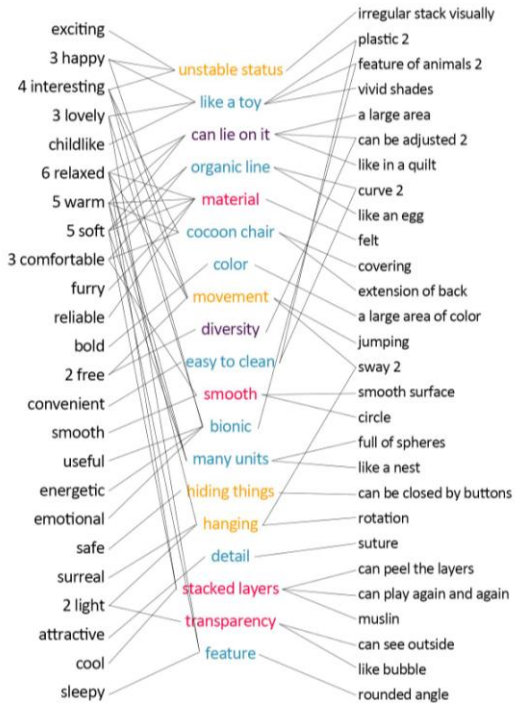
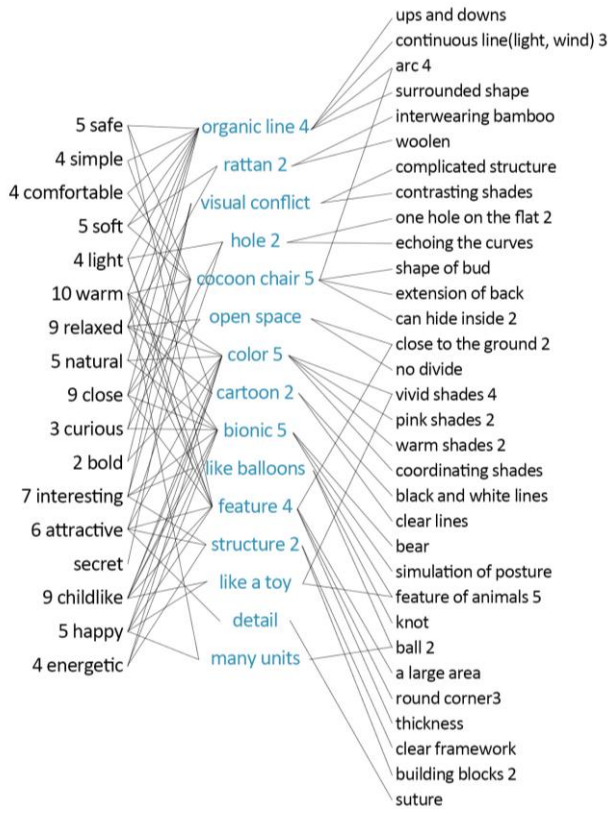


Figure 6: Participant A's classified Evaluation Grid Chart

Subsequently, the authors use KJ method to combine some similar ideas from abstract feelings and original evaluation items to achieve the purpose of reducing the factors, and make out the

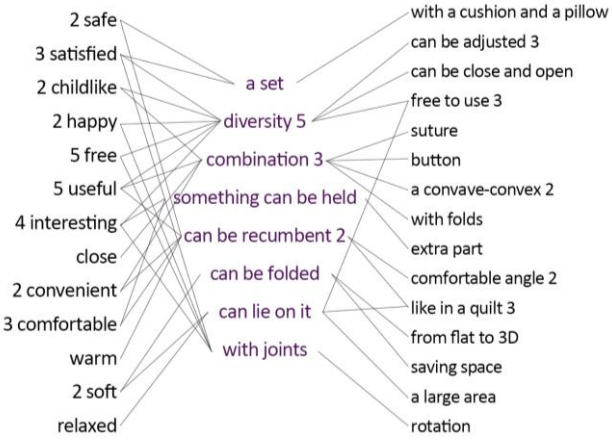
Evaluation Grid Chart of four categories to make the later analysis easier, e.g. figure 7.



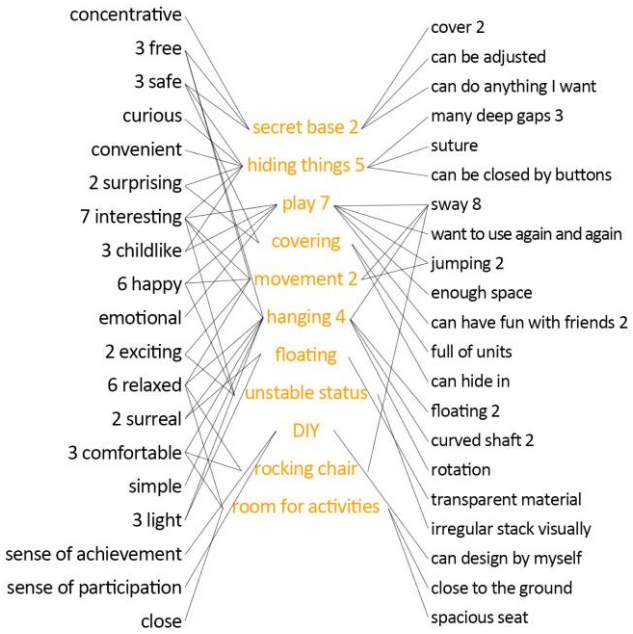
(A) shape



(B) material



(C) multifunction



(D) interaction

Figure 7: The result of Evaluation Grid Charts

4.2.1. Extraction - abstract feelings

In order to make the result of this research more representative, the authors would extract the most frequently mentioned abstract feelings to have more discussion. In the Evaluation Grid Charts, the first chart is "shape", and its top 5 mentioned feelings are "warm", "childlike", "relaxed", "close", and "interesting"; in the second chart - material, its top 5 mentioned feelings are "soft", "warm", "relaxed", "comfortable", and "natural"; in the third chart - multifunction, its top 5 mentioned feelings are "useful", "free", "interesting", "satisfied", and "comfortable", and in the last chart - interaction, the "interesting", "happy", and "relaxed" are the top 3 mentioned feelings.

4.2.2. Extraction - original reasons and solid items

According to the top 5 or top 3 mentioned abstract feelings of each category, in this section, the authors find their corresponding original evaluation items (original reasons) and the solid items. In addition, the authors also count how many times each of the items were mentioned and make out four tables.

5. DISCUSSION

The purpose of this study is using the Evaluation Grid Method to extract the attractive factors of kidult furniture, and the authors hope that in the future, the attractive factors can be referred by someone who would like to design kidult furniture. According to the analysis, the authors have some suggestions about this field.

1. Shape: The authors find that the shape which has the feature of a cocoon chair, with organic lines or having some features of animals can let the users feel more relaxed and warmer when they use this kind of furniture. As for the color, both of the vivid shades and pink shades can be accepted. In addition, if the designer can add some details on the furniture, such as the round corner, the furniture can be more attractive.
2. Material: According to the analysis, people prefer to the elastic cloth, natural material, or soft, furry texture, such as grass, felt, and down. When people use this kind of material, they would feel comfortable and relaxed.
3. Multifunction: Based on the result of the research, people prefer the changeable kidult furniture, where they can adjust the form by themselves. The furniture does not need to have a fixed shape; its shape can be assembled into different forms. With these features, users would feel freer, more interested and satisfied.
4. Interaction: The authors find that if the designer can add some features of interaction to the furniture, such as that people can hide things inside, the furniture can be swayed, or it has enough space which can let people play with their friends. This kind of kidult furniture would let people feel more interested and happier.

Overall, if designers can refer and use some of these features when they design kidult furniture, the outcome might make the users have more positive feelings and love this kind of furniture more. In order to make sure of the result, the authors make the attractive factors compare with the original pictures to see whether they can be matched.

5.1. Shape :



Figure 8: The matched sample of shape

This category of kidult furniture has the feature of a cocoon chair; its shape can be imagined to be similar to a hug, which is like curling in a mother's arms. This image would also affect people's feelings and make them feel warm and attached to the furniture. Furthermore, the warm shades would also make these feelings stronger and provide comfort and safety for the users. As for the details, this kind of furniture also uses the short sutures, thick cushion, short and rounded legs or even on the ground directly. These details would make people think they are lovely and they can feel closer to the furniture.

5.2. Material :



Figure 9: The matched sample of material

In this category, the materials are softer, such as feather, muslin, and elastic cloth, and people would be attracted by these. For instance, the large area which is made of plush or stacked layers would make people want to go through it and roll on it to feel its softness, which is just like a child's behavior, and they would get comfortable and childlike feelings. The furniture which is made of cotton and elastic cloth would make people want to lie on it directly.

5.3. Multifunction :



Figure 10: The matched sample of multifunction

The form of using this category of kidult furniture is freer, for example, people can adjust the furniture according to their hobby and some of these furniture does not have fixed shape, so people can feel like a child to have any kind of posture when they use this. In addition, most of this kind of furniture is close to the ground and have an open space to match the free feeling.

5.4. Interaction :



Figure 11: The matched sample of interaction

This category of kidult furniture can particularly have interaction with users, for instance, hiding things in the special gap of the furniture. The furniture is like people's friend and it can help people keep things, so people can easily have the emotion with this kind of furniture when they use that. As for the hanging or rocking chair, most of the users would drive it to make it sway. This feeling can be connected to the childhood, such as we were held and swayed by the adults or sitting on the toy horse and riding it. These happy feelings and interesting experience can let people feel like a child when they use these kind of furniture.

6. CONCLUSION

In this study, the authors had already classified the features of kidult furniture to four categories, which are shape, material, multifunction, and interaction. When people use this kind of furniture, the furniture could inspire them to have stronger feelings, such as safe, warm, relaxed, free, interesting and so on, which are also the reasons why people like kidult furniture.

Consequently, people prefer to the kidult furniture which can use with more freedom or can make a good connection with the happy memory or an interesting experience in their childhood. In this study, the authors focus on the emotion of kidult and have more discussion on how those emotions connect with the kidult furniture. The authors hope that this kind of research can be further expanded in the future, including having more research on the kidult products and analyze whether there exist other important attractive factors. Thus, designers would know how to apply this emotion to different types of products better in the future.

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KEER2014, LINKÖPING | JUNE 11-13 2014
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Postural Sway with Illusory Motion Induced by Static Visual Stimuli in Migraineurs and Normal Controls

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Abstract: Illusory motion, in which observers can perceive static images to be moving, is an important graphic design concept. Although the mechanism of illusory motion is being uncovered, it is still unclear whether illusory motion can induce postural sway. Patients with migraine headaches (migraineurs) are likely to suffer from motion sickness and are more likely to perceive illusory motion than are individuals without chronic headaches. Since one of the causes of motion sickness is the conflict between visual and vestibular inputs, we hypothesized that migraineurs have an abnormal visuo-vestibular interaction. We measured postural sway during migraineurs' and normal controls' viewing of static visual stimuli with and without illusory motion. We used Kitaoka's artworks as both the illusory motion and control stimuli (Kitaoka, 2003, 2013). The participants stood on a stabilometer while they viewed one stimulus for 30 seconds. Immediately afterward (Experiment 1), or 30 seconds after viewing the stimuli (Experiment 2), the participants closed their eyes and stood on the stabilometer for 30 seconds. The results from Experiment 1 indicated that migraineurs swayed more than controls while their eyes were closed after viewing the illusory motion image. However, in Experiment 2, migraineurs swayed less than controls with their eyes closed following a 30-second interval after viewing the illusory motion. Taken together, these results suggest that static visual stimuli induce not only illusory motion but also postural sway, which may last for 30 seconds in migraineurs.

Keywords: Illusory Motion, Vision, Migraine, Postural Sway

1. INTRODUCTION

Optical illusion, such as illusory motion, is an important aspect of graphic design and art. In this artistic phenomenon, observers may actually perceive physically static images to be moving; for instance, *Op Art* employs geometrical patterns to introduce illusory motion into its brand of visual art in order to enhance the beauty of the relevant pieces. Optical illusion itself may induce beauty and/or preference (Noguchi, 2003). Actually, the magnitude of illusory motion in geometrical patterns has been known to contribute to people's reported preferences for these patterns (Stevanov et al., 2012). Although recent neuroscience studies have proposed a number of findings regarding the mechanism of illusory motion (e.g., Takemura et al., 2012), the mechanism by which illusory motion modulates human body movement has not been well explained. Although illusory motion has been found to induce illusory body movement (vection) in physically stationary observers (Seno et al., 2013), it is not known whether illusory motion can induce actual body movement—that is, postural sway.

Patients with chronic migraine headaches (migraineurs) are likely to suffer from motion sickness (Marcus et al., 2005) and are more likely to perceive visual discomfort (Marcus & Soso, 1989) and more illusory motion (Imaizumi et al., 2011) in visual stimuli such as grating patterns than are individuals who do not suffer from chronic headaches. About 8.4% of the total Japanese population is composed of migraineurs (Sakai & Igarashi, 1997). Some have visual hypersensitivity because the corresponding parts of their brains are easily excitable (Aurora et al., 1998). Since one of the causes of motion sickness is the conflict between visual and vestibular inputs (Reason & Brand, 1975), we hypothesized that migraineurs who are susceptible to motion sickness have an abnormal visuo-vestibular interaction. Although a recent study reported that some migraineurs showed greater postural sway than normal individuals (Carvalho et al., 2013), no study has of yet examined how visual stimuli modulate postural control in both migraineurs and controls.

In this study, we investigated whether illusory motion can influence postural sway and whether there are any distinguishing characteristics in migraineurs in terms of postural control. To accomplish our study goals, we attempted to measure the postural sway of both migraineurs and normal controls during their viewing of static visual stimuli with and without illusory motion.

2. EXPERIMENT 1

2.1. Methods

2.1.1. Participants

Eleven migraineurs (5 male and 6 female; mean age = 22.18 years, *SD* = 0.30) and nine non-chronic headache sufferer controls (7 male and 2 female; mean age = 22.22 years; *SD* = 0.40) participated in our study. We classified the participants into one of two groups—migraineurs or controls—by using a questionnaire based on the second edition of the International Classification of Headache Disorders (Headache Classification Subcommittee of the International Headache Society, 2004). This questionnaire included 18 items about the occurrence of chronic headaches, as well as characteristics, duration, frequency, and accompanying symptoms, among other things. All participants had normal visual acuity, and no one had visual deficits such as colour blindness.

Written informed consent was obtained from each participant. This study was approved by the ethical committee of the Graduate School of Engineering, Chiba University. The experiments were conducted according to the principles of the Declaration of Helsinki.

2.1.2. Stimuli

The static visual stimuli used in this experiment were grey plane and illusory motion images (Kitaoka, 2003; *Rotating Snakes.* See Figure 1, left). A red cross to be fixated on was presented in the centre of each stimulus. These stimuli had the same mean luminance. We refer to this illusory motion image as the 'snake image'. The smallest unit of the component for the snake image was an arrangement of 'black–blue–white–yellow' patches. In the illusory motion image, this order of colour patches was arranged in the same direction throughout, thus inducing an illusory rotational motion. The snake image is known to induce a strong illusory motion perception and has been used in a large number of studies investigating human motion perception (e.g., Conway et al., 2005; Kuriki et al., 2008).

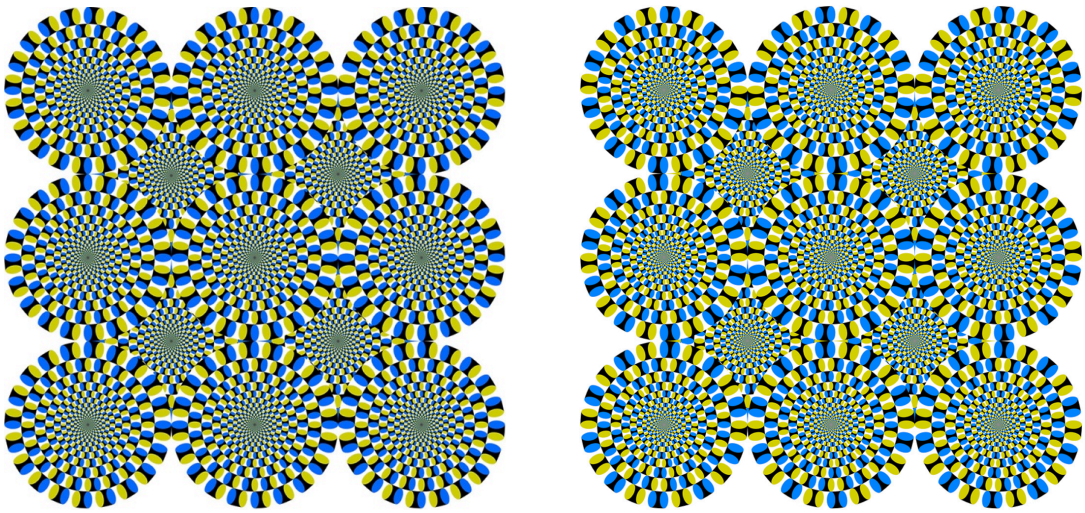

Figure 1: The snake image with illusory motion (Kitaoka, 2003) used in Experiments 1 and 2 is shown on the left side. The non-motion control image (Kitaoka, 2013) used in Experiment 2 is shown on the right side

2.1.3. Apparatus

Each of the stimuli was presented on a head-mounted display (HMD; HMZ-T1, Sony). All stimuli were subtended approximately 29 by 29 degrees on the HMD. We used a stabilometer (UM-BAR2, UNIMEC) to track the displacement of participants' centres of gravity (CoGs) and to sample fluctuations in the CoG at 60 Hz. The stabilometer was installed on the floor 60 cm away from the wall. An example of the experimental setup is shown in Figure 2.

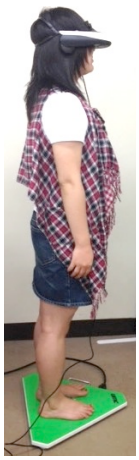

Figure 2: Apparatus used in Experiments 1 and 2

2.1.4. Procedure

The participants removed their shoes and stood erect on the stabilometer. During stabilometric measurement, they were asked to stand still with their knees straight and their hands down flat at their sides. First, the participants stood on the stabilometer without the HMD while viewing a fixation point on the wall in front of them for 30 seconds (Eyes Open condition; EO). Immediately afterward, they closed their eyes and kept standing for 30 seconds (Eyes Closed condition; EC). Next, the participants fitted the HMD on their heads. Following that, they stood on the stabilometer while fixating on the red cross in the centre of one of the stimuli for 30 seconds. Immediately afterward, the participants closed their eyes and kept standing on the stabilometer for 30 seconds. The stimuli were presented in a random order.

In these measurements, we recorded the stabilometric parameters of postural sway, total path length (TPL), rectangular area (REC), and Romberg ratio (RR). TPL refers to the total length of CoG displacement. REC refers to the area of the maximum amplitude of CoG displacement in the x and y coordinates. RR refers to ratio of the postural sway parameters measured with EC and EO. We calculated the RRs for both the TPL and the REC. RR assesses the stabilizing effect of vision in postural control (Diener et al., 1984).

2.1.5. Data Analysis

TPL (EO, EC, and RR) and REC (EO, EC, and RR) were independently analysed using repeated measured ANOVAs with a between-participant factor (migraineurs vs. controls) and a within-participant factor (stimulus type). Pair-wise comparisons with Bonferroni correction were used for post hoc testing.

2.2. Results

The measured TPL, REC, and RR of both the migraineurs and the controls are shown in Figure 3. The ANOVA revealed significant main effects of stimulus types on TPL under the EO and EC

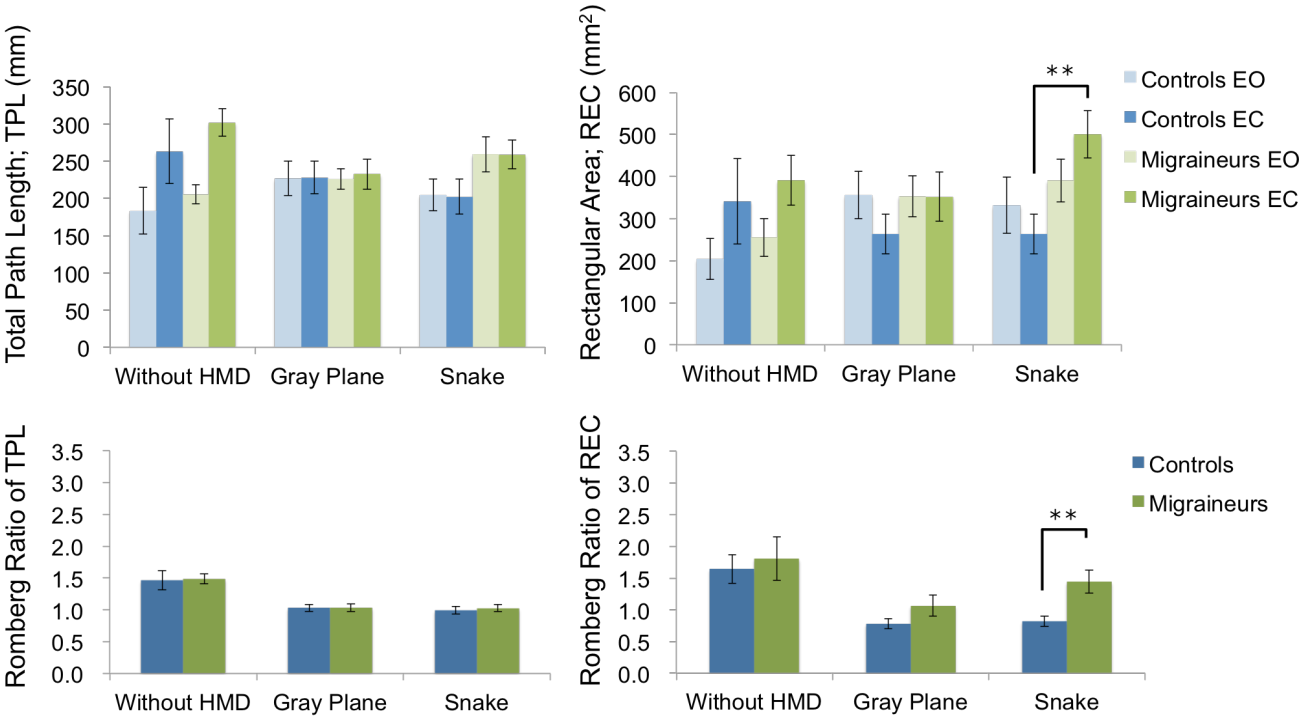

Figure 3: Results of Experiment 1. Error bars denote the standard error of the mean. Asterisks indicate the significant difference (** $p < 0.01$, Bonferroni correction)

conditions. Furthermore, the RR of the TPL was significant (EO: $F_{2, 36} = 4.48$, $p < 0.05$, $\eta^2 = 0.20$; EC: $F_{2, 36} = 7.16$, $p < 0.01$, $\eta^2 = 0.29$; RR: $F_{2, 36} = 19.69$, $p < 0.01$, $\eta^2 = 0.52$). No significant main effects or interaction effects were found for the between-participants factor. We found significant main effects of stimulus types on REC under the EO condition and the RR of REC (EO: $F_{2, 36} = 8.52$, $p < 0.01$, $\eta^2 = 0.32$; RR: $F_{2, 36} = 7.65$, $p < 0.01$, $\eta^2 = 0.30$). We also found a trend toward a main effect of the between-participants factor on the RR of REC ($F_{1, 18} = 4.17$, $p = 0.06$, $\eta^2 = 0.19$). No significant main effects or interaction effects were found for the between-participants factor. Multiple comparisons revealed a significantly larger REC in migraineurs in the EC condition after the observation of the snake image compared to the REC for the controls ($p < 0.01$). Consequently, there was a significantly increased RR of REC in the migraineurs for the snake image ($p < 0.01$).

2.3. Discussion

The results showed that no differences of TPLs existed between the grey plane and the snake image observations, and there were no differences between the migraineurs and the controls. As for REC, migraineurs showed larger postural sway while closing their eyes after viewing the illusory rotating snake image, whereas such differences were not found during the actual observation of the snake image. Given the fact that migraineurs perceive stronger motion aftereffects than do individuals who do not suffer from chronic headaches (Shepherd, 2006), we speculated that the motion aftereffect caused by the illusory motion increased the postural sway evidenced by the migraineurs. To investigate this speculation, we carried out another experiment designed to remove the motion aftereffect probably induced by illusory motion.

3. EXPERIMENT 2

To examine whether the aftereffect due to illusory motion can induce increased postural sway as observed in the EC condition for the migraineurs in Experiment 1, we provided an interval between the EO and EC conditions to decay the aftereffect caused by viewing illusory motion. If the aftereffect due to illusory motion increased postural sway, the removal of the aftereffect would decrease postural sway. Furthermore, we used a non-motion snake image (i.e., one that looked like *Rotating Snakes* but that did not have the rotating effect attached to it) as a control stimulus for a more detailed examination of the effect of the illusory motion induced by the snake image. If illusory motion is enough to modulate postural sway, then the control image should not have the same effect.

3.1. Methods

The method in Experiment 2 was identical to that in Experiment 1, except as noted below.

3.1.1. Participants

Eight migraineurs (4 male and 4 female; mean age = 21.29 years, *SD* = 3.09) and 14 non-chronic headache sufferer controls (7 male and 7 female; mean age = 22.36 years, *SD* = 2.24) who did not participate in Experiment 1 agreed to participate in this experiment.

3.1.2. Stimuli

In addition to the grey plane and the snake image (Figure 1, left), we used a non-motion control image (Kitaoka, 2013; see Figure 1, right). The order of colour patches that composed the control image was reversed between the adjacent units, so that the illusory motion signal would be nulled. All stimuli had the same mean luminance and were presented with a red cross as a fixation point.

3.1.3. Procedure

To prevent the aftereffect of illusory motion in the EO condition from modulating postural sway in the EC condition, we added intervals of 30 seconds between the EO and EC conditions for each measurement. During this interval, the participants who had their eyes open kept standing on the stabilometer while being exposed to a blank display for 30 seconds. They then closed their eyes and their bodily responses were measured under the EC conditions.

Directly after the stabilometric measurements, participants orally rated the magnitude of illusory motion for each stimulus using an 11-point Likert scale, where 0 meant 'the image did not appear to move at all' and 10 meant 'the image appeared to move most strongly'.

3.1.4. Data Analysis

Along with TPL and REC, the ratings of illusory motion were analysed using repeated measures ANOVAs with a between-participants and a within-participants factor (stimulus type). Pair-wise comparisons with Bonferroni correction were used for post hoc testing.

3.2. Results

The measured TPL, REC, and RR of both the migraineurs and controls are shown in Figure 4. An ANOVA revealed significant main effects of stimulus types on TPL under the EO and EC conditions and for the RR of TPL (EO: $F_{3, 60} = 4.16$, $p < 0.05$, $\eta^2 = 0.17$; EC: $F_{3, 60} = 4.68$, $p < 0.01$, $\eta^2 = 0.19$; RR: $F_{3, 60} = 15.43$, $p < 0.01$, $\eta^2 = 0.44$). No significant main effects or interaction effects were found for the between-participants factor. We found significant main effects of stimulus types and between-factors on the RR of REC (stimulus type: $F_{3, 60} = 8.57$, $p < 0.01$, $\eta^2 = 0.30$; between-participants factor: $F_{1, 20} = 7.56$, $p < 0.05$, $\eta^2 = 0.27$), but no significant interaction between these factors. Multiple comparisons revealed significantly larger TPLs for the controls in the EC

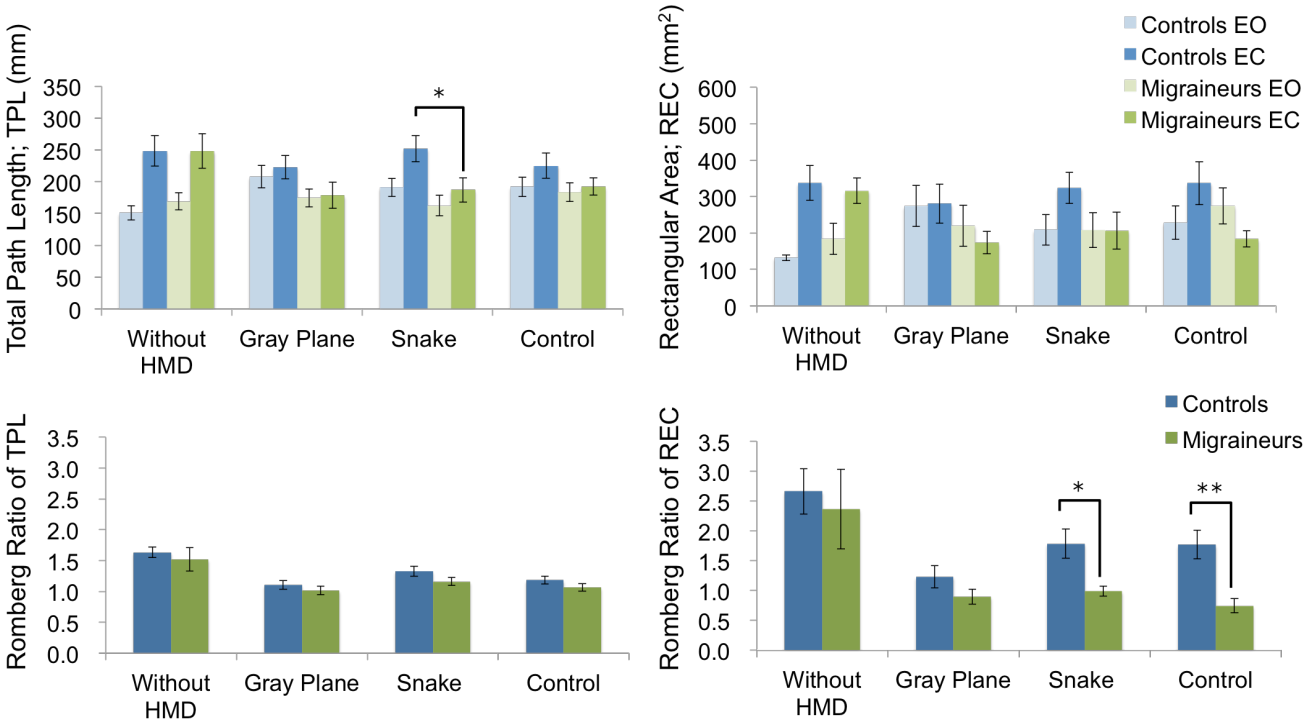

Figure 4: Results of Experiment 2. Error bars denote the standard error of the mean. Asterisks indicate the significant differences (* $p < 0.05$, ** $p < 0.01$, Bonferroni correction)

condition after the observation of the snake image in comparison to the migraineurs ($p < 0.05$).

Contrary to the results from Experiment 1, the RR of REC significantly decreased in migraineurs relative to controls when they observed both the snake image ($p < 0.05$) and the control image ($p < 0.01$).

The subjective magnitude of illusory motion in both the migraineurs and controls are depicted in Figure 5. An ANOVA revealed significant main effects of stimulus types ($F_{2, 40} = 24.53$, $p < 0.01$, $\eta^2 = 0.55$. No significant main effects or interaction effects were found for the between-participants factor. Multiple comparisons revealed that illusory motion significantly increased for the snake image relative to both the grey plane and the control image ($p < 0.01$).

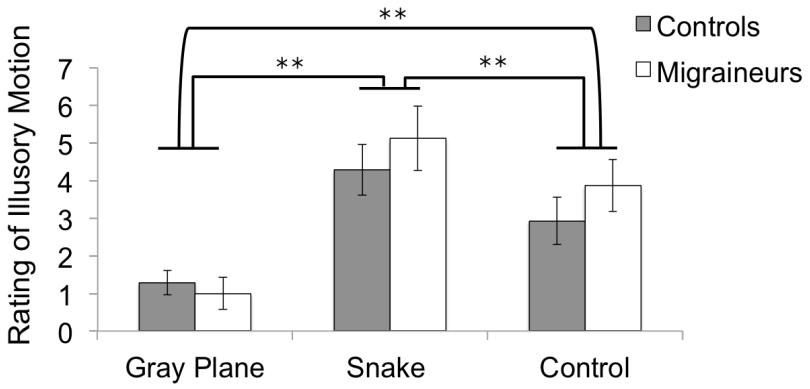

Figure 5: Subjective rating of the magnitude of illusory motion in Experiment 2. Error bars denote the standard error of the mean. Asterisks indicate the significant differences (** $p < 0.01$, Bonferroni correction)

3.3. Discussion

The results showed no differences of TPLs between the grey plane, the snake image, and the control image observations, and there were no differences between migraineurs and controls, except for longer TPL for the controls in the EC condition after the observation of the snake image. On the other hand, as for REC, migraineurs showed decreased postural sway in the EC condition after viewing both snake and control images, contrary to the results in Experiment 1. This suggests that the aftereffect of illusory motion may induce increased postural sway, especially in migraineurs.

Rating the magnitude of illusory motion confirmed that the snake image presented stronger illusory motion than the control image as far as both the migraineurs and controls were concerned. Given the absence of differences between the sway measured by using the snake and the control images, the stronger illusory motion from the snake image did not necessarily increase postural sway. Not only the magnitude of illusory motion, but also other spatial properties (e.g., spatial frequency, colour) may be involved in visually inducing postural sway.

4. GENERAL DISCUSSION

The present study suggests that postural sway can be modulated by static visual stimuli, especially when the stimuli can induce illusory motion perception. In our experiments, migraineurs showed larger sway while closing their eyes after viewing the illusory motion (Experiment 1). However, they showed decreased sway while closing their eyes after a 30-second interval following their viewing of the illusory motion (Experiment 2). Thus, we speculate that static visual stimuli induce not only illusory motion, but also postural sway, and that this effect may last for at least 30 seconds in migraineurs.

In this study, we focused on the relationship between illusory motion and postural sway. However, to more thoroughly understand visuo-vestibular interaction, the influence of emotional processes on the interactions should not be ignored, given the previous findings that postural sway can be modulated by visually evoked emotions, especially negative ones (Stins & Beek, 2007), and by a preference for visual objects (Brunye et al., 2013). In our experiment, since the high contrast of the geometrical pattern can easily induce visual discomfort in observers (Wilkins et al., 1984), the snake image consisting of high contrast geometrical patterns may have induced not only illusory motion but also visual discomfort in our participants, especially in migraineurs (Imaizumi et al., 2011; Marcus & Soso, 1989). If so, postural sway may have been affected by visual discomfort as well as by negative emotion.

Stabilometric measurement may provide a quantitative and objective measure to investigate the interactions between visual perception and cognition, such as optical illusion and emotion (e.g., Stins & Beek, 2007). This type of measurement can be beneficial in advancing Kansei Engineering, which quantitatively assesses the interactions between Kansei and multisensory processing. Recent studies have demonstrated that the relatively inexpensive stabilometric device, the Nintendo Wii Balance Board, can accurately assess postural sway (Bartlett et al., 2014; Clark et al., 2010). It would, therefore, not be so difficult to introduce stabilometric studies into the field of Kansei Engineering.

Our study has at least two limitations regarding the experimental design. First, the weight of HMD fundamentally affected the difficulty to control posture, consequently increasing postural sway. Second, the design of our experiment did not allow for ensuring whether the illusory-motion aftereffect appeared in the participants' visual fields. Further investigations overcoming these limitations should extend the present findings.

ACKNOWLEDGMENTS

We would like to thank an anonymous reviewer who provided valuable comments on this paper and Haruka Lee for her help with the data collection. A Grant-in-Aid for Scientific Research (B) to SK (23330218) and a Grant-in-Aid for JSPS Fellows to SI (13J00943) from the Japan Society for the Promotion of Science supported this work.

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Cultural Influence to the Color Preference According to Product Category

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Abstract: In this study, I focus on color, one of the factors involved in design. It has been assumed that color preference is affected by culture and geographical factors, and much international comparative research has been done on this issue. However, the conclusions vary widely, suggesting that it is difficult to generalize. Therefore, in addition to studying color preference itself, I investigated how basic stated color preference is correlated with specific color preference for commercial products. I analyzed how color preferences vary in different countries and product categories. I interviewed Japanese, Chinese Vietnam and Dutch students on their color preferences, and investigated the correlation between their basic color preference and their specific color preference for product categories such as clothes, cell phones, notebook computers, refrigerators, and vehicles. I found that Japanese participants tend to prefer dark colors. All of three nations other than China liked achromatic colors such as black and white for commercial products. By contrast, the color preferences of Chinese participants varied widely. The Chinese tend to have similar color preferences throughout product categories, whereas the Japanese, Vietnam and Dutch people showed different tendencies for different categories.

Keywords: Color Preference, Product Category, International Comparison, Cultural Background

1. INTRODUCTION

Thanks to the rapid progress of technology, the function and quality of home electronics have developed in a similar way worldwide. Therefore, many firms differentiate their products by form or color. In SoftBank and DS products and the iPod, abundant color deployment has become the fashion. Various color strategies have been used, from the color of the product itself to the logo, advertising, and the shopfront. However, when the most popular model of a cellular phone is black, this color preference is not necessarily transferred to a different product category such as clothes

or furniture. This is evident from the sales situation so far. Moreover, according to the literature, people in countries in East Asia (Japan, South Korea, and China) prefer white or blue. However, if color is investigated according to a product, there is remarkable variation in the favorites, suggesting that the taste for a color changes with the product category.

This research focused on this point and considered the relationship between color taste and some products. And I examined whether it would come from the difference in a country or culture.

2. RESEARCH BACKGROUND

2.1. Relationship between Color Trends and Products

Physiological and psychological factors are believed to cause individual variations in color perception. Differences in visual acuity and perception caused by age and environment are among these factors. Chijiiwa (2001) proposed that color preference is defined by super-cultural and biological factors in any general hierarchy of color preferences, and mentioned generality and specificity based on past literature. However, other factors such as sex, ethnicity, area, age, personality, and education have a major effect on color preference.

Around 1950, Japanese home electronics were almost always white, which symbolizes purity. This is one reason why such appliances are called white goods. Various colors came on to the market after the appearance of color television. For example, vivid yellow-orange, the almond and ivory of natural color, were in fashion in the 1970s, and pastel shades in the 1980s. In the mid-1980s, 80% of Japanese cars were white, possibly because of herd instinct pushing all the purchasers in the same direction.

Moreover, Sugiyama and Nagumo (2008) claim that there is a close relationship between a hot-selling product and a color. For example, red came to be used also for cars, notebook PCs, and a food package immediately after the red packaging of Shiseido Tsubaki shampoo became a big hit. Red started to appear in various product categories, suggesting that often utilized primary colors find their way into other products. Sugiyama and Nagumo have pointed out that a time cycle exists within this phenomenon of color preference.

2.2. Prior Research

2.2.1 Color Preference Factors

A person’s taste in color generally changes with age. People like yellow and red in their infancy, and as they grow they develop a liking for blue or green (Birren, 1961). Garth, T. R. , M. R. Moses and C. K. Anthony (1931) notes that color preference also changes with education, although infants usually prefer the same colors, wherever they are. Researchers argue about whether reaction to color is fundamental (Humphrey 1976, Grossman 1999) or learned (Adame 1973, Hupka 1997), and consider whether color consciousness is associated with meaning and whether preferences change with culture (Sable and Akcay 2010). Furthermore, it is thought that consciousness of color is specific to a geographic factor or a culture factor. In terms of meaning, there is the possibility that both innate individual preferences and environment (education) may be important factors.

2.2.2 Symbolism of Color

Sable and Akcay (2010) compared symbolism and meaning attached to color from the standpoint of cultural marketing. For example, white symbolizes purification in sorrow in East Asia,

but happiness in Australia or the US. Red signals unhappiness in Nigeria or Germany, but is a mark of good fortune in China and Denmark. Yellow in the US signifies warmth, in France distrust, in Russia jealousy, in China happiness, and in Brazil disappointment. Businesses seeking to enter a foreign market need to be aware that the meaning of a color changes with a country or area.

Research into color from a physiological standpoint has been conducted by, for example, Jacob Liberman (1996), who investigated the relationship between color and blood pressure, pulse rate, and respiration rate. He found that yellow caused the numerical value of a physiological function to rise, whereas black and blue caused it to fall. He also found that the color red heightens concentration, whereas blue stimulates the imagination. Other studies have explored the influence that a color has on the brain or the heart.

2.2.3 International Comparisons of Color Tastes

A study by Sakamoto, Shirabe, and Sato (2006) compared tastes in color in Japan and South Korea, specifically relating to a cellular phone and a refrigerator. There was a marked difference. Bluish colors were preferred in Japan, reddish colors in South Korea. For a cellular phone, Japan's breadth of color preference was found to be larger than in South Korea; for the refrigerator, South Koreans tended to prefer a wider range of hues.

Such research shows that, in choosing product colors, it is necessary to consider the influence of the area or the culture, reflected in differing tastes according to symbolism or perception. In addition, colors influence the way in which people relate to and use a product.

3. INVESTIGATION OUTLINE

Two investigations were conducted in order to explore the issue of color preference in preparation for entry into the Chinese market.

3.1. Relationship between Color Tastes and Product Category

Each product category tends to evoke colors that are peculiar to it, and a color conversely tends to evoke particular product categories. This correlation between commercial products and colors has developed over a long time. More traditional categories exhibit a closer correlation with certain colors. In this section, I investigate color preference for selected representative product categories.

Investigation about basic color preference and color preference for a product category was conducted in 2011. As for stated preference, although there was individual difference among individual favorite colors was almost no individual difference among disliked colors. Moreover, the stated color preference and the color preference within a product category tended to be similar only within the T-shirt category, while color preference for Crocs and cars concentrated on a specific color.

These findings suggest that basic color preference is reflected in clothes, whereas such a correlation would not be applicable to other product categories. Color preference within a product category is assumed to be affected by the product's size, form, and feeling as well as the method and situation in which it is used. Therefore, in this study, I focused on a total of five product categories: frequently and officially used products, such as clothes; frequently and personally used products, such as cell phones (small in size), computers (middle in size) and refrigerators (large in size); and non-frequently, officially and personally used products, such as stationary.

Thirty-six colors were chosen from the Munsell color system based on intensity, saturation, and

hue balance. Participants were interviewed about their favorite colors and their specific color preference for each product category



Figure.1 color chart

Surveys were carried out in the Netherlands, Japan, and China. The Netherlands was chosen from the EU because of its history with Japan. It was diplomatically privileged to trade with Japan during the Edo era (1603-1868), called Dejima; thus, it has had a longer relationship with Japan than have other European countries. The Dutch culture, including its knowledge and materials, affected Japan. In addition, the Netherlands, which produced Van Gogh and Vermeer, is a kingdom of design

We then investigated the differences between design tastes in the Netherlands and Japan.

Because balance and harmony are needed, it is not necessarily beneficial to collect the best things. Here, a combination of the optimal elements was extracted from a rough set theory.

Summary of survey:

The Netherlands

Enforcement period: September 15-28, 2012

Subjects: 77 undergraduate and graduate students from Eindhoven University of Technology

Examination method: Questionnaire

Japan

Enforcement period: October 15–22, 2012

Subject: 125 undergraduate and graduate students in the Kyoto area

Examination method: Questionnaire

China

Unlike the other two cases, investigation was performed through WEB questionnaire.

Enforcement period: January 30, 2013

Examination method: WEB questionnaire ¥conducted by a living questionnaire monitor in Beijing.

The number of respondents: 100 persons in their twenties

Vietnam

Enforcement period: September 9-10, 2013

Subject: 95 undergraduate and graduate students in Ho Chi Minh City

4. RESULTS

The result of the investigation is shown in the graphs.

Color preferences in all of three nations other than China show a clear trend. Dutch participants prefer blue, green and red, While Japanese participants tend to like pink and pale green and blue. However, Chinese participants show a wide variety of preferences. An apparent characteristic among the Chinese is that their preferences vary widely.

Also, trends of specific color preferences within product categories were similar among Japanese ,Vietnam and Dutch participants. Only Chinese participants showed a different trend.

Japanese participants tend to prefer black for product categories, except for refrigerators and stationary. Black is especially preferred as a color for clothing. White is preferred for refrigerators, while no specific color preferences were seen in the stationary category. Specific color preference in clothing shows trends similar to those of fundamental color preference, while in other categories such the correlation between fundamental and specific was not observed, except in the stationary category where such a tendency existed with the color pink.

Among Dutch participants there was a similar trend. They much preferred achromatic colors, such as black for cell phones and clothes and white and gray for computers. Specific color preferences in clothes show trends similar to those of simple color preference.

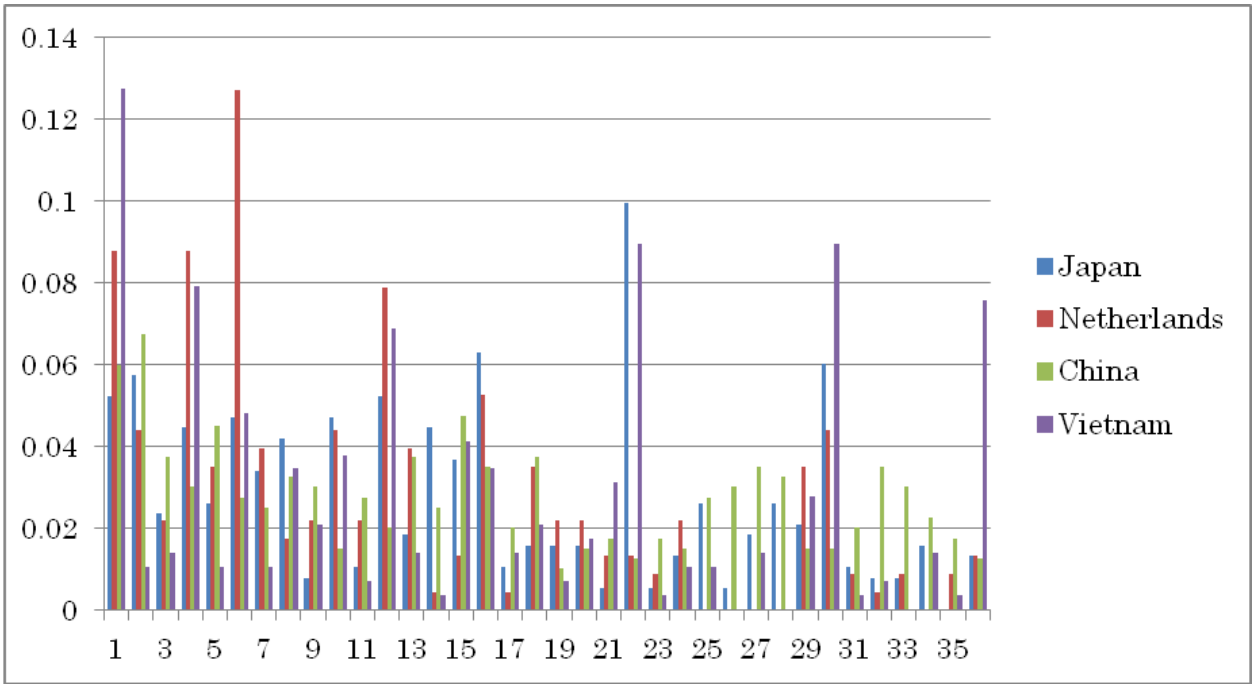

Figure 2 four countries comparison of color preference

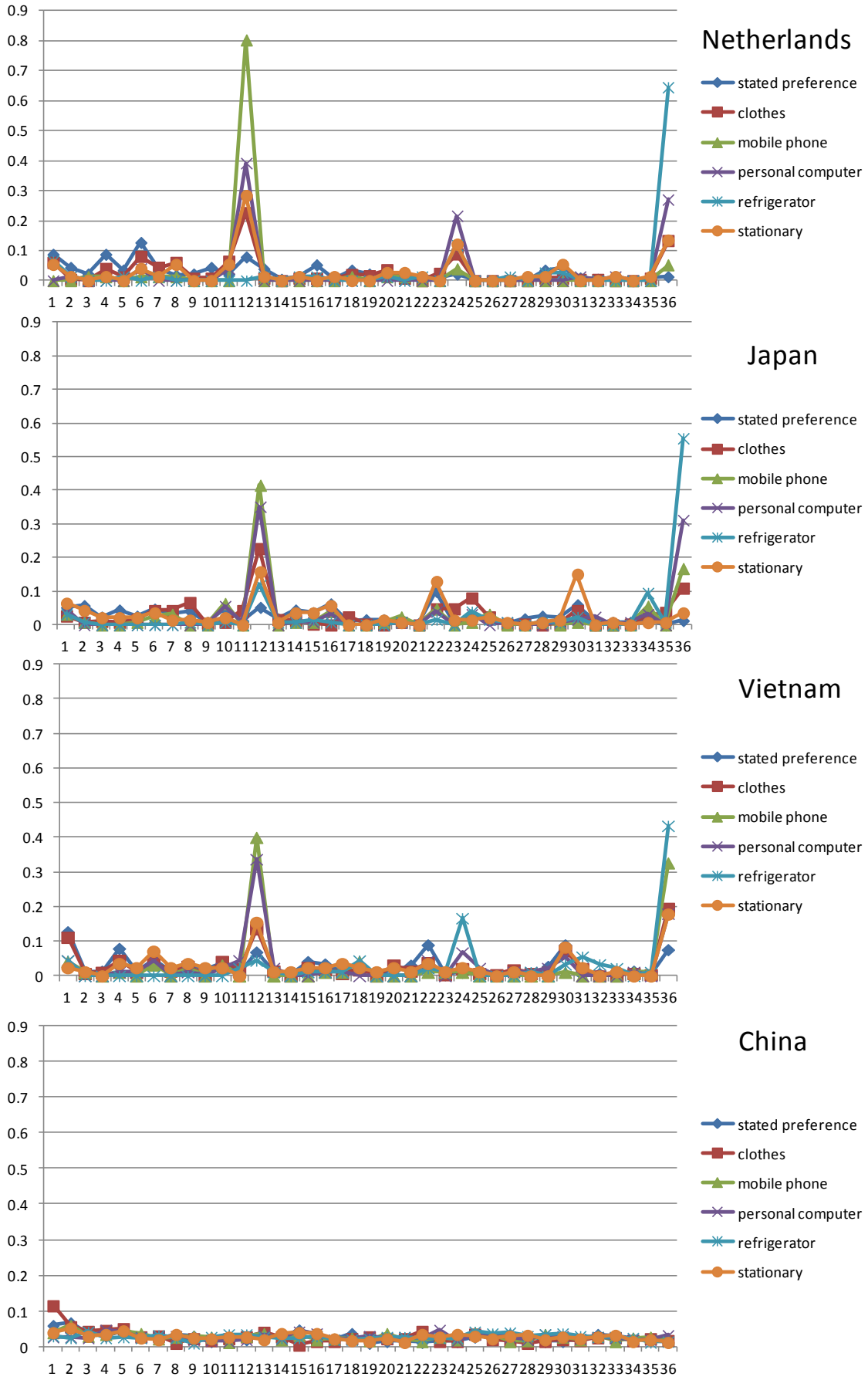

Figure 3 Color preference according to product category

It is difficult to detect trends among Chinese participants, since they show a wide variety in product-specific color preferences as well as simple color preferences. However, they definitely tend to prefer red for clothes and warm colors for all product categories. Simple color preference and category-specific preferences did not show any correlation within this ethnic group, while there is likely some correlation in the stationary category.

5. DISCUSSION

In this study, I investigate the correlation between basic and product-specific color preferences in Japan, China and the Netherlands. It has been assumed that there were different tendencies among countries regarding basic color preferences countries. However, it is also assumed to be difficult to generalize rules of color preference, since previous literatures have demonstrated widely varied results. Therefore, here I focus on the correlation between basic and product category-specific color preferences. The data demonstrated very interesting trends. Firstly, All of three nations other than China showed similar tendencies, as they much prefer achromatic colors for officially used products such as clothes and cell phones. Color preference within these categories is very different from basic color preferences. Also, achromatic colors are preferred for refrigerators and computers, suggesting a strong correlation between color and product categories. Possible causes for this is that since their creation these commercial products have been associated with achromatic colors and that achromatic colors such as white and black are recognized as cool and/or innocuous colors. However, Chinese participants did not show any product-specific preferences except for red for clothes. This could be caused by the fact that since the Chinese began attaching a high value to design a wide variety of products can be seen in market. Also, cultural background would be reason for Chinese preference for warm colors, such as red.

Basic and product-specific preferences are correlated with mutual in Japan, the Netherlands, and Vietnam., whereas such trends cannot be seen in China.

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7B - Music

KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Does Architecture affect Acoustic perception in music halls?

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Abstract: Acoustics and architecture are two of the main parameters that influence the quality of a music hall. However, does the user perceive these two factors independently? A good architectural design may affect the perceived acoustic quality and vice-versa?

In this line, the present work aims to determine the conceptual structure employed by the users when evaluating a music hall. This study also pursued analyzing whether architectural variables have an influence on the perceived acoustic quality and vice-versa.

To achieve these goals, a previous research was conducted in 17 venues of the Valencian Region using Semantic Differential within the frame of Kansei Engineering. A sample of 221 users classified as “non-experts” (neither musicians, nor acousticians or architects, nor people related professionally to concert halls) participated in this experience evaluating the architectural and acoustic quality of these venues.

Results showed that, from a conceptual perspective, the users clearly differentiated the acoustic variables from the architectural ones. Nevertheless, it was observed that architecture influenced the perceived acoustic quality and vice-versa. Thus, regression models were obtained and tested to measure the perception of acoustic and architecture quality. These results may be interesting to enable optimization of design features of future music halls.

Keywords: music hall, acoustics, architecture, perception, non-experts.

1. INTRODUCTION

The study of perception in the field of music hall acoustics (opera houses, theatres and venues for classical music and orchestra performances) has been of great interest since many years ago. Physical parameters which determine the acoustic quality of these venues wanted to be identified and measured. Thus, in the early 20's, Sabine research pointed out that reverberation time was the only parameter that represented the acoustic quality of a music hall (Sabine, W. C., 1922). However, later on, researchers realized there were some other parameters which influenced the acoustic perception: Early Decay Time (EDT) (Jordan, V. L.,1981), Initial Time Delay Gap (ITDG) (Beranek, L.L., 1962), Spatial Impression (Schroeder, M.,R., Atal, B., S., Sessler, G., M. & West, J., E., 1966), Clarity Factor C_{50}, C_{80} (Reichardt, W., Abel Alim, O. & Schmidt, W., 1975), Gain Factor (G) (Gilbert Soulodre, A. & John Bradley, S., 1995), Interaural Cross-Correlation (IACC) (Ando, Y., 1983) ... among others.

All this knowledge resulted in a new branch of acoustics: psychoacoustics. This discipline studies the relation between all these physical parameters and the subjective evaluation that they evoke on the listener (intimacy, enveloping sound, clarity, loudness, balance, warmth, etc...). In fact many authors have conducted researches in this field; though particularly important was Leo Beranek (Beranek, L.L., 1962). He highlighted the importance of the feeling of intimacy in a music hall and its influence over the global assessment. After him, many other authors studied and quantified the influence of other acoustic parameters on the listener's perception: influence of Lateral Energy Fraction (LF) on the perception of enveloping sound (Barron, M., 1988); influence of the Clarity Factor C_{80} on the subjective clarity perceived (Fischetti, A., Hemim, Y. & Jouhaneau, J., 1992); influence of the Gain Factor G(A) on the loudness (Gilbert Soulodre, A. & John Bradley, S., 1995); influence of the IACC on the diffusion of sound (Hidaka, T. & Beranek, L.L., 2000); influence of the Speech Transmission Index (STI) on the intelligibility of sound (Farina, A. 2001; Fischetti, A., Hemim, Y. & Jouhaneau, J., 1992; Gilbert Soulodre, A. & John Bradley, S. 1995; Semidor, C. & Barlet, A. 2000), reverberation (Barron, M. 1988; Kürer, R. & Kurze, U. 1968; Sabine, W. C. 1922; Seraphin, H. P. 1958); intimacy (Ando, Y. 1983; Beranek, L.L. 1962; Farina, A. 2001; Hawkes, R.J., Douglas, H. 1971); power (Gilbert Soulodre, A. & John Bradley, S. 1995; Hidaka, T. & Beranek, L.L. 2000; Schroeder, M.R., Gottlob, D. & Siebrasse, K.F. 1974; Wilkens, H. & Lehmann, P. 1980), etc.

All these studies have a common link: listeners' impressions were evaluated through questionnaires and tests. The sample of listeners was composed of experts in some studies (musicians, acousticians, conductors, etc...) (Barron, M. 1988; Beranek, L.L. 1962; Farina, A. 2001; Hidaka, T. & Beranek, L.L. 2000); and non-experts in others (students or usual listeners) (Hawkes, R.J., Douglas, H., 1971; Semidor, C. & Barlet, A. 2000; Wieihwa Chiang & Weichung Wang 2002). However, in all cases the concepts and attributes to evaluate had been set by experts (professional musicians, conductors, acousticians). That is, the mental scheme of non-experts was not taken into account to build the questionnaires. This could led to wrong results since non-experts may misunderstand some of the concept set by the experts, and moreover, as experts filter the information to assess, some of the parameters appreciated by non-experts may not be never evaluated. Besides, several studies have shown that the brain of professional musicians work in a different way from that of the non-musicians (Brandler, S. 2003; Ja-Young Kim & Nicholas J. Belkin 2002; Ohnishi, T., Matsuda, H., Asada, T., Aruga M. 1999; Stefan Koelsch, Eric Schröger & Mari Tervaniemi 1999; Thomas F. Münte, Eckart Altenmüller & Lutz Jäncke 2002).

On the other hand, it is well known that Kansei Engineering is a technique that allows studying the perception of a product based from the user point of view since it may be different from that of

experts (Nagamachi, M. 1989; Nagamachi, M. 1997; Schütte Simon, T. W., Eklund, J., Axelsson Jan, R. C. & Nagamachi, M. 2004). There are many studies which have used this technique to analyse this perception over multitude of products: automotive industry (Jindo, T. & Hirasago, K. 1997; Tanoue, C., Ishizaka, K. & Nagamachi, M. 1997); mobile phones (Chuang, M. C, Chang, C. C. & Hsu, S. H. 2001; Hsu, S.H., Chuang, M.C. & Chang, C.C. 2000); shoes (Alcántara, E., Artacho, M. A., González, J. C. & García, A. C. 2005; Ishihara, S., Ishihara, K., Nagamachi, M. & Matsubara, Y. 1995); beer cans (Ishihara, S., Tsuchiya, T., Nagamachi, M., Ishihara, K. & Nishino, T. 2007); building sector (Llinares, C., Page, A. (2007), etc... and it has been proved that non-experts and experts work with different mental schemes.

Taking all this information as a basis, the authors carried out a previous research in the field of music hall acoustics, using the technique of Differential Semantics (DS) (Osgood, C.E., Suci, C.J. & Tannenbaum, P.H.,1957) within the context of Kansei Engineering (KE), (Galiana, M., Llinares, C., Page A. 2012a; Galiana, M., Llinares, C., Page A. 2012b). Results showed that non-expert users of music halls have a different conceptual structure than expert users, what means that both groups use different cognitive factors to assess music hall acoustics; and therefore their perception is different. Thus, both collectives should be studied in a separate way since the perceptual scheme of one group may be not valid for the other and vice versa.

This led the authors to continue studying in depth the collective of non-experts users, in this case in the area of architectural perception in music halls. Since they are massive users of these venues, more information about this collective wanted to be gathered and analyzed. Thus, the present research proposes to implement KE in the context of music halls as a useful tool to include the “voice” of the user in the whole process from the beginning.

On the other hand, as it has been commented before, music halls have been traditionally studied from the acoustic point of view. Few works have taken into account some architectural parameters (Beranek, L.L. 1962; Hawkes, R.J., Douglas, H. 1971; Semidor, C. & Barlet, A. 2000). However, in no case these parameters have been related in a quantitative way to acoustics perception or connected in a particular way to subjective evaluation of these venues.

In this paper several variables related to the architecture of music halls have been studied, as well as their interaction with acoustics perception. The objective is to analyze and quantify the influence of architecture on the acoustic perception and vice-versa, for non-expert users.

2. MATERIALS AND METHODS

As in the previous research (Galiana, M., Llinares, C., Page A. 2012b), materials and methods follow the same structure: firstly, select a representative sample of subjects composed by non expert users of music halls (neither musicians, nor acousticians, nor professionals related to music halls). Secondly, select a sample of music halls and auditoria across the Comunitat Valenciana (Spain) to be assessed by the subjects according to a set of acoustic and architectural parameters.

2.1. Subjects

Non-expert users of concert halls in different towns and cities of the Comunitat Valenciana were chosen in order to collect a representative sample of subjects. The technique was simple random sampling and users were contacted before the performance at the music hall. Finally, a sample of 221 participants was collected, which had to reply a questionnaire in order to asses a set of subjective parameters related to the acoustics and architecture of the music hall.

2.2. Questionnaire

Three blocks composed each questionnaire. The first block gathered objective information about the subject (gender, age, concerts attended per year, kind of music mostly listened at the music hall and usual location in the venue). The second block contained subjective information about acoustics parameters perception, and the third block the same about architecture. These parameters were expressed by means of a group of 27 acoustic adjectives and 26 architectural expressions in Spanish. The first step to obtain this set of expressions involves collecting as many adjectives as possible (*kansei words*) to describe the product domain (Schütte Simon, T. W., Eklund, J., Axelsson Jan, R. C. & Nagamachi, M. 2004). All available sources must be used to obtain the most comprehensive choice of words: scientific papers, specialized bibliography, acoustic journals, magazines and the internet. The aim of collecting as much adjectives and expressions as possible, was to gather a set of words able to reflect any possible perception about a specific acoustic and architectural attribute of a concert hall. The process finishes when no new words appear. According to (Schütte Simon, T. W., Eklund, J., Axelsson Jan, R. C. & Nagamachi, M. 2004), the final set can vary between 50-600 words depending on the particular field of study. These kansei words form the *initial semantic universe*, which in our case was composed by 162 acoustic adjectives and 259 adjectives related to architecture. However this is a number of words too large to be included in a questionnaire. Hence, it was necessary to reduce the initial number of words and several techniques can be used with this purpose (Schütte, S. 2005). In this study the *Affinity Diagram* was used, which groups the semantic descriptions according to their affinity (Terniko, J., 1997). The grouping was made by 2 professional musicians, 2 acousticians, 2 architects and 2 non-expert users as follows: (a) the kansei words were transferred into post-it notes, so that each note contained only one expression; (b) the notes were grouped by similarity or affinity, the grouping process ended when all the ideas or words were grouped and (c) each group was given a title or heading that represent all the kansei words in the group. The set of expressions finally obtained formed the *reduced semantic universe*, which was composed of 27 adjectives related to acoustics and 26 architectural expressions. These were evaluated by means of a 5 point Likert scale ranging from: totally disagree, disagree, neutral, agree, totally agree.

Additionally, two new variables were included to show the global user opinion from the expression “Considering the whole set of features I think this is a good music hall from the architectural point of view” and idem about acoustics. These parameters were also evaluated through the former Likert scale.

2.3. Stimuli

The stimuli used to carry out the field study consisted of 17 concert halls (opera houses, theatres and venues for classical music and orchestra performances) located in two regions of the Comunitat Valenciana (Spain) with a long musical tradition: Valencia and Alicante. These music halls were selected so as to have a variety of them: large music halls in big cities like Valencia, Alicante, Xàtiva or Gandía and other modest auditoria in smaller towns. In order to increase the variety of the sample of stimuli we also chose music halls of new construction or recently restored and others with long tradition.

These stimuli were: Gran Teatre (Alzira), Teatre Serrano (Gandía), Centre Cultural (Almussafes), Auditori Municipal (Aielo de Malferit), Casa Cultura (Denia), Auditori Molí de Vila (Quart de Poblet), Centre Cultural “El Olivar” (Alaquàs), Auditori de Torrent (Torrente), Casa Cultura (Alfàs del Pi), Sala Tívoli (Burjassot), Gran Teatre (Xàtiva), Casa Cultura (Benifaió), Palau de la Música (Valencia), Palau de les Arts (Altea), Casa Cultura de La Pobla de Vallbona, Centre Social (La Vila

Joiosa) and Teatro Principal (Alicante).

The subjects had to evaluate the acoustics and architecture of the music hall *in situ*, so that they were “immersed” into the stimulus. It was decided to undertake the field study under these conditions instead of doing it in the laboratory because lab conditions cannot represent with 100% reliability the real settings.

Figure 1 shows an example of an auditorium participating in the field study. The most relevant data of each venue was collected:

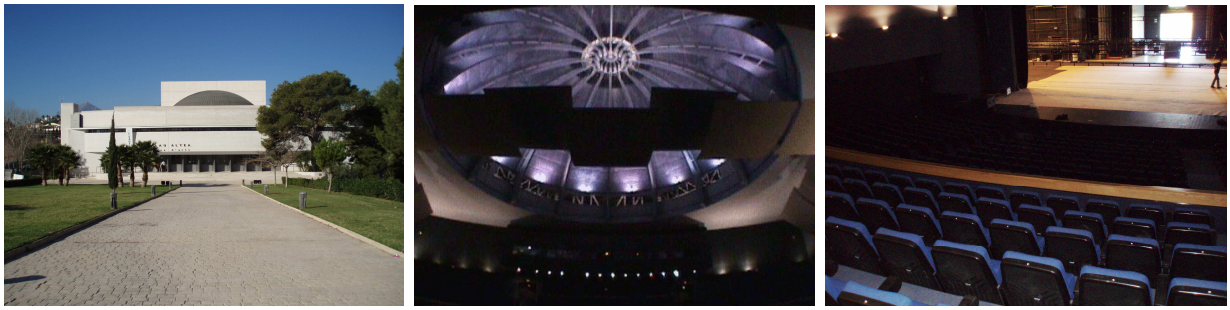

Figure 1: Example of concert hall of the stimuli sample: Palau de les Arts de Altea (Alicante). Capacity: 900 people. Year of construction: 2001.

2.4. Development of the field study

The field study was developed as follows: the subjects participating in the experience were handed a questionnaire before the performance took place. Subjects were informed of the objectives of the study but the questionnaire also included instructions to fulfil it in the correct way. Moreover, participants were asked to respond the questionnaire as soon as the performance had finished so that they had all the stimuli fresh in their minds. In addition, they were told to express their opinions in a spontaneous way to catch their first and truly impressions. Finally, responded questionnaires were gathered all together. Fulfilling the questionnaires took an average time of 15 minutes which was considered a reasonable interval to answer the questions before losing interest.

2.5. Data processing

Data base of answers was statistically processed with specific software: SPSS. 16.0. Then, the following data processing procedure was applied:

In a first step, to determine whether non-experts collective is able to clearly differentiate in their mental scheme the acoustic parameters from architectural ones, a factor analysis was made using the whole set of parameters:

1- Identifying semantic axes. It was necessary to reduce the amount of information to handle, in order to facilitate the next steps. Hence, it was essential to group the set of adjectives into major structures: the semantic axes. These are uncorrelated variables that characterize the perception of a concrete product; a music hall in this study. A combination of adjectives of the original set (acoustic + architecture) composes each axis in a way that these attributes present significant correlations in the users’ responses. The technique used to identify and extract the semantic axes was principal components factor analysis (Basilevsky, A., 1994). Only principal components with eigenvalues greater than one were selected. Then, Varimax rotation was applied to obtain the semantic axes factors.

In the next step, the purpose is to determine whether architectural factors have influence on the acoustics subjective assessment and whether the acoustic factors influence the evaluation of the architecture of the music hall. Thus, it was necessary to calculate two linear regression models.

2- Ranking semantic axes. It was essential to analyse the influence of each axis on the global assessment (acoustics and architecture) since it may be different. The attributes associated to the semantic axes represent common concepts which explain the perceived differences between acoustic properties from the user's point of view and the same for architecture. Therefore, in order to quantify the influence of each axis, linear regression analysis was applied and nonparametric Spearman correlation coefficient between the factor scores and the overall opinion about acoustics and architecture were used to get this ranking.

3. RESULTS

3.1. Identifying semantic axes

At this point the amount of information to handle was still quite large, so it was necessary to condense it. Therefore, the original set of 53 adjectives (27 acoustic + 26 architecture) was reduced by means of factor analysis to 9 uncorrelated factors which explained 61,92% of the variance in the original variables. Table 1 shows these factors, their correlations with the original adjectives and their Cronbach's Alpha coefficient (α), (Cronbach, L. J. 1951). This parameter ensures the internal consistency of the axes for values $\alpha \geq 0.6$.

Table 1: Range of meaning of kansei factor axes and representative terms for non-experts users, with their Cronbach's Alpha coefficient (α)

FACTOR AXES	CORRELATION WITH KANSEI WORDS	VARIANCE EXPLAINED
1- Acoustic quality *($\alpha = 0.91$)*	Harmonious (0.827), Good pitch quality (0.816), Good direct sound (0.777), Balanced (0.743), Clear sound (0.736), Warm (0.714), Homogeneous (0.708), Powerful (0.683), Bright (0.673), With texture (0.668), Wide dynamic range (0.657), Faithful sound (0.638), Natural (0.614), Close (0.602), Enveloping sound (0.449), Dull (-0.577), Weak (-0.556), Distant (-0.477), Resounding (-0.46)	19.09%
2- Architectural quality *($\alpha = 0.90$)*	Well-proportioned (0.742), Practical distribution (0.694), Organized (0.681), Quiet-peaceful (0.635), Wide (0.620), Versatile (0.619), Quality materials (0.581), Good view of stage (0.564), Warm-friendly (0.559), Comfortable (0.486), Light-filled (0.466), Stylish (0.460), Good interior organisation (0.450)	11.81%
3- Original, emblematic *($\alpha = 0.86$)*	Original-different (0.795), Emblematic-prestigious (0.750), Luxurious (0.678), Elegant (0.652), Innovative (0.643), Lively (0.443)	8.94%

4- Good interior organisation *(α = 0.62)*	Good interior circulation (0.712), No background noise perceived (0.534), Formal (0.517)	4.45%
5- "Sad" architecture *(α = 0.72)*	Dark-sad architecture (0.691), Poor (0.532), Dull (0.469),	3.94%
6- Acoustic intimacy *(α = 0.63)*	Intimate sound (0.668), Soft (0.585)	3.80%
7- Classic vs. Modern style *(α = 0.61)*	Classic architecture (0.787), Excessively ornate-baroque (0.548), Modern style (-0.516)	3.74%
8- Bass enhanced *(α = 0.63)*	Bass enhanced (0.799), Resounding (0.428), Dissonant (0.426), Reverberant (0.419)	3.25%
9- Good view of stage *(α = 0.60)*	Good view of stage (0.570), Incomparable framework (0.476)	2.90%

As it can be seen from Table 1:

- 1st axis: it presents a strong correlation with the adjectives: Harmonious (0.827), Good pitch quality (0.816), Good direct sound (0.777), Balanced (0.743), Clear sound (0.736), Warm (0.714), Homogeneous (0.708), Powerful (0.683), Bright (0.673), With texture (0.668), Wide dynamic range (0.657), Faithful sound (0.638), Natural (0.614), Close (0.602), Enveloping sound (0.449); and negative correlation with: Dull (-0.577), Weak (-0.556), Distant (-0.477), Resounding (-0.46). All items included in this factor refer to acoustic features. It has been interpreted as the dimension "*Acoustic quality"* and it is the main axis since it explains 19.09% of the sample variance. Therefore, it is the first attribute identified by the non-experts to discriminate between different music halls.
- 2nd axis: it represents the dimension *"Architectural quality"* and gathers a whole set of attributes related to the architecture of the venues. It shows high positive correlation with the items: Well-proportioned (0.742), Practical distribution (0.694), Organized (0.681), Quiet-peaceful (0.635), Wide (0.620), Versatile (0.619), Quality materials (0.581), Good view of stage (0.564), Warm-friendly (0.559), Comfortable (0.486), Light-filled (0.466), Stylish (0.460) and Good interior organisation (0.450). It explains 11.81% of the variance so it is the second axis in importance to discriminate between different music venues.
- 3rd axis: it also groups adjectives related to architecture: Original-different (0.795), Emblematic-prestigious (0.750), Luxurious (0.678), Elegant (0.652), Innovative (0.643), Lively (0.443). This axis has been interpreted as the dimension *"Original, emblematic"* and explains 8.94% of the sample variability. This may lead to think that users appreciate music halls with some singular features that make it unique and different from the rest of venues.
- 4th axis: it includes the attributes Good interior circulation (0.712), No background noise perceived (0.534) and Formal (0.517). This set of adjectives may be related since if the interior circulation of the venue is well organized, this can reduce the sensation of

background noise, and therefore the architecture is perceived as formal (well-designed). It reflects the dimension *"Good interior organisation"* and explains 4.45% of the variance.

- 5th axis: it represents the dimension *"Sad" architecture* and shows positive correlation with some adjectives with negative meaning: Dark-sad architecture (0.691), Poor (0.532) and Dull (0.469). These are non-desired attributes and this axis explains 3.94% of the sample variance.
- 6th axis: *"Acoustic intimacy".* It groups two adjectives related to acoustics: Intimate sound (0.668) and Soft (0.585). This factor explains 3.80% of the sample variability and reflects the sensation of the user that the performance takes place in a cosy, intimate place.
- 7th axis: *"Classic vs. Modern style".* This factor includes the items: Classic architecture (0.787), Excessively ornate-baroque (0.548), Modern style (-0.516) and it explains 3.74% of the sample variability.
- 8th axis: it presents a positive correlation with several adjectives related to acoustics: Bass enhanced (0.799), Resounding (0.428), Dissonant (0.426), Reverberant (0.419). It has been interpreted as the dimension *"Bass enhanced"* and explains 3.25% of the variance. This may lead to think that non-expert users do not appreciate music halls that present this feature due to the negative connotation of some items.
- 9th axis: it is correlated to two architectural attributes: Good view of stage (0.570), Incomparable framework (0.476); both associated to good visual impression. This axis has been interpreted as the dimension *"Good view of stage"* and explains 2.90% of the sample variability.

These 9 factors represent the semantic space for non-expert users, associated to music hall acoustics and architecture; and they are able to explain almost 62% of the variance in the original variables. This may become a useful tool for quantifying perceived differences among different music halls.

3.2. Ranking semantic axes according to importance in the global assessment

Once the axes have been obtained, the next step is to determine whether factors related to architecture have an impact on the acoustics assessment, and whether acoustic factors affect architectural evaluation. Therefore, the axes obtained previously, were analysed in order to quantify their influence on the overall evaluation. Hence, two linear regression models were obtained for the sample of subjects and the influence of the axes on the overall opinion could be quantified.

3.2.1. Linear regression model for acoustics global assessment

In order to obtain this model, the variable "acoustics global assessment" was taken as the dependent one, while the nine axes obtained before were the independent variables. The linear regression model showed 5 significant factors (s.l.<0.05) while the rest were excluded. The axes "*Acoustic quality"* and *"Architectural quality"* mainly determined the overall evaluation with high positive correlations: 0.750 and 0.329 respectively. Next in importance appeared the axis *"Acoustic intimacy"* with a correlation of 0.199; followed by the axis "*Good interior organisation"* with a load of 0.128. Last, the axis *"Original, emblematic"* contributed with a correlation of 0.100. This analysis showed a high linear correlation coefficient (0.804) which confirmed the power of the model:

{1} *Acoustics Global Assessment = 0.603 + 0.750 (Acoustic quality) + 0.329 (Architectural quality) + 0.199 (Acoustic intimacy) + 0.128 (Good interior organization) + 0.100 (Original, emblematic)*

Observing model {1} it can be noticed that acoustic and architectural factors are taken into account by the non-experts when evaluating the acoustics of a music hall. Logically, the factor with the higher load is related to acoustic quality. However, the influence of architectural factors is not negligible since three out of five factors in the model are related to architecture: *Architectural quality, Good interior organization, Original-emblematic*.

3.2.2. Linear regression model for architectural global assessment

In this case, the variable "architectural global assessment" was taken as the dependent one, and the nine axes worked as independent variables. The linear regression model showed 7 significant factors (s.l.<0.05) while the rest were excluded. This analysis showed a high linear correlation coefficient (0.814) which confirmed the power of the model:

{2} *Architectural Global Assessment = 0.429 + 0.660 (Architectural quality) + 0.343 (Original, emblematic) + 0.337 (Acoustic quality) + 0.192 (Good interior organization) + 0.140 (Good view of stage) + 0.136 (Acoustic intimacy) – 0.107 ("Sad" architecture)*

As it can be seen in model {2}, the factors with higher impact on the assessment of the architecture are: *Architectural quality, Original-emblematic* and *Acoustic quality*, with high positive loads: 0.660, 0.343, 0.337, respectively. It is remarkable that an acoustic factor is the third in importance. Next, it appears the axis "*Good interior organization"* with a correlation of 0.192, followed by "*Good view of stage"* (0.140). Then, another acoustic factor "*Acoustic intimacy"* influences the architectural assessment with a load of 0.136. Last, the axis *"Sad architecture"* contributed with a small negative correlation of -0.107. The negative sign reveals that the absence of this factor was positively appreciated by the collective of non-experts.

4. DISCUSSION OF RESULTS

This paper has attempted to analyze the listener's (non-expert) emotional response to music hall acoustics and architecture. Besides, the purpose was to study the interaction between acoustic and architectural parameters and their influence on the global assessment.

Firstly, the possibility of defining a set of variables which captures non-expert user's perception of music hall acoustics and architecture in his own words was verified using Differential Semantics (DS). Hence, this perception can be expressed through 9 uncorrelated factors obtained by factor analysis; which explained 62% of the variability. These factors (Table 1) are by order of explained variance: 1st *"Acoustic quality"* (19.09%); 2nd *"Architectural quality"* (11.81%); 3rd *"Original, emblematic"* (8.94%); 4th *"Good interior organisation"* (4.45%); 5th *"Sad architecture"* (3.94%), 6th *"Acoustic intimacy"* (3.80%), 7th *"Classic vs. Modern style"* (3.74%), 8th *"Bass enhanced"* (3.25%), 9th *"Good view of stage"* (2.90%). Internal consistency of these axes was ensured by means of Alpha Cronbach coefficient ($\alpha \geq 0.6$). Moreover it was observed that, in general, each factor gathered items related either to acoustics or architecture. This means that the sample of subjects was able to separate in their mental scheme the concepts related to both fields.

On the other hand, the order of these factors gives information about the parameters that this collective use to differentiate one music hall from another. It can be seen form Table 1 that the 1st,

2nd and 3rd axes altogether are able to explain almost 40% of the variability. This means that these are the attributes that non-experts appreciate most to discriminate between different music venues.

Secondly, the influence of architectural parameters on the acoustic assessment and the influence of acoustic parameters on the architectural evaluation wanted to be analyzed. Thus, factors were ordered depending on their influence on the corresponding assessment variable. Two linear regression analysis determined the following results giving the load of each factor (β):

{1}: Factors influencing Acoustics Global Assessment: 1st "*Acoustic quality"* (β:0.750); 2nd *"Architectural quality"* (β:0.329); 3rd *"Acoustic intimacy"* (β:0.199), 4th *"Good interior organization"* (β:0.128) and 5th *"Original, emblematic"* (β:0.100).

{2}: Factors influencing Architectural Global Assessment: 1st "*Architectural quality"* (β:0.660); 2nd *"Original, emblematic"* (β:0.343); 3rd *"Acoustic quality"* (β:0.337), 4th *"Good interior organization"* (β:0.192), 5th *"Good view of the stage"* (β: 0.140), 6th *"Acoustic intimacy"* (β:0.136) and 7th *"Sad architecture"* (β: -0.107). The negative sign means that the absence of this factor was positively appreciated.

The linear correlation coefficients of these models was high (>0.8) which confirmed its power.

It is noteworthy that, in both models, acoustic and architectural factors are present. This means that not only architecture influences the acoustic perception, but also acoustics influences the perception of architecture. Besides, this influence was quantified thanks to the previous models by means of the weights of each factor.

In model {1} it can be seen that two acoustic parameters contribute to the rating of the acoustics (*Acoustic quality* (β:0.750) *and Acoustic intimacy* (β:0.199)*)*. However, a non-expert listener will increase in a positive way his acoustic perception if he/she perceives the music hall as a venue with architectural quality (β:0.329), with a good interior organization (β:0.128), original and emblematic (β:0.100). Therefore, equation {1} shows the importance of this architectural axes and their influence on the acoustics assessment since their weights are relevant for this evaluation. So, if acoustic satisfaction of the users is to be increased, the perception of these architectural factors should be also improved since this will result in a better rating of the overall acoustic impression of the venue.

On the other hand, model {2} shows that several architectural axes contribute to architectural global assessment: "*Architectural quality"* (β:0.660); 2nd *"Original, emblematic"* (β:0.343); 4th *"Good interior organization"* (β: 0.192), 5th *"Good view of the stage"* (β:0.140), 6th and 7th *"Sad architecture"* (β: -0.107). Nevertheless, two factors related to acoustics also influences this perception: *Acoustic quality* (β:0.337) *and Acoustic intimacy* (β:0.136). Therefore, if the user perceives a good acoustic quality and intimate sound sensation, this will have a positive impact on the architectural perception.

Comparing these results with those obtained in previous studies, it can be observed that music hall acoustics have been traditionally rated depending on acoustic parameters exclusively. We can find many studies related to the influence of *"Intimacy"* and *"Power"* on the acoustics evaluation. Beranek, L. (Beranek, L.L. 1962), concluded that *"Intimacy"* contributed up to a 40% of the perceived quality of a music hall. In his study made with expert subjects, the weight of this attribute on the overall assessment was 3 times bigger than the rest of attributes. On the other hand, the present study corroborates that *"Acoustic intimacy"* is also an important factor for non-expert users to evaluate acoustics and architecture, since this axis is present in both regression models. It is the 3rd in importance for its influence on the acoustics assessment (β:0.199) and the 6th in importance

on the architectural global assessment (β:0.136). These results confirm that intimacy is a significant factor for non-expert users but not the main factor as Beranek stated using a sample of experts. Something similar happens with the parameter *"Power"*. This factor, understood as loudness and power of sound, has been considered of great importance for many authors in their research (Gilbert Soulodre, A. & John Bradley, S. 1995; Hidaka, T. & Beranek, L.L. 2000; Schroeder, M.R., Gottlob, D. & Siebrasse, K.F. 1974; Wilkens, H. & Lehmann, P. 1980). Results achieved in the present study show that for non-expert users this is an important item but as a component of a bigger axis, not as a factor itself. It is part of the factor *"Acoustic quality";* 1st in importance on the acoustics assessment and 3rd over the architectural global evaluation.

On the other hand, according to several studies (Barron, M. 1988; Beranek, L.L. 1962; Kürer, R. & Kurze, U. 1968; Sabine, W. C. 1922; Seraphin, H. P. 1958), *"Reverberation"* is the "key factor" for acoustic quality in music halls. However, in the present study this item was part of the factor *"Bass enhanced"* which was excluded from both regression models since it did not have a significant influence on the global assessment (s.l.<0.05), neither acoustics nor architecture. This result is particularly important because it shows that mental scheme of expert and non-expert users are different, since the present study analyzed non-expert users' response while the cited works gathered opinions from expert subjects.

Besides the acoustic aspect, few studies have compiled data related to music halls architecture and its relation to perception has not been quantified or determined in a specific way. Beranek (Beranek, L.L. 1962), gathered a lot of information about materials, decoration, seats, carpets, curtains and main dimensions of different music halls. These parameters were evaluated by him to classify the venues depending on their quality. Later on, Hawkes & Douglas (Hawkes, R.J., Douglas, H., 1971), affirmed that acoustic perception could be influenced by other aspects such as: illumination of the hall, temperature, comfort of the seats and "enjoyment" of the performance. In no case these parameters were quantified, and their influence on the global assessment was neither measured. Another research carried out by Semidor & Barlet (Semidor, C. & Barlet, A. 2000) at the Grand Theatre de Bordeaux analyzed acoustic parameters and the influence of other parameters such as view of the stage, temperature of the hall, space between seats and other aesthetic aspects of the lounge. They concluded that after a good acoustics, the most appreciated parameter was a good view of the stage.

In summary, these works dealt with attributes related to music halls architecture; although they present some drawbacks: the parameters to be studied were exclusively set from an expert point of view, so the user's opinion was removed from the beginning of the process. In addition, architectural attributes were considered as a complementary data to the acoustic information, not giving them a specific importance. Finally, the impact of these architectural parameters on the acoustic assessment was not measured.

On the contrary, results of the present paper show the importance of quantifying the influence of architectural attributes in the acoustic perception as well as consider the influence of acoustics on the architectural assessment. This has been studied in the scope of non-experts users. It must be taken into account that this collective are massive users of music halls; therefore these evaluations and opinions are essential for acousticians, architects and designers since they make it possible to compare a music hall with its competitor; identifying weak and strong points. This is fundamental when defining a future design or restoring strategies for this kind of venues.

5. CONCLUSIONS

In a previous study (Galiana, M., Llinares, C., Page A., 2012a) it was already confirmed that expert and non-expert collectives use different cognitive factors to assess music hall acoustics and therefore their perception is different. In addition, results achieved in this study show some significant implications: at a theoretical level it can be concluded that non-expert users of music halls are likely to have a different mental structure than expert users when evaluating music halls architecture, so its impact on acoustics perception may be different. Thus, both collectives should be studied in a separate way since the perceptual scheme of one group may be not valid for the other and vice versa. Hence, it is essential the fact that the parameters which have been traditionally used to evaluate acoustic and architectural quality of a music hall from an expert point of view (reverberation, intimacy, power, lighting, comfort, etc…), are not perceived in the same way by non-expert users. Thus, it is necessary to implement techniques such as Kansei Engineering in this field so that the "voice" of the user is included in the whole process from the beginning. This make it possible to take into account the acoustic and architectural parameters of his own mental scheme, as a truly and potential variables to be improved.

From the methodological point of view, it is remarkable the application of Differential Semantics (in the context of Kansei Engineering) to evaluate music hall acoustics and architecture through a set of adjectives and expressions provided by non-expert users. Thus, SD is a verbal measurement instrument capable of measuring the subjective component of the emotional state which this collective is able to recognize.

Another significant result has been confirmed: in the context of non-expert users of music halls, architectural parameters have an influence on the acoustic perception and acoustic parameters influence the evaluation of architecture. In addition, these factors have been identified and its contribution to acoustic and architectural assessment has been quantified.

Regarding to limitations, it must be said that the sample of stimuli used in the present study was chosen in order to have a wide range of combination of design elements: large and small concert halls, new and traditional, located in big cities and small towns, etc… However, the sample of stimuli consisted of real music halls so the combination of design elements of each venue was fixed. It represents a limitation since the possible combination of design elements that may influence the acoustics and architecture perception was given by the availability of those combinations in the real "product".

As a final remark, obtaining and analyzing non-experts' affective dimensions which influence the global assessment of music hall acoustics and architecture, is the first phase of Kansei Engineering. With these results, it would be very interesting to identify what design elements in a music hall cause them. This is established for further research. On the other hand, the authors studied in previous research the differences of acoustic perception between expert and non-expert users in music halls (Galiana, M., Llinares, C., Page A. 2012a; Galiana, M., Llinares, C., Page A. 2012b). Following this line of work it would be also interesting to analyze the perception of expert users in the context of music halls architecture, and determine the differences between both collectives.

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BIOGRAPHY

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Attractive Phrase Detection from Musical Lyric Focusing on Linguistic Expressions

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Abstract: This paper describes a method for extracting attractive phrases of lyric focusing on linguistic expressions. Not only chorus but also linguistic expressions seem to be a cause of attractive phrases. We conducted impressive evaluation experiments to clarify the important factors of attraction of phrase. As the result, it was confirmed that “uniqueness of co-occurred terms” and “repetition” especially influenced attraction. Therefore, we modeled the uniqueness of co-occurred terms and repetition as seven mathematical features. And the proposed method detected attractive phrases using support vector machine with the modeled features, which is known as a high performance pattern recognition method. Through the attractive phrase detection experiments, we confirmed availability of the proposed method: the accuracy level and the precision was each 69% and 86%, respectively. Moreover, we discussed about the correctly detected attractive phrases comparing key sentences detected by the existing summarization methods. As the result of the discussions, the proposed method correctly detected the phrases that were ranked in low by the conventional methods though human evaluated the phrases as attractive. From these facts, it was suggested that lyrical linguistic expressions were well modeled in the proposed method, and the proposed method detected the attractive phrases better than the existing summarization method.

Keywords: Music, Lyric, Attractive Phrase, Natural Language Processing.

1. INTRODUCTION

People have been enjoying music since ancient time. Music can be briefly classified into two types: music played with only musical instruments and the one with singing. In music played with only musical instruments, acoustic features, which are tone, rhythm and melody, represent scenery and psychological descriptions. Meanwhile, in music with singing, feelings of lyric writer can be

represented by terms used in lyric. For example, emotions and moods for precious ones and nature have been often written in ancient song as well as pop music. When people listens to song, the acoustic features, lyrical features and combination of the both features influence human impression for the song. Then, some of phrases remain in listener's heart; we defined such a phrase as an attractive phrase. Attractive phrase can be assumed as an index of music, because the attractive phrase is strongly connected with human emotion.

In the most of the existing studies that try to relate music with emotion, acoustic features have been related with emotions (Lu et al., 2006; Yamanishi et al., 2011). Acoustic feature is truly one of the most important factors related with musical impression. However, it is assumed that meanings of term and linguistic expressions also greatly influence human emotion for music with singing. Therefore, we believe that we have to take lyric features in our consideration in order to clarify the relationships between music with singing and emotion. The existing studies about relationships between acoustic features and emotions do not cover lyric features. And, there are few studies focusing on emotion caused by only lyric, though there are some studies about both acoustic and lyrical features (Eric et al., 2009; Mayer & Rauber, 2011).

Chorus, which is a high point of music, is known as an attractive phrase of music, and several existing studies that estimate chorus based on acoustic features have been reported (Goto, 2006). However, naturally enough, attractive phrase is not always chorus. For example, in "Your song" by Elton John, both "I hope you don't mind" that is chorus and "It's a little bit funny this feeling inside" that is the first phrase of the song are known as attractive phrases. It is considered that lyrical features such as linguistic expressions cause attraction of a phrase that is not chorus.

In this paper, we target at Japanese songs, which language is native language for authors, and try to clarify relationships between attractive phrase and linguistic expression in musical lyric. And, we propose attractive phrase detection method focusing linguistic expression especially found in musical lyric. We define a line in musical lyric as a phrase in this paper; hereafter, phrase means line.

2. LINGUISTIC EXPRESSIONS IN LYRIC AND ATTRACTION

Scenery and psychological descriptions that are represented in lyric might influence impressions. Linguistic expressions including repetition of chorus, which are especially observed in musical lyric, impress the phrase on people listening to music. In order to detect attractive phrase from musical lyric, It is considered that the first thing to do is clarification of the features related with impressions of musical lyric; some of the features might be the features often used in natural language processing. However an existing study proposed Japanese lyric writing support system focusing on syllable number and rhyme (Abe & Ito, 2012), it has no mention of relationships between linguistic expressions and attractive phrase in musical lyric.

In the field of natural language processing, summarization is realized by extracting key sentences based on Term Frequency and Inverse Document Frequency: TF-IDF, which shows an important degree of a term in a document. In the existing studies focusing on musical lyric, important terms were extracted from musical lyric based on TF-IDF (Wang et al., 2011; Zaanen & Kanters, 2010). However, TF-IDF covers only term frequency and does not cover lyrical expressions. In order to detect attractive phrase from musical lyric, we consider to have to define lyrical expressions that are not shown in general documents and model the expressions as mathematical features.

2.1. Linguistic expressions in Lyric

The following expressions are described as key factors to make a sentence be lyrical, according to instructional books for writing musical lyric, e.g., lecture book (Ueda, 2010).

- Uniqueness of co-occurred terms;

  Terms that are rarely combined in general document are often combined in musical lyric. Using terms that are uniquely combined in general document, a sentence can be an attractive phrase even though the sentence is semantically unnatural. And, it is considered that the terms that the combination is unique in general document artistically represent scenery and psychological descriptions.

- Repetition;

  Repeated phrase attracts people. Repetition is effectively used in musical lyric; chorus phrase is generally repeated among song, and some terms are often repeated in a phrase. Unnecessary repetition is not shown in general document.

- Analogy;

  Analogy can be categorized into two types: simile and metaphor. Simile means a sentence like "*X* such as Y", and then *Y* is explained using *X.* Metaphor is also a type of analogy, however, term that shows directly analogy (e.g., "such as" and "like") is not used in a sentence. Analogy is often used in musical lyric and makes musical lyric more artistically.

- Characteristic reading;

  Particularly for Japanese musical lyric, lyric writer sometimes gives special reading to Kanji. This is sometimes depended on melody, however, special reading to Kanji provides us with unconventional semantics and makes a phrase be more attractive. Lyric writer adapts four types of character and reading to Kanji in order to well represent feelings of the lyric writer.

- Rhyme;

  Rhyme is a technique often used in musical lyric, and means that same or similar pronunciation is used at given interval. Rhyme makes lyric be rhythmical and comfortable sound.

It is considered that linguistic expressions in musical lyric described above greatly influence impressions. Thus, in order to detect attractive phrase from musical lyric, it is needed to clarify which the linguistic expressions are strongly related with human impressions of musical lyric.

2.2. Relationship between linguistic expressions and attraction

In order to clarify the relationships between impressions and linguistic expressions detailed in section 2.1, we conducted impressive evaluation experiments for Japanese musical lyric. Eight subjects in their twenties read musical lyrics and selected attractive phrase based on their feelings. Then, 10 musical lyrics used in the experiments were randomly selected from top 10 songs in each year's Japanese song sales ranking from 1992 to 2012, that is 200 songs in all. In this experiment, we defined the phrase that more than four subjects evaluated as an attractive phrase as a correct attractive phrase.

Experimenter subjectively analyzed the attractive phrases selected by subjects in the experiment, and the relationships between attractive phrase and linguistic expressions used in musical lyric were discussed. **Table 1** shows ratios that each linguistic expression is related with attractive

Table 1: Ratio of influence of each linguistic expression to attractive phrase (%).

	Uniqueness of Co-occurred terms	Repetition	Analogy	Characteristic reading	Rhyme
Ratio of influence	**23**	**45**	**23**	7	6

phrase. The ratio was calculated as follows; number of phrases that each linguistic expression occurred is divided by number of attractive phrases in a musical lyric.

From **Table 1**, it was suggested that uniqueness of co-occurred terms, repetition and analogy have strong relation with attractive phrase. Therefore, in this paper, we focus on uniqueness of co-occurred terms and repetition, and modeled these linguistic expressions as mathematical features. Here, this paper does not cover analogy because semantic explanation is needed to use analogy as mathematical features.

3. MODELING OF LINGUISTIC EXPRESSIONS

Lyric of song s can be expressed as a sequence of phrase ln, and shown as the following equation.

$$s = ln_1, ln_2, \dots, ln_N, \tag{1}$$

where, N shows the number of all phrases in song s. In this paper, one feature concerning uniqueness of co-occurred terms and six features concerning repetition, which influences attraction of phrases in musical lyric and was detailed in section **2**, are calculated for each $ln_{i \in N}$. Seven-tuple feature set of linguistic expressions for phrase ln_i in song *s*: $Exp^s_{ln_i}$ can be shown as the following equation (2).

$$\begin{aligned} &Exp^s_{ln_i} \\ &= \left(NUqL^s_{ln_i}, RepL^s_{ln_i}, Imp^s_{ln_i}, FRepW^s_{ln_i}, SRepW^s_{ln_i}, TRepW^s_{ln_i}, RPoS^s_{ln_i}\right), \end{aligned} \tag{2}$$

where, $NUqL^s_{ln_i}$ shows a feature concerning uniqueness of co-occurred terms, and the others show features concerning repetition. Calculation of each feature will be detailed in the following subsections.

We use MeCab (Kudo et al., 2004) for morphological analysis. Then, we prepare a dictionary for morphological analysis that entry names in Wikipedia are added as proper noun. In this paper, we combined case-making particle and binding particle with the previous noun, and assumed the combined one as one word. Also, if a conjugated form of a given part-of-speech is imperfective, conjunctive and hypothetical, the part-of-speech is combined with the following part-of-speech and the combined one is assumed as one word. This process is conducted in order to analyze musical lyric in increments of that human recognizes musical lyric.

The target in this paper is Japanese written musical lyric. We would rather not modify the original data, and also would like to provide readability with readers. Thus, examples are shown as the following style; [original Japanese title/phrase] ([romanized spelling Japanese]: [the translation by authors]).

3.1. Uniqueness of co-occurred terms

As conducting morphological analysis of phrase ln_i in song s, independent words are extracted from the phrase and a sequence of independent words of the phrase is generated. Here, we use independent word because it has singularly has semantics. Referring newspaper corpus for one year (100,609 data), which is collected from Mainichi newspaper (Nichigai Associates, 2004). In the

corpus, ordered co-occurrence frequency of independent words id_p and id_{p+1}: $CoOc(id_p, id_{p+1})$ is calculated. It is shown that the lower $CoOc(id_p, id_{p+1})$ is the more ordered combination of id_p and id_{p+1} is unique. Ordered uniqueness of id_p and id_{p+1}: $Uq\ (id_p, id_{p+1})$ can be calculated as the following equation (3).

$$Uq(id_p, id_{p+1}) = \frac{1}{CoOc(id_p, id_{p+1})+1}. \quad (3)$$

Uniqueness of co-occurred terms in phrase ln_i in song s: $UqL^s_{ln_i}$ can be calculated from the following equation (4).

$$UqL^s_{ln_i} = \frac{\sum_p Uq(id_p, id_{p+1})}{NCid^s_{ln_i}-1}, \quad (4)$$

where, $NCid^s_{ln_i}$ shows the number of independent words in phrase ln_i in song s. Note, however, that $UqL^s_{ln_i} = 0$ when $NCid^s_{ln_i} \leq 1$.

Range of UqL_{ln_i} greatly differs depending on theme addressed in each song. Therefore, normalized UqL_{ln_i} for each song s: $NUqL_{ln_i}$ is calculated according to the following equation (5). In this paper, we used $NUqL^s_{ln_i}$ as a feature concerning uniqueness of co-occurred terms of phrase ln_i in song s.

$$NUqL^s_{ln_i} = \frac{UqL^s_{ln_i}}{\sum_i UqL^s_{ln_i}}. \quad (5)$$

3.2. Repetition

In this paper, we represent repetition of musical lyric as the following four features: “repetition of phrase,” “string repeated among phrases,” “repetition of word in a phrase” and “number of kinds of morpheme in a phrase.”

3.2.1. Repetition of phrase

In this subsection, phrase that is repeated in a song is modeled. Phrase that is repeated in a musical lyric accounts for large portion of the musical lyric. In song s consisted of N phrases, the portion that a phrase accounts for: $RepL^s_{ln_i}$ can be calculated as the following equation (6).

$$RepL^s_{ln_i} = \frac{\sum_{j\ (j\neq i)} EqL^s_i}{N}, \quad (6)$$

where, EqL^s_i shows the number of phrase that is in absolute agreement with the phrase ln_i. For example, in musical lyric of “ひまわり (*Himawari*: Sunflower)” by 遊助 (*Yusuke)*, “青い空と雲 (*Aoi sora to kumo*: Blue sky and cloud)” is occurred at the first phrase for the first time. This phrase is occurred for 4 times in all the song, thus $EpL_1 = 4$.

3.2.2. String repeated among phrases

In this subsection, string that is repeated among phrases is modeled; this feature shows the importance of string in a phrase for all phrases in the song. The importance of string in phrase ln_i in song s consisted of N phrases: $Imp^s_{ln_i}$ can be calculated as the following equation (7).

$$Imp^s_{ln_i} = \frac{\sum_{j\ (j\neq i)} ComL_{ln_i, ln_j}}{N}, \quad (7)$$

where, $ComL_{ln_i, ln_j}$ shows the portion that terms occurred in both ln_i and ln_j account for in phrase ln_i, and is calculated as the following equation (8).

$$ComL_{ln_i, ln_j} = \frac{2 * EqTerm_{ln_i, ln_j}}{NTerm_{ln_i}+NTerm_{ln_j}}, \quad (8)$$

where, $EqTerm_{ln_i,ln_j}$ shows the number of words that occurred in both phase ln_i and ln_j, and $NTerm_{ln_i}$ and $NTerm_{ln_j}$ each shows the number of words in phase ln_i and ln_j, respectively.

For example, in musical lyric of "ありがとう (*Arigato*u: Thank you)" by いきものがかり (*Ikimono gakari*), the first phrase is " 'ありがとう'って伝えたくて あなたを見つめるけど ('*Arigatou' tte tsutaetakute anata wo mitsumeru kedo*: I stare at you to tell my thanks, but…)" and the 21th phrase is " '愛してる'って伝えたくて あなたに伝えたくて ('*Aisiteru' tte tsutaetakute anata ni tsutaetakute:* I want to tell you 'I love you,' I want to tell you)." In the two phrases, "って (tte)," "伝えたくて (tsutaetakute)" and "あなた (anata)" are common, thus $EqTerm_{ln_1,ln_{21}} = 3$. And, the number of words is each 7 and 6 in the 1st and 21th phrase, respectively: $NTern_{ln_1} = 7$ and $NTern_{ln_{21}} = 6$. Therefore, it can be calculated that $ComL_{ln_i,ln_j} = 0.462$ according to equation (8).

3.2.3. Repetition of word in a phrase

The repetition of word in a given phrase is modeled in this subsection. The word frequency of word w_k in phrase ln_i in song s: $RepW^s_{ln_i,w_k}$, which is normalized by the number of term in the phrase: NT_{ln_i}, can be calculated as the following equation (9).

$$RepW^s_{ln_i,w_k} = \frac{Freq^{ln_i}_{w_k} - 1}{NT_{ln_i}}. \quad (9)$$

For each phrase ln_i, the top three words that have high $RepW^s_{ln_i,w_k}$ are selected, and then the three feature values are assumed as the features concerning the repetition of word of phrase ln_i: $FRepW^s_{ln_i}$, $SRepW^s_{ln_i}$, and $TRepW^s_{ln_i}$.

For example, in musical lyric of "And I love you" by Mr. Children, the 33th phrase is "未来がまた一つ ほらまた一つ (*Mirai ga mata hitotsu hora mata hitotsu*: A future again, here a future again)." In this phrase, $NT_{ln_{31}} = 6$ (note, "が (*ga)*" is just a postpositional particle and not assumed as word in this paper), and "また (*mata*)" and "一つ (*hitotsu*)" are occurred for 2 times. Thus, the features concerning repetition of word in the phrase can be calculated as $FRepW_{ln_{33}} = 0.167$, $SRepW_{ln_{33}} = 0.167$ and $TRepW_{ln_{33}} = 0$.

3.2.4. Number of kinds of morpheme in a phrase

Relation between numbers of morpheme and kinds of morpheme in phrase: $RPoS^s_{ln_i}$ is calculated as the feature concerning repetition of morpheme in a phrase. $RPoS^s_{ln_i}$ is calculated as the following equation (10).

$$RoP^s_{ln_i} = \frac{VPoS^s_{ln_i}}{NPoS^s_{ln_i}}, \quad (10)$$

where, $NPoS^s_{ln_i}$ and $VPoS^s_{ln_i}$ each shows number of morphemes and kinds of morpheme in phrase ln_i in song s, respectively. It means that the lower $RPoS^s_{ln_i}$ is the more repeated morpheme in phrase ln_i.

4. EVALUATION EXPERIMENTS

In order to verify the availability of the proposed method, we conducted evaluation experiment to detect attractive phrases from musical lyric. At first, we conducted subjective evaluation

Table 2: The result of attractive phrase detection experiment (%).

	Accuracy	Precision	Recall
Values	69	86	25

experiments in order to obtain human affective evaluations about phrases in musical lyric.

Relationships between the proposed linguistic expressions in musical lyric and human affective evaluation obtained through the subjective evaluation experiment were leaned, and then attractive phrases were detected by the proposed method.

4.1. Subjective evaluation aquirement experiments

20 participants in their twenties read lyrics of 50 songs and evaluated each phrase whether the phrase was attractive or not. The songs used in the experiment were randomly selected from the top 10 songs in each year's Japanese song sales ranking from 1992 to 2012, that is 200 songs in all. Here, the songs used in the experiment were not included in the songs used in the impressive evaluation experiment detailed in subsection 2.2. In this paper, the phrase that more than five participants evaluated as an attractive phrase was assumed as correct attractive phrase. Then, 504 phrases were evaluated as correct attractive phrases in all 1493 phrases.

4.2. Attractive phrase detection experiments

In this paper, we used support vector machine (SVM), which is known as a classifier that has high performance for two classes classification. We calculated seven-tuple features $Exp^{s}_{ln_i}$, which is linguistic expressions modeled for musical lyric and shown as equation (2), for each phrase of 50 songs prepared for the experiment. The relationships between the calculated features and human affective evaluation were learned using SVM. Then, we used "SVM light" (Joachims, 2008) as SVM tool, and radial basis function was used as kernel function. We conducted five-fold cross validation and verified the availability of the proposed method.

Table 2 shows the result of the attractive phrase detection experiment: average of the results of five-fold cross validation. From **Table 2**, it was confirmed that the attractive phrases were detected for 69% accuracy. And, it was confirmed that the precision was 86%, thus the phrases detected by the proposed method were largely the correct attractive phrases. Meanwhile, the recall was 25% and it can not be said as good result but is considered as natural. From the result of preliminary experiment shown in **Table 1**, it was confirmed that the level that uniqueness of co-occurred terms and repetition influence human attraction, which were modeled as mathematical features in this paper, was each at the highest 23% and 45%, respectively. Considering these facts, we believe that the proposed method achieved an adequate level of recall.

4.3. Discussions about the results comparing with existing summarization methods

In this subsection, we discuss about the detected result while comparing with the key sentences detected by conventional summarization methods that are made for natural documents. We use "Panoramic view system" (Sunayama & Yachida, 2005) and "*Hinata* System" (Nishihara & Sunayama, 2011) as the conventional methods, and phrases in a musical lyric are ranked by the conventional methods based on the importance of the phrases.

4.3.1. Conventional methods and the points for discussion

Panoramic view system is a system for extracting key sentences with discovering keywords featuring a document. The system does not impose a limitation about length, genre and field of a document to be summarized. From a document to be summarized, the system extracts high frequency noun, verb and adjective as keywords that show a theme and the related words with the

keywords as keywords that show feature. The system ranks sentences in a document based on the importance of keywords.

Hinata System is a system for visualizing texts using light and shadow based on topic relevance ("*Hinata*" means sunny place in Japanese). The system assumes a set of nouns in a title as a topic of a document, and calculates the relevance to the topic for each sentence. The system visualize texts that have high relevance to the topic as light, and the ones that have low relevance to the topic as shadow. In *Hinata* system, as reading lines in a document, the words co-occurred with the topic are dynamically added into a set of the related words with the topic. That is to say, sentences in a latter part of a document have more related words with the topic for calculating importance, thus the sentence in the latter part of a document tends to be evaluated as more important.

The difference between the proposed method and the two conventional summarization methods can be marshaled as the following three points: 1. The proposed method covers the uniqueness of co-occurred terms. 2. Repetition of word in a phrase is expressly modeled in the proposed method. 3. The proposed method absolutely evaluate a phrase whether the one is attractive or not, while the conventional methods rank all phrase in a lyric. Focusing on these points, we discuss about the attractive phrases correctly detected by the proposed method.

4.3.2. Comparison of results between the proposed and conventional methods

We consider that uniqueness of co-occurred terms was effective through the discussions about the detected results. The proposed method correctly detected "ほろり・ほろり ふたりぼっち (*Horori Horori futari bocchi*: shed, shed, we two are in loneliness)" as an attractive phrase from "もらい泣き (*Morai naki*: cry in sympathy)" by 一青窈 (Yo Hitoto). In this phrase, "ふたりぼっち (*futari bocchi*: we two are in loneliness)" was generally unused in natural Japanese document and conversation; instead of the phrase, we generally use "ひとりぼっち (*hitori bocchi*: I am in loneliness)." Therefore, the combination of "ふたり (*futari:* two)" and "ぼっち (*bocchi*: loneliness)" was unique. It was considered that the proposed method realized to well model uniqueness of co-occurred terms, thus this phrase was correctly detected by the proposed method. Meanwhile, the conventional methods do not cover uniqueness of co-occurred terms at all, and ranked this phrase in low; panoramic view system and *Hinata* system each ranked this phrase as 23th and 15th in all 40 phrases of the song, respectively.

Also, the proposed method realized to well detect attractive phrases in which a given term was repeated in the phrase better than the conventional methods. For example, the phrase: "人生 人生 人生 夢で生きてる (*Jinsei jinsei jinsei yume de ikiteru*: Life, life, life, we live with dream)" in "羞恥心 (*Shuchishin*: Shame)" by 羞恥心 (Shuchishin) was subjectively evaluated as an attractive phrase and correctly detected as an attractive phrase by the proposed method. Meanwhile, panoramic view system and *Hinata* system each ranked this phrase as 23th and 18th in all 42 phrases, respectively. Thus, this phrase should be not included in a summary generated by the two conventional methods though the one is attractive for human. Likewise, from "宙船 (*Sorafune*: Spaceship)" by TOKIO, "何の試験の時間なんだ 何を裁く秤なんだ (*Nan no shaken no jikan nanda Nani wo sabaku hakari nanda*: Is this the time for any examination? What is judged by the scale?)" and "何を狙って付き合うんだ 何が船を動かすんだ (*Nani wo neratte tsukiaunnda Nani ga fune wo ugokasunnda*: What is the target of the relation? What is the power source of the ship?) were also subjectively evaluated as attractive phrases and correctly detected as attractive phrases by the proposed method though these phrases evaluated in low rank by the two conventional methods.

5. CONCLUSIONS

In this paper, we proposed attractive phrase detection method focusing on linguistic expressions of musical lyric. In musical lyric, characteristic expressions that are rarely used in general document are used. Such linguistic expressions enrich affective and scenery descriptions, and make musical lyric be artistically. We conducted affective evaluation experiment as preliminary experiment, and clarified the relationships between linguistic expressions characteristically used in musical lyric and attraction; “uniqueness of co-occurred terms” and “repetition” highly influenced human attraction. And, we modeled the two types of linguistic expressions as seven-tuple mathematical features, and conducted attractive phrase detection experiment using the modeled features with SVM.

As the result of the detection experiment, the attractive phrases were detected for 69% accuracy and 86% precision, and the availability of the proposed method was confirmed. Through the discussions about the detected results comparing with the existing summarization methods, it was suggested that the proposed method realized to detect attractive phrase that has uniqueness of co-occurred terms and repetition of terms in a phrase better than the conventional methods. We believe that linguistic expressions that are especially occurred in musical lyric were well modeled in the proposed method, thus the attractive phrases were well detected by the proposed method.

In this paper, we showed examples in Japanese and conducted experiments for Japanese musical lyrics, however, the linguistic expressions modeled in this paper can be calculated regardless of language. And, we consider that the linguistic expressions in musical lyrics are often common also in other languages. Therefore, it is expected that the proposed method can be applied to other languages. The followings can be considered as the directions for future research.

- Using a corpus of lyrical expressions;
  In this paper, a newspaper corpus was referred to calculate uniqueness of co-occurred terms in general documents. The uniqueness of co-occurred terms in musical lyric would be possible to be evaluated by using a corpus of musical lyric. Then, the attraction of phrase will become to be evaluated referring two different domains: newspaper and musical lyric. We believe that this improvement would increase the performance on attractive phrase detection.

- Covering a variety of expressions in Japanese;
  One meaning has so many varieties of expressions in Japanese, and it causes an issue specific to Japanese. For example, the first person is shown as only “I” in English, however, the one is shown as “私 (*watashi*),” “僕 (*boku*),” and so on in Japanese. Moreover, 3 types of character are generally used in Japanese: *Hiragana*, *Katakana* and *Kanji*. Thus, “あなた (*anata*)” can be also expressed as “アナタ (*anata*),” “貴方 (*anata*)” and other *Kanji*. We consider that the attraction of a phrase differs depending on the used terms and its character even though the massage in the phrase is same.

- Introduction of semantic relations among terms;
  In musical lyric, semantically similar and distant relative terms are often used in a phrase. For example, using both “like” and “love” in a same phrase, semantic and affective contrast can be generated. We would model sematic relations among terms, and improve linguistic expressions model for attractive phrase detection.

We will address the above issues and improve the attractive phrase detection method. Moreover, we will develop a songwriter support system that evaluates whether a given lyric is attractive or not as an application of the proposed method.

ACKNOWLEDGMENTS

This paper referred some phrases in Japanese lyric as an example, for which we are most appreciative.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Psychological responses to sound stimuli

Joint consideration of AAE model and CV model

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Abstract: Psychological evaluation remains an important problem. Among the current objective methods, Anterior Asymmetry and Emotion model (AAE model) is widely accepted as a trait-related and state dependent measure. However, other inconsistent results suggested that the AAE model is more likely to reflect the motivational direction than the affective valence. Combination with another index to provide more credible evaluation is being considered. Comfort Vector model (CV model) proposed by Yoshida uses the characteristic of the frontal alpha wave fluctuations to evaluate the mood states from affective valence and arousal dimensions. In the present study, we evaluated the psychological responses to two kinds of sound (scary and soothing) in a group of eighteen healthy graduate students by AAE model as well as CV model. Then we discuss the relation between the results of these two models.

Keywords: AAE model, alpha wave fluctuation, Comfort Vector model, sound stimulus.

1. INTRODUCTION

Emotion includes a series of completed psychophysiological responses in the interaction with external stimuli or circumstances both in conscious and unconscious processes. Although various attempts in previous studies have been made to evaluate the psychological states, the objective evaluation still remains an important problem.

Because the psychological response is a substantial process occurring in the central nervous system, the electroencephalogram (EEG) which reflects these electrical activities could be used as the appropriate indices. The Anterior Asymmetry and Emotion model (AAE model) which uses the asymmetrical cortex activity between the left- and right-sided frontal lobes in the emotional experience and behavioral expression is widely accepted as a reliable index (Ahern & Schwartz,

1985; Davidson & Hugdahl, 1996; Hofmann, 2007; Jacobs & Snyder, 1996; Schmidt & Hanslmayr, 2009; Sutton & Davidson, 2000; Tomarken et al., 1992; Wheeler et al., 1993). According to the AAE model, the left frontal cortex is involved in the approach-related behavior and positive affect, while the right frontal cortex is involved in the withdrawal behavior and negative affect. However, the inconsistent result suggested that the frontal asymmetry is more likely to reflect the motivational direction rather than the affective valence if the motivation is not in accordance with the affective valence for some emotion (e.g., anger is approach-related but negative emotion) (Harmon-Jones & Allen, 1998). For a reliable evaluation, we consider that the combination use with other indices that mainly focus on capturing affective state become necessary.

Yoshida (2002) proposed a comfort vector model which is to use the frontal alpha-wave fluctuation to evaluate the mental mood from affective valence and arousal dimensions. 1/f fluctuation has been found in most natural events, like the birdsongs and the murmur of river. And the classic music which follows the 1/f fluctuation characteristic could reduce the negative mood (Levitin et al., 2012; Gough, 2000). Yoshida suggested that if the 1/f fluctuation characteristic is observed in the bio-physical rhythms, the individual is experiencing a positive mood state, otherwise is negative.

Based on the results of a great number of samples, Yoshida suggested the relation between the slopes of the alpha fluctuation power spectra and the emotional experience. The left prefrontal lobe is related to the affective valence, while the right is to the arousal (Yoshida & Iwaki, 2000). This method is to use the characteristic of the alpha-wave fluctuation in the left and right prefrontal lobes to estimate the psychological states as a point in a circle surface (Comfort Vector surface). This surface is comprised of two orthogonal axes: the affective valence and arousal.

In a previous study, we suggested the validity of CV model for evaluating the affective states (Chen et al., 2013). In this present study, we aim to investigate the psychological responses to sound stimuli by using the combination of AAE model and CV model, and discuss their correlation.

2. EXPERIMENT

2.1. Subjects

Subjects were 18 healthy university students, aged from 20 to 24. They were asked to have enough sleep before the experiment day, and to refrain from intense exercises, tobacco, coffee and alcohol.

2.2. Stimuli

Two kinds of affective sound clips were used in the experiment. One was a 5 minute “scary sound (including woman scream, gasping respiration, zombie scream)” which was selected to tense the body and elicit negative affect. The other soothing stimulus was a 5 minute classical music excerpt extracted from Pachelbel’s Canon which was selected to elicit the positive affect.

2.3. EEG recording and processing

EEG was recorded according to the international 10-20 system from 19 referenced channels (Fp1,Fp2,F3,F4,C3,C4,P3,P4,O1,O2,F7,F8,T3,T4,T5,T6,Fz,Cz,Pz) linked to ear lobes, with ground electrode attached to the glabella. Data were digitized at 1 kHz (0.05-100 Hz). The impedances at frontal lobes: Fp1, Fp2, F3, F4 which were the main analysis positions in the study, were kept less than 5kΩ. A bipolar vertical electrooculogram (EOG) was recorded from supra- and infra-orbital positions of the right eye. After all the electrodes were attached, subjects were instructed to initially

rest in a sitting position in a sound-dampened chamber. For each stimulus, EEG was recorded during twenty-five minute period, including ten minutes baseline, five minutes one stimulus presentation, and ten minutes recovery periods. After ten minutes break, the same EEG recording was carried for the other stimulus. During the whole EEG recording periods, subjects were instructed to maintain the eye-closed state to prevent the influence of eye-blinks.

The left- and right-sided alpha power (8Hz~13Hz) was calculated by the Fast Fourier Transform method (FFT method). Power values were then log-transformed, and the alpha power asymmetry values were calculated by subtracting left-sided alpha power from right –sided alpha power (ln(Right) – ln(Left)). Because the alpha power is inversely related to the cortical activation, positive values indicate relatively greater left frontal activity, while negative values indicate relatively greater right frontal activity.

3. METHOD

Comfort Vector model (CV model). We described the procedure to calculate the comfort vector in our previous study (Chen et al., 2013). Firstly, the recorded EEG data from Fp1 and Fp2 was passed through a band-pass filter (8Hz~13Hz) where the alpha-wave component was extracted. Next, we transformed the alpha wave into a time series of frequency fluctuation by zero-crossing method. Then the spectral power density of alpha fluctuation was calculated every twenty seconds. We took the frequency where the spectra changed most significantly for the inflection point. According to the inflection point, the spectra were divided into two part, lower frequency band field and higher frequency band field. The absolute slope obtained through regression curves of the lower frequency spectra in the left- and right-prefrontal lobe was used for the indicator of affective valence and arousal, respectively. Slope value approaching to 1 at Fp1 indicates more pleasant while approaching to 0 indicates more unpleasant. Slope value at Fp2 approaching to 1 indicates more calm while approaching to 0 indicates more excited.

The comfort vector is shown in algorithm (1), (2): where Fp1_slope and the Fp2_slope are the absolute values of slopes of regression lines of alpha fluctuation power spectra recorded at Fp1 and Fp2, respectively. The vector represents a point on the comfort surface shown in Figure 1. The surface consists of two orthogonal axes, pleasant-unpleasant and excited-calm, which makes four quadrants. The angle (θ) of the vector which is measured counterclockwise from the x-axis corresponds to the emotion valence while the length (*L*) of the vector which is the distance from the center represents the strength of comfort. One point shows the mood state of 20-second interval.

$$\theta = A\tan\left(\frac{Fp1\_slope - 0.5}{0.5 - Fp2\_slope}\right) \times \frac{180}{\pi} \quad (1)$$

$$L = 100 \times \sqrt{\frac{Fp1\_slope^2 + Fp2\_slope^2}{2}} \quad (2)$$

In the present study, we treated the upper half surface (the first and the second quadrants) as the pleasant filed while the lower one as unpleasant field, and the left half surface as clam field while the right side as excited (Figure 2). To quantify the mood states, we calculated the ratios of points lying in these respective fields as the indices of psychological states.

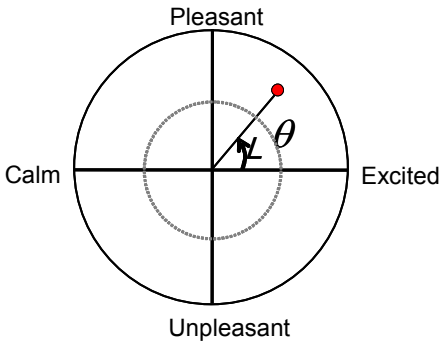

Figure 1: Comfort Vector surface

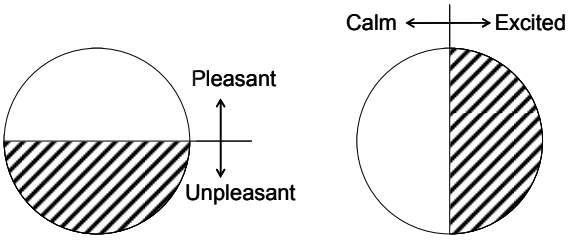

Figure 2: Classification of mood states

Table 1: Changes in frontal asymmetry in response to scary sound

Group	Baseline	Sound	Recovery	Subjects
I	-0.06 (0.04)	-0.14 (0.08)	-0.08 (0.04)	A,B,C,H,J,Q
II	-0.08 (0.07)	0.04 (0.01)	0.02 (0.08)	E,F,G
III	0.09 (0.08)	0.05 (0.08)	0.08 (0.08)	D,K,L,M,N,O,P,R,T

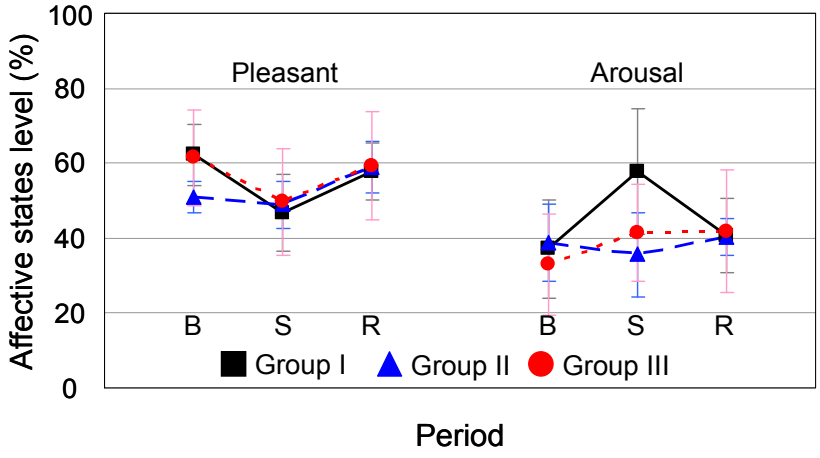

Figure 3 Changes in affective states (pleasant and arousal) to scary stimulus evaluated by CV model (B: Baseline; S: Sound presentation; R: Recovery)

4. RESULTS

In this present paper, we mainly focus on showing and discussing the results of the AAE model and CV model of the scary sound stimulus. And discuss the results of the soothing sound stimulus at the final section. The results of AAE model and CV model in response to the scary sound are shown in Table 1 and Figure 3.

As shown in Table 1, subjects were divided into three different groups (Group I, II, and III) according to their baseline frontal asymmetry and their sound stimulus-elicited changes. Six subjects who had negative values of frontal asymmetry at baseline displayed more negative values in response to the stimulus (Group I). Three subjects in Group II had negative values at baseline and showed positive values while listening to the scary sound. And Group III had positive values at baseline while presented the decrease in these values during the sound presentation period.

To discuss the relation between AAE model and CV model, we investigated and compared the results of CV model among Group I, II and III. Figure 3 shows the pleasant and arousal states of these three groups at baseline, sound presentation, and recovery periods. Indices for pleasant and arousal states of CV model were the ratios of the number of the points located in the upper and right part of the CV surface (Figure 2) for three different periods (baseline, sound presentation and recovery).

As shown in Figure 3, these subjects in Group I and III who displayed decreased values in frontal asymmetry (AAE model) showed significant decrease in the pleasant affective states and increase in the arousal (more excited affective states), compared to baseline (Group I: ΔPleasant = -15.56%, $t(5)=-2.51, p<0.05$, ΔExcited=20.55%, $t(5)=2.29$, $p<0.05$; Group III: ΔPleasant=-11.85%, $t(8)=-2.33, p<0.05$, ΔExcited=8.52%, $t(8)=2.55, p<0.05$). During the resting period after the stimulus presentation, the pleasant affective states of these two groups recovered to the baseline level. While these subjects in Group II who displayed positive values of frontal asymmetry (AAE) showed non-significant changes neither in pleasant nor arousal states.

5. DISCUSSION

In this study, we investigated the psychological responses to two kinds of sound stimuli by using AAE model and CV model. However, the significant results were only observed for the scary stimulus. Group I as well as III showed significant decrease in their asymmetry values as well as the pleasant level. Their arousal level in sound presentation period also increased compared to baseline. From these results, it seems that this scary stimulus aroused pronounced withdrawal motivation (relatively increased right frontal activation), more negative mood and more cautiousness in these subjects. This result is consistent with a previous study suggesting that we react more significantly to the negative stimuli compared with the positive stimuli, perhaps as a consequence of evolutionary pressures to avoid harm (Davidson et al., 2000). Group II displayed non-significant change in affective state while listening to the scary sound. According to the opponent-process theory (Kline et al., 2007), affective and motivational states are modulated by two opposing processes: the initial reaction to stimuli and a compensatory process which tends to regulate the affective states. According to the result of the CV model, subjects in Group II did not express so much negative affect or withdrawal motivation in response to the scary sound stimulus. For this reason, the initial reaction which is related to the right frontal activation (negative affect and withdrawal-related motivation) in this case disappeared early while the opposite regulatory process became dominant, thereby leading to greater relative activation on the left frontal side (Davidson,

2004). From the results above, we considered that there was a correlation between the AAE model and CV model for scary stimulus.

Nevertheless, no correlation was observed for the soothing sound stimulus. These subjects who showed the similar changed patterns of their affective states (CV model) displayed different change direction of frontal asymmetry (AAE model). Some subjects showed increased positive affect as well as frontal asymmetry. This pleasure in classical music may activate the rewarding system of the brain (Salimpoor et al., 2009), which is considered to be related to greater left frontal activation. However, some other subjects displayed increased pleasant affect but decreased frontal asymmetry. According to a previous study (Davidson, 1998), not all positive affects are related to left frontal activation, only those accompanied by goal-pursuit motivation. Some other positive affective states, such as relaxation, calm and other post-goal affects may inhibit the approach-related behavior, i.e., appeared withdrawal behavior. The difference between these two kinds of pleasure might be distinguished by jointing the AAE model and CV model. The joint consideration would evaluate the psychological states from affective valence as well as motivation dimensions, thereby may provide the multifaceted evaluation.

Although the 'Pachebel's Cannon' which was used as the soothing stimulus is generally considered as a pleasant sound, nevertheless, the positive affects were not necessarily elicited in all subjects in the present study. Salimpoor et al. (2009) suggested that, music emotions are based on aesthetic stimuli, and do not have an obvious adaptive or survival value, thereby the emotional experience of music would not be universally similar, but depends on personal preference and previous experience. Also, the affective states while listening to music may be affected by some external factors such as the listening environment. These effects are highly individualized, and are thereby difficult to estimate. More significant result would have be expected if we could use some simple but distinct stimuli with positive valence, such as laughing sounds, or select the proper stimuli according to personal preference.

ACKNOWLEDGMENTS

We would like to thank all subjects who volunteered in this study and our colleagues in the laboratory for technical assistance.

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BIOGRAPHY

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7D - Packaging

Cognition and Product Design Features of Emotional Branding

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Abstract: Companies try to employ shapes that are both emotionally appealing and compatible with the brand's image of aesthetics in generating favorable consumer responses. Existing research on branding and product design have demonstrated the importance of emotions. Consumers may base their evaluations of a brand extension on their subjective affective reactions toward the products. In this research, the authors choose products from the emotional branding survey to be the stimulus samples for investigating the product design features. The purpose of this study is to discover the relationship between the brand and the product, and to generate specific guidelines for a product's emotional design characteristics (Attractiveness, Beauty and Creativity) in the future. There were three steps in this study. They are listed as follows: The first step involves the selection of sixteen brands from fifty public brands by the experts to survey brand awareness. The second step was finding the five tops emotionally appealing brands from the above sixteen brands through a consumer survey to understand brand preferences. The third step was finding products from the four tops emotionally appealing brands to analyze the product design features. The findings are listed as follows: (a) Most of the emotionally appealing brands have over 50 years of brand history. (b) Emotionally appealing brands benefit more strongly from user recommendations and repurchase. (c) Product design features of emotional brand are the following: attractiveness, beauty and creativity. The results from this study can provide a guide for future product design development endeavors and growth of an aesthetic economy.

Keywords: Emotional Branding, Product Design, Emotional design characteristics.

1. INTRODUCTION

Most people choose one global brand over another because of brand awareness and global brand competition. Nowadays, the current trend and future challenges in the market include consumers paying more attention to the impression given by the products. Therefore, a product's emotional design characteristics (attractiveness, beauty and creativity) and brand effect are as important. Due to the growth of e-commerce, many obscure brands rose to fame from the packaging design and high quality of their products. As Holt, Quelch, and Taylor (2004) summarized in their review of experimental studies, global branding has lost more luster recently because transnational companies have been under virtual siege. Market research companies offer studies on the love consumers feel for brands (Pawle & Cooper, 2006). Based on previous researches, this study aims to investigate what the consumers considered about the interaction between a product's emotional design and brand emotion. The authors have attempted to explore the role of emotion in a brand and product design through emotion and subjective evaluation experiments. To explore this issue objectively, real cases offered a deeper understanding. The purpose of this study is to investigate the following research questions:

(a) What are the emotionally appealing brand features?

(b) What are the emotionally appealing brand's product emotional design features?

(c) What is the relationship between a brand and an emotionally appealing product?

2. LITERATURE REVIEW

2.1. Emotional design

Are attractive or beautiful products more effective in terms of use than others? As Tractinsky (1997) summarized in his review of experimental studies that there was a very high correlation between perceived aesthetics of the interface and a priori perceived ease of use of the system. It additionally confirmed that there is something really attractive about being easy to use, and this sentiment is a positive emotion. The Ministry of Economic Affairs in Taiwan promotes the Qualia plan of Small and Medium Enterprises which integrates both cultural and creative product characteristics. "Qualia" includes five elements; attractiveness, beauty, creativity, delicacy and engineering. The plan proposes that enterprises make the value-addition to the product from Qualia in order to make the consumer experience the products' value (Lin, D.-G., 2012). McLoone et al. (2012) proposed that a successful product design meets or exceeds the emotional needs of users, beyond utility and quality. Integrating "feeling" into products to present the emotional communication of user experiences has become a design trend in the 21st century. As a result, "design for feeling" has become the key factor for innovative products (Ko, Lin, & Lin, 2009). As American design expert, Norman (2004), stated, affective/emotional factors are the ultimate determiner of the success or failure of product design. Therefore, a good product is a craft which exercises a discourse with people through its sensation evoking image and brings inspiration to them. The appearance attributes together provide the consumer with an overall impression of the product. Further, they are more actionable and informative than physical properties for designers to use in briefings or product evaluation studies which can be used to assess if consumers do actually perceive the meanings that the designer intended to convey using appearance attributes (Blijlevens, Creusen, & Schoormans, 2009). Sense of difference lies in the qualia and quality is qualia including attractiveness, beauty and creativity rendered in the product's external features.

2.2. Emotional brand

Rahinel and Redden (2013) found instead that people enjoy products with matching brand labels more than those with mismatching brand labels. Marketing research has been concerned about the attitude of consumers toward a brand such as liking or disliking. Gobé (2007) proposed that in this post-modern consumer democracy, people can't operate in a vacuum. Brands need to show their emotional side. Roberts first proposed the concept of brand love in 2005, and this topic has been getting increased attention (Roberts, 2005). Bergkvist and Bech-Larsen (2010) also proposed brand loyalty and active engagements as outcomes of brand love. Brand love includes passion for the brand, attachment to the brand, positive evaluation of the brand, positive emotion in response to the brand, and declarations of love for the brand. Brand love is a positive brand emotion, covering brand loyalty. Therefore, brand love is also a need to create a functional, symbolic and experiential value, which belongs to consumer awareness. (Park, Jaworski, & MacInnis, 1986)。The authors drew conclusions based on the literature review and provided motivation for the current study.

3. METHODS

The experiment of this study is composed of three stages. The first step was the selection of sixteen brands from fifty public brands by experts to survey brand awareness. The second step was finding the five tops emotional brands from the above sixteen brands through a consumer survey to understand brand preferences. The third step was finding products from the four tops emotionally appealing brands to analyze the product design features.

3.1. First step

The writers asked 10 specialists who were not involved in the main study to evaluate 1 out of 50 products on a scale that ranged from 1 ("highly unfavorable") to 7 ("highly favorable") and to report their subjective feelings toward the products on a scale that ranged from 1 ("very bad") to 7 ("very good"). Alba and Hutchinson (1987) suggested that increasing familiarity with a brand might create a better knowledge structure. Sheth, Mittal, and Newman (1999) proposed that brand familiarity was the experience of a consumer product (or service) purchase, consumption and information obtained. This study integrated the two perspectives to build the attribute assessments of the brand familiarity questionnaire, and with this questionnaire identified consumers who are familiar with the brand (shown in Table1).

Table 1: Attribute assessments of the brand familiarity questionnaire survey

Attribute assessments	
familiarity	I am familiar with this brand.
understanding	I understand this brand.
experience	I bought or used the products of this brand.

(Alba & Hutchinson, 1987; Sheth et al., 1999)

3.2. Second step

The authors asked 118 students from the Chinese Culture University to evaluate 2 out of 16 brands on a scale that ranged from 1 ("highly unfavorable") to 7 ("highly favorable") and to report their subjective feelings toward the brands on a scale that ranged from 1 ("very bad") to 7 ("very

good"). Carroll and Ahuvia (2006) proposed brand love of the consumers as an overwhelming emotion attribution to a particular brand, which including: attachment, positive emotion, passion. Brand love has positive brand feelings, covering brand loyalty. This study integrated the two perspectives to build the attribute assessments of the brand emotion questionnaire, and with this questionnaire identified consumer's feelings toward the brand (shown in Table2).

Table 2: Attribute assessments of the brand emotion questionnaire survey

Attribute assessments	
repurchase	I will continue to buy the products of this brand.
recommend	This is a good brand, and I would recommend it to other people.
attachment	This brand is my first choice when buying related products.
positive emotion	My love for this brand is incomparable to the other brand.
passion	This brand is very appealing to me.

(Carroll & Ahuvia, 2006)

3.3. Third step

The authors asked 109 undergraduates from the second step to evaluate 3 out of 20 products on a scale that ranged from 1 ("highly unfavorable") to 7 ("highly favorable") and to report their subjective feelings toward the products on a scale that ranged from 1 ("very bad") to 7 ("very good"). Attribute assessments of the brand familiarity questionnaire are shown in Table 3.

Table 3: Attribute assessments of the product emotional design characteristics questionnaire survey

Attribute assessments	
attractiveness	This product can convey cultural meaning.
	This product can impress people.
	This product has a fashion sense.
beauty	This product looks perfect proportion.
	This product has a sense of design.
	This product has pleasing appearance.
creativity	This product is a creative product.
	This product has a story.
	This product has a clever use of materials.

(Adapted from Lin, D.-G., 2012)

4. RESULTS AND DISCUSSION

4.1. Experiments 1

After 10 specialists have made their choice of brands, the result is the sixteen tops brands. The sixteen tops brands are shown in Figure 1. 3C and electronic brands are shown in blue bars; household brands are shown in orange bars, and the sports brand is shown in green bar.

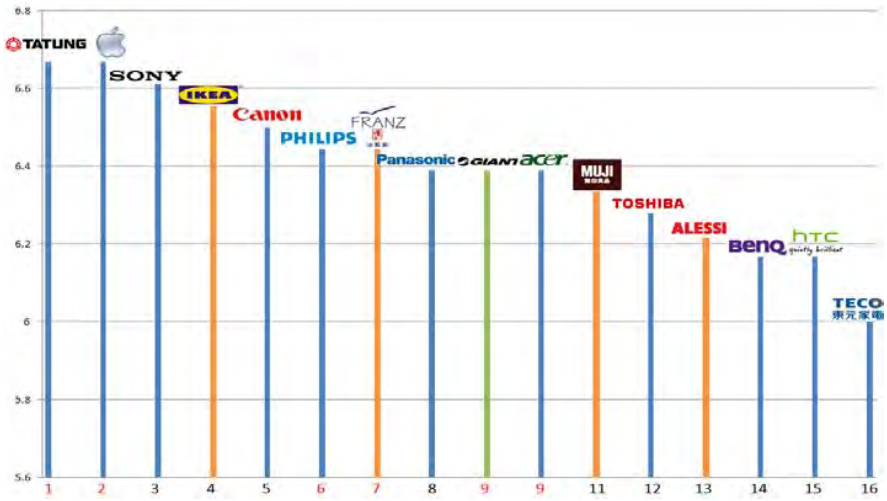


Figure 1: The sixteen tops brands from brand familiarity questionnaire survey

4.2. Experiments 2

Following the result of experiment 1, 118 students from the Chinese Culture University were asked to evaluate 2 out of 16 brands on a scale. The resulting data is the ten tops brands (shown in Figure 2). The four tops brands are MUJI, APPLE, IKEA and SONY. 3C and electronic brands are shown in blue bars; household brands are shown in orange bars. The finding is that most of the emotionally appealing brands have over 50 years of brand history.

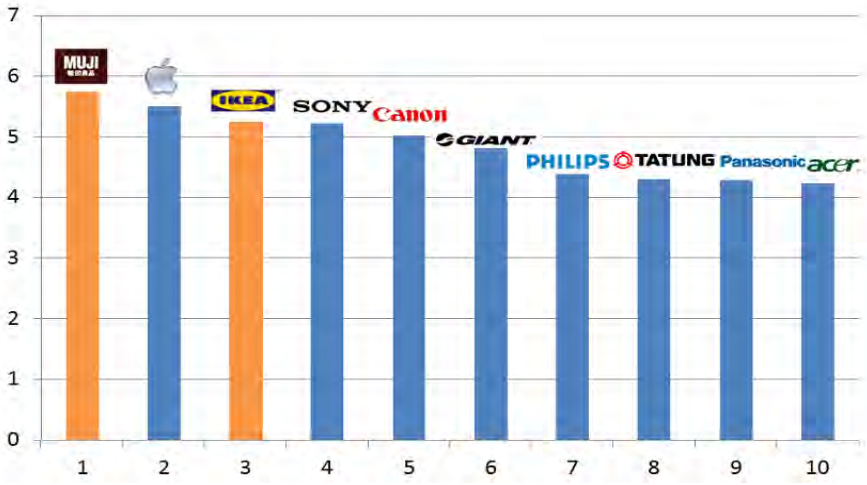
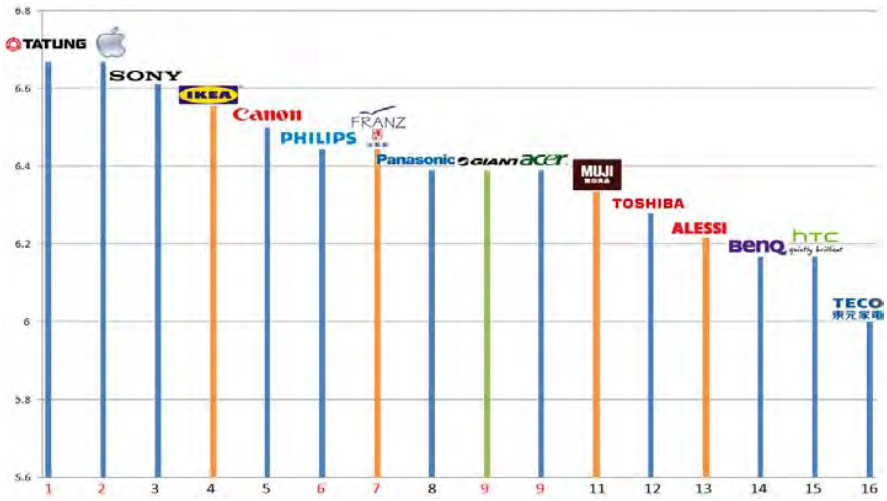


Figure 2: The ten tops brands from the brand emotion questionnaire survey

Table 4: Brand emotional score from the brand emotion questionnaire survey

Code	Brand	repurchase	recommend	attachment	positive emotion	passion
2	APPLE	5.24	5.42	4.99	4.75	5.42
4	MUJI	5.82	5.87	5.03	4.83	5.39
5	IKEA	5.20	5.32	4.76	4.43	4.90
7	SONY	4.97	5.20	4.38	4.14	4.55



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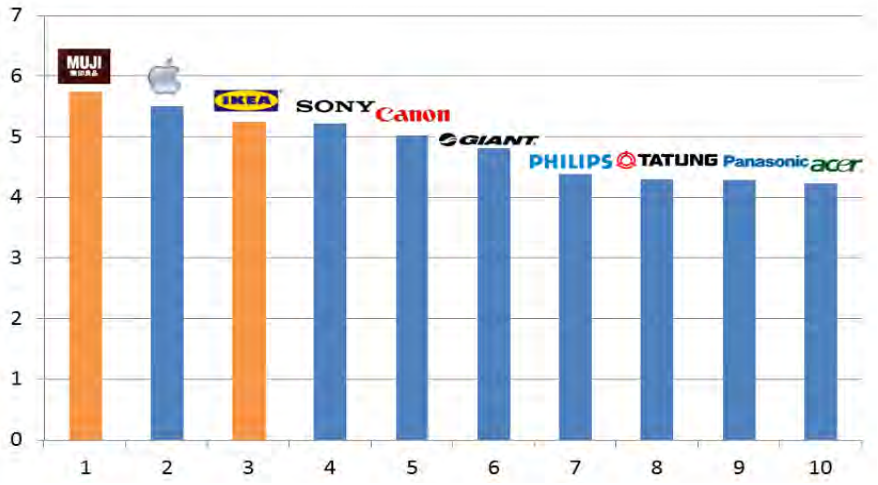

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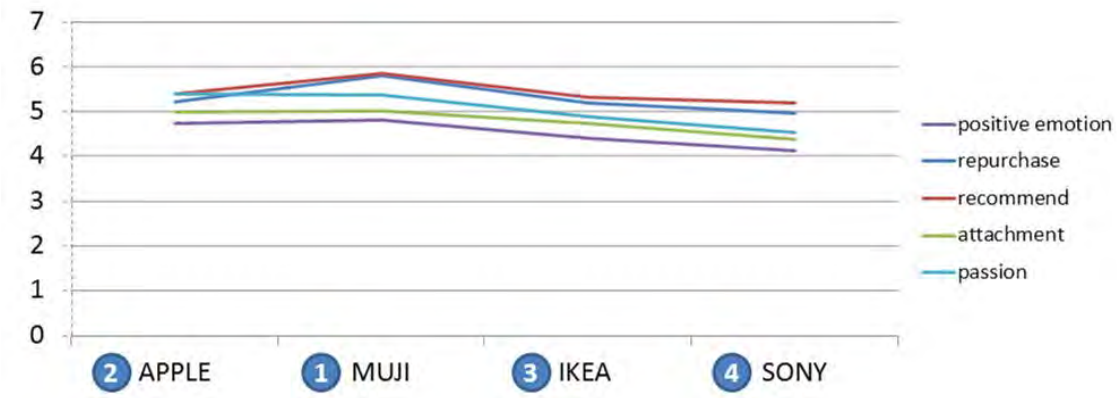

Figure 3: Brand emotional line chart from the brand emotion questionnaire survey

The finding is that emotionally appealing brands benefit more strongly from the user recommendation and repurchase. Overall brand emotion is significant in order to recommend more than repurchase, repurchase more than be passionate about it, passion greater than the attachment, and attachment greater than positive emotion.

4.3. Experiments 3

Following the result of experiment 2, the writers selected 20 products from the four tops brands, and 109 undergraduates from the second step were asked to evaluate 3 out of 20 products on a scale. These products currently sell products with higher visibility.Through the product emotional design characteristics questionnaire survey, the average value was 4 points or more of product attractiveness, product beauty and product creativity of emotional brands. The result is shown in Table 5 and Figure 4.

Table 5: The average value obtained from the product emotional design characteristics questionnaire survey

Code	Brand	Product	attractiveness	beauty	creativity
1	APPLE	iPhone	5.68	6.07	5.45
2		MacBook Air	5.60	6.19	5.46
3		iPod shuffle	4.88	5.26	4.84
4		iPad Air	5.32	5.92	5.20
5		iPod classic	4.95	5.31	4.83
6	MUJI	Wall Mounted CD Player	4.89	5.63	4.72
7		Beech wood Clock	4.63	5.02	4.55
8		Ultrasonic fragrance spray	4.63	5.14	4.57
9		Taxi Watch	4.16	4.38	4.38
10		Lightweight folding portable speaker	4.08	4.22	4.24
11	IKEA	SKOVEL Wall clock	4.42	4.48	4.36
12		STOCKHOLM Vase	4.71	4.90	4.69
13		PS 2012 LED Wall lamp	4.94	5.24	4.95

14		SKURAR Pillar candle lamp holder	4.47	4.78	4.50
15		HURRIG Mug	4.32	4.74	4.47
16		Xperia Z1	4.80	5.27	4.65
17		Bluetooth Speaker Ball	4.62	4.91	4.62
18	SONY	Sony DSC-QX 10	4.96	5.06	5.10
19		VAIO® Duo 13	4.59	4.94	4.81
20		Bass headphones	4.45	4.87	4.42

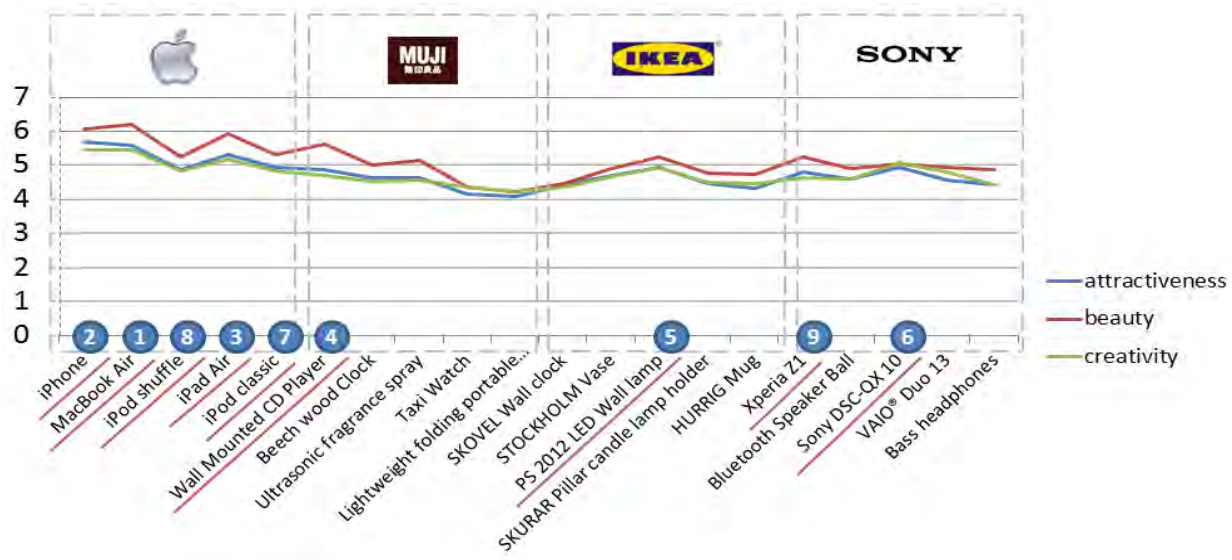

Figure 4: Design characteristics line chart from the product emotional design characteristics questionnaire

The finding is that the product design features of an emotionally appealing brand include product attractiveness, product beauty and product creativity characteristics, especially in the beauty products section. Apple products are in the three tops of all brands, and the three tops products are the most popular products amongst the young people. The top four product is from MUJI, and the top five product is from IKEA. Here we also found more than half of the ten tops products are 3C products. Daily life products have the potentials for product creativity, and IKEA is better than MUJI.

The above findings confirm the past studies. Product aesthetics may stimulate positive and pleasant sensory responses, arouse emotional feelings/expression and create symbolic meanings (Rahman, 2012). Therefore, the interface of product aesthetics gives people a sense of beauty and impression; it also encourages people to consume and collect (Yen, Lin, & Lin, 2013)

5. CONCLUSIONS AND FUTURE WORK SUGGESTIONS

There are three findings suggested by this paper. First: most of the emotionally appealing brands have over 50 years of brand history, so brands need to be in business for the long-term; the new brand must continue to insist on branding and product emotional design. Second: consumer's direct emotional expression toward the brand is action, so consumer's repurchase and recommendation of emotionally appealing brands are important for new products. Third: product design should enhance product creativity and product attractiveness of the emotionally appealing

brands; and the emotionally appealing brands should collaborate with young designers to inspire more creativity. The results from this study can provide a guide for future product design development endeavors and growth of an aesthetic economy.

From the perspective of emerging brands, the product design of emerging brands in addition to paying attention to product attractiveness, beauty, creativity and balanced development in all aspects, can enhance brand image and brand emotion. Product design of emerging brands achieve high standards of product attractiveness, beauty and creativity, and influence the outcome as to whether it will cause the consumers to repurchase, recommend, be attached, have a positive emotion and passion towards it, which will have to be discussed in future in-depth studies on the matter.

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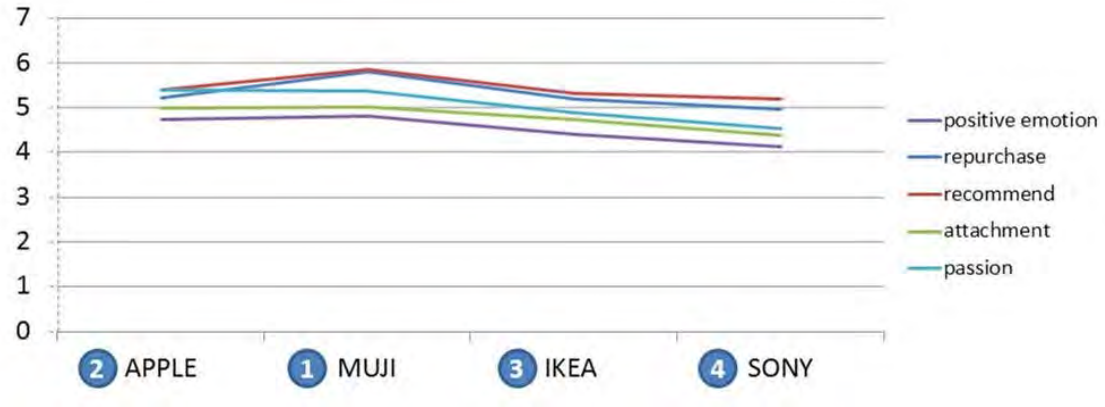

Figure 3: Brand emotional line chart from the brand emotion questionnaire survey

The finding is that emotionally appealing brands benefit more strongly from the user recommendation and repurchase. Overall brand emotion is significant in order to recommend more than repurchase, repurchase more than be passionate about it, passion greater than the attachment, and attachment greater than positive emotion.

4.3. Experiments 3

Following the result of experiment 2, the writers selected 20 products from the four tops brands, and 109 undergraduates from the second step were asked to evaluate 3 out of 20 products on a scale. These products currently sell products with higher visibility.Through the product emotional design characteristics questionnaire survey, the average value was 4 points or more of product attractiveness, product beauty and product creativity of emotional brands. The result is shown in Table 5 and Figure 4.

Table 5: The average value obtained from the product emotional design characteristics questionnaire survey

Code	Brand	Product	attractiveness	beauty	creativity
1	APPLE	iPhone	5.68	6.07	5.45
2		MacBook Air	5.60	6.19	5.46
3		iPod shuffle	4.88	5.26	4.84
4		iPad Air	5.32	5.92	5.20
5		iPod classic	4.95	5.31	4.83
6	MUJI	Wall Mounted CD Player	4.89	5.63	4.72
7		Beech wood Clock	4.63	5.02	4.55
8		Ultrasonic fragrance spray	4.63	5.14	4.57
9		Taxi Watch	4.16	4.38	4.38
10		Lightweight folding portable speaker	4.08	4.22	4.24
11	IKEA	SKOVEL Wall clock	4.42	4.48	4.36
12		STOCKHOLM Vase	4.71	4.90	4.69
13		PS 2012 LED Wall lamp	4.94	5.24	4.95

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Kansei Engineering Approach for Consumer's Perception of the Ketchup Sauce Bottle

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Abstract: Day by day, consumers look into more high quality products to choose and pay more attention to details such as sensual value. To fulfill this essential requirement of consumers, it will be necessary to progressively develop new products with dual nature addressing both functional and emotional needs. Kansei engineering is a successful methodology for gathering and analyzing the relations between consumers' impressions and products' properties. In Iranian food market, different food products with huge variety in type, taste, shape, size, packaging, and so on are available to consumers. A different approach to include consumers' desire and feel is highly appreciated in Iranian food business. Such a strategy will be developed to fulfill customers' feelings in order to attract them to purchase the food product. In Iran ketchup sauce are so much popular. Therefore, ketchup sauce bottle has been selected as a case in current study. 31 Kansei words and 8 different types of sauce bottles with different shapes and function were selected. All experiments were conducted in city of Tehran and 47 people participated in the study, comprising 23 men and 24 women in ages ranging from 20 to 50 years old. 5-point semantic differential scale was considered to determine the relations between products' features and adjectives. The data were analyzed using SPSS software by multivariate statistical techniques such as factor analysis. The expected results and findings can provide a reference to make decisions on the properties of developing new products, which has great impact on future studies.

Keywords: Kansei Engineering, Semantic Differential Method, Factor Analysis, Sauce Bottle, Packaging Design.

1. INTRODUCTION

Todays the product development is shifted from product oriented strategy to consumer oriented

strategy, the consumer's psychological feeling and needs are recognized more invaluable in product development than ever before [Nagamachi, 2002, Norman, 2008]. The affective product design is aimed at determining the relationships between consumers and products and to define the emotive properties that products intend to communicate through their physical attributes [Jiao et. al., 2006]. At present, many product development theories based on consumer were described. Kansei Engineering techniques support affective product design by linking the customer needs mathematically to the technical characteristics of the product [Nagamachi, 2002]. The term Kansei is defined as ‘‘a Japanese word which implies a customer's psychological feeling and image regarding a new product'' [Nagamachi 1997]. Kansei engineering is, foremost, a product development methodology [Harada1998], but Schütte et al. [2004] also shows how it is possible to use it as an improvement tool for existing products or concepts. Also Schütte [2005] in his paper described the concept of Kansei as closely connected to affective, emotional values of human beings. In the theory of Kansei engineering, the relation of design elements and image word is important and the element is drawn out from the product design to analyze, each element will be discussed. In the design process, because the product properties and all aspects of design elements involve the human subjective feeling, there is no certain standard to judge the correctness of the design and whether the proposal meets the users' feeling. Therefore, this research quantifies users' perceptual cognition with the theories of Kansei engineering technology [Haykin, 2004]. Many studies have proven that Kansei engineering works very well in the engineering field [koleini and Tojoddini, 2010]. Kansei engineering is a comprehensive human-centered technology for developing new products and it has been widely used in automobile, construction machine, electric home appliance, house construction, costume, textile industries clothing fields, packaging and so on [Lu et. al., 2008].

In food business as well as other market sectors, variety of added values by design can be observed. For example, in Iranian food market, different food products with huge variety in type, taste, shape, size, packaging and so on are available to consumers. Among them, sauces, and particularly ketchup sauce, are so much popular. This has made sauce making industry a very lucrative business. Consequently, an endless variety of sauce bottles are seen in Iran food market. Obviously, in this area of design, packaging plays an essential role both in production of needs and attraction of consumers. Normal packaging design concentrates on protection, preservation and distribution of contents. That mostly will cause over focus on packaging content rather than packaging consumers. Therefore, a different approach to include consumers' desire and feel is highly appreciated in Iranian food business. Such a strategy will be developed to fulfill customers' feelings and emotions in order to attract them to purchase the food product. Having this in mind, the purpose of the current study is an attempt to use Kansei engineering to connect the product parameters of the ketchup sauce bottle to the affective values.

2. METHODOLOGY OF KANSEI ENGINEERING

The most usual methodology of Kansei Engineering includes an evaluation experiment followed by statistical analysis of the obtained data. In summary, the implementation involves three steps included: first step- selection of Kansei words, collecting and choosing adjectives, second step- the Kansei evaluation experiment, which is a subjective evaluation of customer perceptions of various products and product samples using a questionnaire that contains Kansei words, and third step- statistical analyses of data from the evaluation experiment. If we know what combination of the product properties results in a high score among the descriptive words, we should be able to

produce a guideline for emotional interface design of the new product.

2.1. Kansei measurement process

Since Kansei is the state of consumer's internal sensation, the measurement process can be very challenging. Kansei Engineering provides diverse method to measure consumer's sensation, in particular biological signals such as brain waves by electroencephalogram (EEG signal), muscular activity measurement by electromyography (EMG signal), eye movement and subjective evaluation or self-reporting system such as different emotional scale, semantic differential scale or free labeling system. In the field of subjective evaluation and in specific to measure consumer's emotion, mainly words that describe the emotional expression have been used.

2.2. Semantic differential method

A popular scaling device for the quantification of subjective consumer's emotion is the semantic differential method developed by Osgood [1957]. The purpose of the semantic differentials technique is to supply a quantitative support that allows having an objective measurement of a product psychological meaning to a customer. This requires descriptive scales with adjectives to establish the similarity or discrepancy degree among the various issues. The semantic differential usually takes the form of a 5- or 7-point scale. In this study, a five point semantic differential was employed. Five point scales are commonly used in consumer research, mainly because researchers suspect these scales tend to be more easily understood by respondents than scoring systems using more points. Figure 1 shows the Kansei checklist developed was organized in a 5-point semantic differential scale and consists of 31 Kansei words.

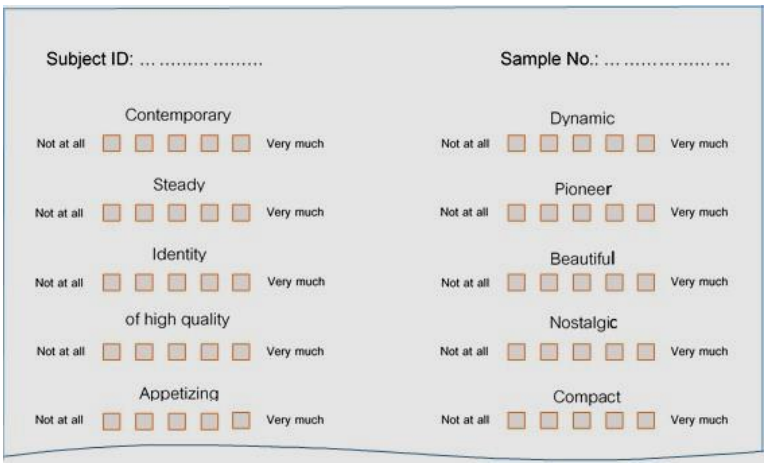

Figure 1: The sample Kansei checklist

2.3. Product samples

From comparison among all types of products from the company and other makers, samples are collected. Then 8 different types of sauce bottles in term of the feeling that they evoke, with different shapes and functions were used to map properties from within the product domain. These product samples belonged to seven different food products companies. Figure 2 shows collected used samples in this study.



Figure 2: Eight sauce ketchup bottle samples used in the Kansei experiment after selection

2.4. Participants

All experiments were conducted in city of Tehran, Iran and 47 people participated in the study, comprising 23 men and 24 women in ages ranging from 20 to 50 years old. Subjects were asked to answer questioners based on their feelings about each of the samples which placed in front of the subject and has been operationally tested.

2.5. Data analysis

In general, the average value of the Kansei responses for each samples are well distributed where the values are above and below the value three, which is the neutral response point. This indicates that subject's Kansei are well distributed to both negative and positive value. Statistical procedures using mathematical and nonmathematical methods have been developed for use in Kansei studies [Nagamachi, 2001], however the use depends on the context. On the other hand, in order to give a concrete support to designers, Kansei engineering needs integration with quality and statistical tools [Nagamachi and Matsubara, 1997]. When a large amount of variables is simultaneously collected, the interest may be to determine how the answers of a study may be grouped. To this aim, compared to the other techniques such as variance analysis or multiple regression, factor analysis has the advantage that all the involved variables play the same role. This analysis method is a statistical data reduction technique employed to explain variability among observed random variables, in terms of fewer unobserved random variables named factors. This reduction is possible because the attributes are related. Applying a factor analysis to the collected responses on a given questionnaire, it is possible to group responses with common meaning, reducing the number of required indicators to explain all the responses. The rating given to any one attribute is partially the result of the influence of other attributes. The observed variables are modeled as linear combinations of the factors. Its proper application implies the interrelation analysis between variables (using statistical covariance and correlations) to determine a new smaller set of variables than the original set [Santesmases, 1997]. It should be noted that the reduction is possible without the loss of an important part of the reliability in the original data.

3. RESULTS AND DISCUSSION

In this study to reveal the reliability and effectiveness of questionnaire survey, reliability analysis is conducted. A high value of reliability coefficient means the questionnaire survey is stable, namely, the consistency of survey results conducted in different durations. The Cronbach's alpha of the Kansei checklist was calculated to measure the internal consistency. The analysis yielded an overall Cronbach's alpha value of 0.948, which is higher than the common benchmark value of 0.7.

This confirms the reliability of the Kansei checklist. The participants' Kansei responses were then computed to determine the average response and the range for each sample. Using factor analysis the number of semantic adjectives is reduced and also categorized. To confirm if exploratory factor analysis is a suitable statistical technique to analyze our data, the Kaiser-Meyer-Olkin (KMO) measure of sample adequacy and Bartlett's Test of sphericity has been used (Table 1). The value of KMO statistic was 0,950, which means that the sample size is suitable for factor analysis. Sheskin [2007] refers that KMO statistic should be 0.6 or greater. Bartlett's Test has a p-value less than 0, 0001 showing that there are significant bivariate correlations between some of the variables.

Table 1: Kaiser-Meyer-Olkin and Bartlett's Test

KMO Measure		0.9500
Bartlett's Test	Approx. Chi-Square	6034.813
	df	465
	Sig.	0.0000

Using factor analysis in order to find psychological structure of Kansei space, the detail of Kansei space were investigated with average value of evaluation results. Table 2 only shows first five component result of factor analysis after varimax rotation. Varimax, which was developed by Kaiser [1958], is the most popular rotation method that simplifies the interpretation of variables. This is because, after a varimax rotation, each original variable tends to be associated with one of factors, and each factor represents only a small number of variables. In addition, the factors can often be interpreted from the opposition of few variables with positive loadings to few variables with negative loadings.

Table 2: Contribution and cumulative contribution table

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	13.538	43.672	43.672	6.887	22.215	22.215
2	1.557	5.023	48.694	3.88	12.516	34.731
3	1.416	4.568	53.262	3.73	12.033	46.764
4	1.193	3.847	57.109	3.118	10.058	56.822
5	1.132	3.65	60.759	1.221	3.938	60.759

In Table 2, it is evident that the first factor explains 43.672% of the data which represents majority of main factor contribution and have dominant effect on Kansei words. The second, third, fourth, and fifth factor explains 5.023%, 4.568%, 3.847%, and 3.650% of the data, respectively. The first factors alone represent 43.672% of the variability while four factors explain 60.759% of the variability. Inclusion of the forth factor is deemed considerable, and therefore the first five factors could explain most of the data. The proportion of variability explained by the sixth factor and above is minimal (3.077, 2.871, 2.779, etc., respectively) and they can be eliminated as being insignificant. The following table shows partial result of factor analysis in ascending order.

Table 3: The Factor loading of the 29 adjective using five factors

	Adjectives	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
13	Attractive	**0.733**	0.24	0.241	0.225	-0.012
5	Beautiful	**0.722**	0.159	0.386	0.111	0.065
17	Stimulator	**0.673**	0.329	0.107	0.147	-0.097
19	Hearty	**0.658**	0.369	0.228	0.21	0.049
3	Pioneer	**0.634**	0.2	0.316	0.222	-0.004
25	Funny	**0.625**	0.292	0.061	0.329	-0.109
31	Enlivening	**0.615**	0.262	0.087	0.4	-0.053
2	Contemporary	**0.612**	-0.109	0.339	0.384	-0.007
1	Dynamic	**0.602**	0.252	0.333	0.236	0.046
27	Encourager	**0.591**	0.383	0.161	0.381	0.02
23	Friendly	**0.597**	0.456	0.137	0.168	0.012
15	Delicious	**0.568**	0.52	0.152	0.026	0.078
22	Formal	**0.554**	0.102	0.455	-0.019	-0.082
10	Appetizing	**0.553**	0.326	0.268	0.341	0.02
16	Fresh	**0.521**	0.103	0.377	0.349	-0.139
6	Identity	0.191	**0.742**	0.127	0.208	-0.012
7	Nostalgic	0.206	**0.692**	0.106	-0.004	-0.045
14	Truthful	0.282	**0.659**	0.296	0.216	0.036
28	Dependency	0.379	**0.498**	0.217	0.114	-0.18
8	High quality	0.239	**0.485**	0.351	0.436	0.088
12	Communicative	0.208	**0.456**	0.314	0.452	-0.058
9	Compact	0.233	0.108	**0.666**	0.103	-0.198
18	Handy	0.114	0.243	**0.658**	0.155	-0.063
26	Flexible	0.207	0.174	**0.644**	0.146	-0.056
11	Pretty color	0.485	0.11	**0.607**	-0.023	0
30	Useful	0.179	0.226	**0.544**	0.466	0.088
4	Steady	0.219	0.385	**0.465**	0.46	0.131
20	Unique	0.336	0.202	0.2	**0.688**	-0.059
21	Different	0.467	0.123	0.059	**0.653**	-0.02
24	Hurried	-0.096	0.046	-0.093	-0.348	**0.707**
29	Brittle	0.055	-0.072	-0.089	0.228	**0.73**

The bold numbers indicate the groups of associates with factors 1-5.

The structure of Kansei words is observable in the analysis result. It is evident from the Table 3 that sample ketchup sauce bottle Kansei are structured by 5 factors. The first factor consists of attractive, beautiful, stimulator, hearty, pioneer, funny, enlivening, contemporary, dynamic, encourager, friendly, delicious, formal, appetizing, and fresh. This Kansei space could be represented as ‘aesthetic’. The second factor consists of identity, nostalgic, truthful, dependency, of high quality, and communicative. This Kansei space could be represented as ‘personality’. The third factor consists of compact, handy, flexible, pretty color, useful, and steady, and therefore it could be represented as ‘operational’ Kansei space. The fourth factor consists of unique, different, and therefore could be represented as ‘unique’ Kansei space. The fifth factor consist of hurried and brittle, and could be represented as ‘brittle’ Kansei space. The result demonstrates that ketchup sauce bottle samples are structured by five factors; aesthetic, personality, operational, unique and brittle. These five factors altogether explains 60.759% of the total data. As a result from the present study case it has been shown that it is possible to have a mechanism to identify, among various object designs, a design proposal which is closer to satisfy the subjective requirements which is wanted to externally be shown by the object. The purpose of this study is to examine the relationship between visualization of appearance properties of the ketchup sauce bottle and users'

impressions of it. With Kansei engineering, it is possible to determine what the ketchup sauce bottle properties obtained from existing samples, result in a high score among the affective value words. The main advantages of conducting a Kansei engineering study is revealing the users feelings or affectivity towards the design. Analyzing and generalizing these affective interactions, can get a better idea about the user's impression towards the design of ketchup sauce bottle. Also our study shows that Kansei design which has a power of interpretation of people's emotion and feeling is possible to create pleasure with products in our daily lives. Because it focuses on human behaviors including emotional actions and responses.

4. CONCLUSION

This paper presents an exploratory extension of the Kansei engineering method which includes an in depth study of the customer experience. Also the current study has highlighted the need for instructional designer to refocus on the often neglected affective aspects of a design. It is noted from the literature [Wilson, 2005] that instructional designer have often put affective factors into secondary position and overlooked its role in promoting effective and engaging learning. The research explores the implementation of Kansei engineering in the effort of embedding emotional signature in our product design. Factor analysis was performed to identify factors, Kansei word's structure, association between Kansei responses and design elements, and determine specimen's Kansei. Factor analysis demonstrates that the first factors explain most of data, i.e. aesthetic, represent 43.672% of data. This means that this first factor is very important Kansei space. It suggests that all ketchup sauce bottle samples should have this factor in order to gain good business appeal. However the second, third, fourth, and fifth factors, personality and operational, are also important but have weak influence. Therefore, these four factors are suggested to be used as background/supporting features in good ketchup sauce bottle samples design. Finally, the results from this study have made it possible for the study to produce a guideline for emotional interface design of the ketchup sauce bottle. Since Kansei is highly dependent on the specific characteristics of any culture, the results of this study of our product may not produce universally accepted features.

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BIOGRAPHY

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A Study on the Impression of Package Designs Featuring Woodgrain Printing

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Abstract: This study sought to examine the impression of product package designs featuring woodgrain printing through experiments and to find out impression differences they give depending on their patterns and printing methods. In particular, it focused on the “authentic” impression of the woodgrain patterns. The experiment used 15 samples with different combination of sheets with various woodgrain patterns or printing methods, shapes (box package), different pattern directions, etc. 100 male and female participants aging from 20s to 70s evaluated their impressions from the viewpoint of three evaluation items, “high-class”, “beautiful”, and “authentic”, through paired comparison tests. The test results were then put to the analytic hierarchy process and interval analytic hierarchy process. The analyses clarified the following features:
1.The woodgrain patterns printed with the new printing method obtained high score in the “authentic” and overall evaluations;
2.Different age groups and genders demonstrated different evaluation tendencies in assessing the “beautiful” and “high-class” features;
3.No significant difference was observed between the evaluations for sheets and boxes;
4.As for the printing method for the box side, participants found it more authentic-looking when the pattern on the top seamlessly continues to the side.
5.The “high-class” evaluation item was found to be prioritized above the “beauty” and “authenticity”.

Keywords: Package Design, Woodgrain, Impression, authenticity

1. PURPOSE OF RESEARCH

This study sought to examine the impression of product package designs featuring woodgrain printing through experiments and to find out impression differences they give depending on their patterns and printing methods. In particular, it focused on the “authentic” impression of the woodgrain patterns.

2. LITERATURE

The study cases in recent years about package design may be classified into two types, the studies based on viewpoint of company or the studies based on viewpoint of consumer. The group of the viewpoint of company includes the studies examine what kinds of package design are effective in the position of branding or market strategy, etc. Cases of this kind in recent years are the study by Lin et al. and the study by Chou et al. Lin examined worth of the hood packages from the position of branding strategy. Moreover, Chou studied the features in the package designs of the beverage market in Taiwan. The purpose of the research based on viewpoint of consumer is to clarify the factors of the evaluation of consumers to package design, therefore the researches which investigate the impression or remarkable point of consumers are included in this group. Cases of this kind in recent years are the study by So et al. and the study by Hashida et al. In study by So, the elements of the package design which consumers are observing were clarified by measurement of eye movement using eye-tracker. Moreover, in study by Hashida, consumers' visual attention was studied using the method of saliency map.

This research is classified into the type of the studies based on viewpoint of consumer. The results of impression evaluation experiment were analyzed by the analytical methods. Analytical method is not a new method. However, the method of this research is effective and reliable as a quantitative approach of investigating consumers' sense of values which cannot be clarified by measurement of eye movement.

3. EXPERIMENT

3.1. Outline

Various woodgrain sheets which differ in the kind of grain or a printing method, what made them for the boxes and the boxes into which the pattern direction was changed, are prepared. Participants evaluate their impressions from the viewpoint of three evaluation items, “high-class”, “beautiful”, and “authentic”, through paired comparison tests. In totaling the evaluation results and analyzing by a multivariate analysis, it is investigated how the subject's impression changes with differences in the pattern or the printing method.

3.2. Impression Evaluation

3.2.1. Experiment Method

The experiment is divided into six steps, and is conducted and from 1 to 6 is continuously performed in one experiment about one subject. The method of evaluation is paired comparison tests between samples.

In Step 1, four kinds of the printing sheets of Japan cedar in which the design of grain and the printing method differ from each other are compared and evaluated. Arranging every two sheets of those on a table, a participant compares the samples and enters an evaluation result in an

evaluation paper. The entry method of evaluation is the way of checking either of nine steps of rate scales. Evaluation time is not restricted. After filling finishes, the combination of the samples is changed, evaluation is repeated, and all the combinations are evaluated. Evaluation criteria are three items of “high-class”, “beautiful”, and “authentic”.

Step 2 is the same procedure as Step 1, and is performed for the sheets of the pattern of three kinds of paulownia.

In Step 3, three of four kinds of samples used at Step 1 are made for three boxes, and those samples are evaluated. This evaluation is performed in order to check whether evaluation results differ in the case of sheets, and in the case of three-dimensional objects. Methods of operation are the same as that of Step 1 and Step 2.

Step 4 is the same purpose as Step 3, and it is performed to the samples of paulownia grain used at Step 2. Methods of operation are the same as that of Step 3.

Step 5 targets two kinds of woodgrain patterns, sample 1-A (Japan cedar by the new printing method) of Step 1, and sample 2-A (paulownia by the new printing method) of Step 2. The samples are made for boxes, the samples which the pattern of the side printed in the direction follows the pattern on top are compared with the samples which does not follow a pattern on top, and “authentic” is evaluated. This evaluation is performed in order to investigate which print direction and which woodgrain is felt with more “authentic”.

In Step 6, three evaluation criteria of Step 1 are compared about which item is thought as important at the time of purchase. Since this step is only evaluation between items, the samples do not use.

3.2.2. Evaluation Samples

The experiment used 15 samples with different combination of sheets with various woodgrain patterns or printing methods, shapes (box package), different pattern directions, etc. The sample A of Step 1 and Step 3 is the woodgrain of Japan cedar by new print method. The sample A of Step 2 and Step 4 is the woodgrain of paulownia printed in the similar way. Although the usual grain printing is printed by 4 colors, the original new printing method is the method of printing by 7 colors. As the other sample, three kinds of grain of Japan cedar by the general printing method for Step 1 were chosen. Moreover, for Step 3, two kinds of samples were chosen from the three. Since the purpose of Step 3 was to check the difference with the result of Step 1, the number of samples was reduced. Similarly, two kinds of grain of paulownia by the general printing method for Step 2 and Step 4 were chosen. At Step 5, the box samples of Japan cedar and paulownia by the new printing method used at Step 4 were used, and the samples by which the print direction of the side was changed were also prepared. As for the samples of Step 5, height was made higher than the samples of Step 4 so that it might be easier for the participants to understand the difference in the side of the box. The size of each sample group is the following.

Sheet: 275 W x 170 H (mm)

Box (Step 4): 225 W x 270 D x 30 H (mm)

Box (Step 5): 225 W x 270 D x 70 H (mm)

The samples are shown in Figs. 1 - Figs.5.



Figure 1: Samples for Step 1 (1-A, 1-B, 1-C, 1-D from the left)



Figure 2: Samples for Step 2 (2-A, 2-B, 2-C from the left)



Figure 3: Samples for Step 3 (3-A, 3-B, 3-C from the left)



Figure 4: Samples for Step 4 (4-A, 4-B, 4-C from the left)



Figure 5: Samples for Step 5 (5-A, 5-B, 5-C, 5-D from the left)

3.2.3. Evaluation Items

The impression of “authentic” is the first of evaluation item. Furthermore, the “high-class” and the “beautiful” which are considered to Samples for Step 3 (3-A, 3-B, 3-C from the left)be thought as important by the package design of grain were added to evaluation criteria. By evaluating these three items, respectively, the difference in the evaluation results of the samples for every item Moreover, in Step 6, it is shown clearly which item is more important for the participants by comparison of evaluation items.

3.2.4. Participant

The participants are 100 male and female aging from 20s to 70s who are considered to be the buyers of goods in which the woodgrain package is used. It was considered that each age was distributed as much as possible equally. The participants were classified into five groups of 20s, 30s, 40s, 50s, and over-60. The number of each group was made into about 20 persons.

4. EXPERIMENTAL RESULTS

100 male and female participants aging from 20s to 70s evaluated their impressions from the viewpoint of three evaluation items, “high-class”, “beautiful”, and “authentic”, through paired comparison tests. The numbers of each participant group were 22 in 20s, 19 in 30s, 21 in 40s, 18 in 50s, and 20 in over-60. 44 of 100 participants were males. The evaluation results obtained by paired comparison tests were converted into nine steps numerical values, and all were totaled.

5. ANALYSIS

5.1. Analytic Hierarchy Process (AHP)

In this research, the analytic hierarchy process (AHP) is used as the analysis method. It was developed by Thomas L. Saaty at the University of Pittsburgh in the 1970s and has been refined since then. AHP is a structured technique for organizing and analyzing complex decisions, and is one of the methods which changes subjective judgment of human into numerical values. Moreover, in order to verify the validity of the analysis result by the AHP, the interval analytic hierarchy process method is used.

The interval AHP is a kind of the section analysis which receives attention in recent years, and is the expansive method of the AHP. The interval AHP is a nonlinear analysis and it is the method of reflecting the inconsistency (non-transitivity) between evaluation values on a result. In addition, analysis was conducted by having divided into each age group, males, and females other than all the participants, and checked the difference arising from the participant's attribute.

5.2. Analysis Results

5.2.1. Analysis Results of Steps 1- 4

The test results were put to the analytic hierarchy process and interval analytic hierarchy process.

The analysis result of Step 1 by AHP was as follows (Table 1). In the analysis result of “authentic” to the grain of Japan cedar, the sample 1-A by new print method obtained high score. In the analysis result of a "high-class", the sample 1-D was the 1st place, the sample 1-A was the 2nd place, and the sample 1-C was the 3rd place. Those numerical values were near. In a "beautiful" analysis result, although the 1st place was the sample 1-B, the 2nd place was the sample 1-D and the 3rd place was the sample 1-A, there was almost no difference. In the comprehensive evaluation which united evaluation of three items, the sample 1-A was the 1st place and the sample 1-D was the 2nd. Since both consistency index (C.I.) value and consistency ratio (C.R.) value were low enough in the analysis result, it was judged that the analysis result of Step 1 was significant.

The analysis result of Step 2 is shown in Table 2. In the analysis result of “authentic” to the grain of paulownia, the sample 2-C was the 1st place and the sample 2-A by the new print method was the 2nd. In the item of the "high-class ", the sample 2-C was the 1st place and the sample 2-A was the 2nd. At the analysis result of " beautiful ", the sample 2-A was the 1st place in the very high score. In comprehensive evaluation, sample 2-A was the 1st place, and sample 2-C was the 2nd. Since both C.I. value and C.R. value were low enough in the analysis result, it was judged that the analysis result of Step 2 was significant. In addition, since the result of Step 6 is used for the analysis between evaluation items in common, the degrees of priorities between items are the same as the values of Step 1.

The analysis result of Step 3 is shown in Table 3. According to the item of "authentic" and "high-class", sample 3-A showed the high score clearly compared with other samples. In the item of "beautiful", sample 3-B was the 1st place, and sample 3-A was the 2nd. Also comprehensive evaluation, sample 3-A was the 1st place in the very high score. Since both C.I. value and C.R. value were low enough in the analysis result, it was judged that the analysis result of Step 3 was significant.

The analysis result of Step 4 is shown in Table 4. Sample 4-A shows the very high score compared with other samples according to all the items “authentic”, "high-class", and "beautiful". Also comprehensive evaluation, sample 4-A was the 1st place in the very high score. Since both C.I. value and C.R. value were low enough in the analysis result, it was judged that the analysis result of Step 4 was significant.

Table 1: Analysis Result of Step 1

Item	authentic	high-class	beautiful	comprehensive
Priority	0.188	0.498	0.314	evaluation value
1- A	0.473	0.283	0.277	0.317
1- B	0.090	0.145	0.293	0.181
1- C	0.195	0.222	0.152	0.195
1- D	0.241	0.351	0.278	0.307

Item	authentic	high-class	beautiful	Priority
Lamda	4.016	4.009	4.007	3.019
C. I.	0.005	0.003	0.002	0.009
C. R.	0.006	0.003	0.003	0.016

Table 2: Analysis Result of Step 2

Item	authentic	high-class	beautiful	comprehensive
Priority	0.188	0.498	0.314	evaluation value
2 - A	0.353	0.328	0.591	0.415
2 - B	0.184	0.308	0.247	0.266
2 - C	0.462	0.364	0.163	0.319

Item	authentic	high-class	beautiful	Priority
Lamda	3.037	3.001	3.000	3.019
C. I.	0.019	0.001	0.000	0.009
C. R.	0.032	0.001	0.000	0.016

Table 3: Analysis Result of Step 3

Item	authentic	high-class	beautiful	comprehensive
Priority	0.188	0.498	0.314	evaluation value
3 - A	0.519	0.422	0.382	0.428
3 - B	0.170	0.230	0.407	0.274
3 - C	0.311	0.348	0.211	0.298

Item	authentic	high-class	beautiful	Priority
Lamda	3.040	3.018	3.000	3.019
C. I.	0.020	0.009	0.000	0.009
C. R.	0.034	0.015	0.000	0.016

Table 4: Analysis Result of Step 4

Item	authentic	high-class	beautiful	comprehensive
Priority	0.188	0.498	0.314	evaluation value
4 - A	0.528	0.453	0.562	0.502
4 - B	0.179	0.267	0.254	0.246
4 - C	0.293	0.280	0.184	0.252

Item	authentic	high-class	beautiful	Priority
Lamda	3.041	3.024	3.061	3.019
C. I.	0.020	0.012	0.030	0.009
C. R.	0.035	0.021	0.052	0.016

5.2.2. Analysis Result of Step 5

Only the item of " authentic " was evaluated in Step 5. The result is shown in Table 5. According to the degree of priorities of this analysis result, the sample 5-A was felt the most authentic by the participants. It is the sample of the grain of Japan cedar which the pattern on the top seamlessly continues to the side. The 2nd place was the sample of Japan cedar which the pattern of the side and the pattern on the top does not continues to the side. The 3rd place was the sample of paulownia which the pattern on the top continues to the side, and the lowest was the sample of paulownia which the pattern does not continues. From these results, the Japan cedar is felt " authentic " rather than paulownia, moreover, about the print direction, the printing method which the pattern on the top seamlessly continues to the side is felt " authentic ". Since both C.I. value and C.R. value were low enough in the analysis result, it was judged that the analysis result of Step 5 was significant.

Table 5: Analysis Result of Step 5

authentic	5 - A	5 - B	5 - C	5 - D	Priority
5 - A	1	1.460	2.273	1.469	0.359
5 - B		1	1.474	1.473	0.262
5 - C			1	1.541	0.200
5 - D				1	0.180

Lamda	4.069
C. I.	0.023
C. R.	0.026

5.2.3. Analysis Result of Step 6

The item judged to be the most important for the participants with the priorities of three evaluation items "authentic", "high-class ", and " beautiful ", was "high-class" (Table 6). This result was common irrespective of age groups or genders. It became clear that the "high-class" is thought most as important to the package using woodgrain.

Table 6: Analysis Result of Step 6

Item	authentic	high-class	beautiful
Priority	0.188	0.498	0.314

5.2.4. Analysis Result by Interval AHP

Interval AHP was conducted using the same data analyzed by AHP. By the interval AHP method, since the result of having unified the result of each item was not computed, it was analyzed for every item. Some graphs of the analysis results are shown in Fig. 6 - Fig. 9. At these results, in the item of the "beautiful" of Step 1, part of sections of the 1st place, the 2nd place, and the 3rd place overlapped. The relation of the 2nd place and the 3rd place of the item of the "beautiful" of Step 4, the 2nd place and the 3rd place of the item of the "high-class" of Step 4, and the 2nd place to the 4th place of Step 5 are also the same. For this reason, it cannot be judged that a clear difference is among these samples. However, it was checked that the samples of the 1st place have clear predominancy to the samples below the 2nd place except for the item of the "beauty" of Step 1.

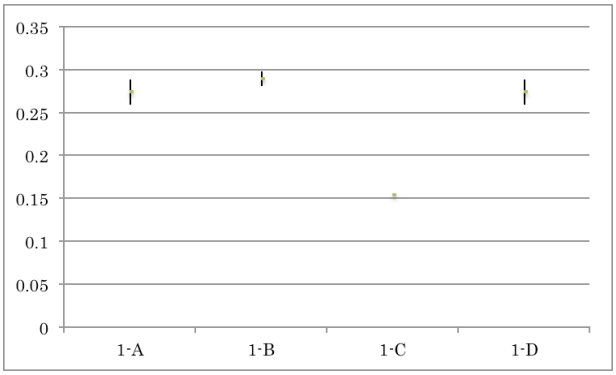

Figure 6: Result of Step 1 ”beautiful”

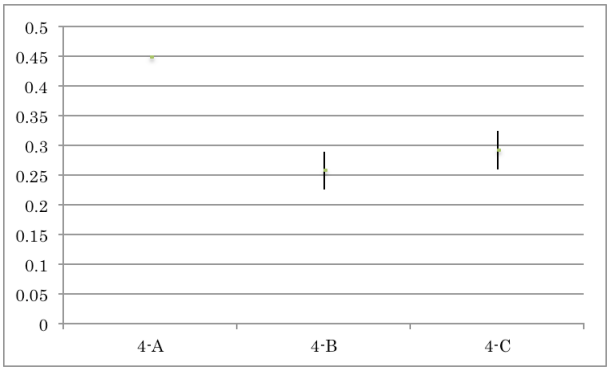

Figure 7: Result of Step 4 “high-class”

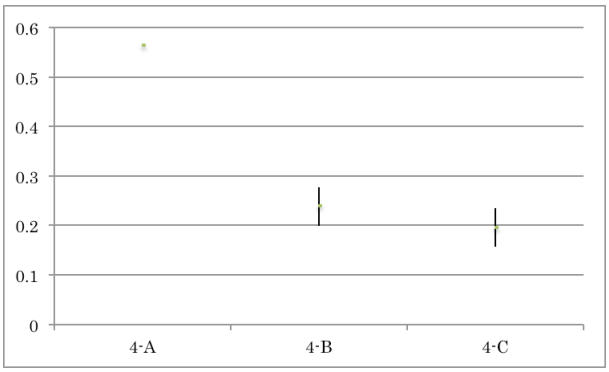

Figure 8: Result of Step 4 “beautiful”

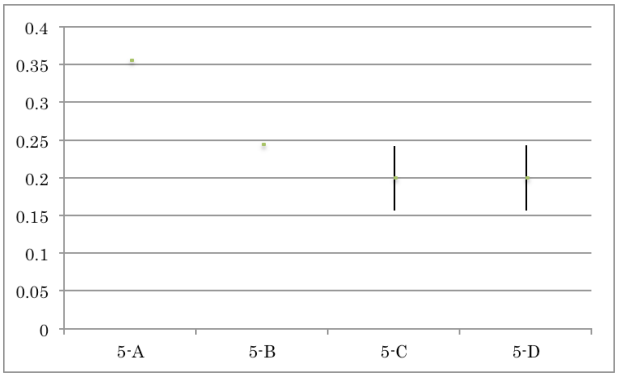

Figure 9: Result of Step 5 “authentic”

6. DISCUSSION

6.1. Overall Tendency of Analysis Results

With the comprehensive evaluation values of the analysis results for the full participant of Step 1 to the Step 4, the ranking of the samples was shown in Table 8. Moreover, the ranking for every evaluation items are shown in Table 7 – Table 10. At the result of the item of the "beautiful" of Step 1, there was almost no difference in the values of top three samples, virtually there are no superiority or inferiority. In the comprehensive evaluation values of the other analysis results, the sample A was the 1st place at every step. They were all the samples by original new print method.

Table 7: Ranking of each step (comprehensive evaluation)

Comprehensive evaluation	Step1	Step 2	Step 3	Step 4
1st	A (0.317)	A (0.415)	A (0.428)	A (0.502)
2nd	D (0.307)	C (0.319)	C (0.298)	C (0.252)
3rd	C (0.195)	B (0.266)	B (0.274)	B (0.246)
4th	B (0.181)			

Table 8: Ranking of each step (authentic)

Authentic	Step1	Step 2	Step 3	Step 4
1st	A (0.473)	C (0.462)	A (0.519)	A (0.528)
2nd	D (0.241)	A (0.353)	C (0.311)	C (0.293)
3rd	C (0.195)	B (0.184)	B (0.170)	B (0.179)
4th	B (0.090)			

In the results of the item of "authentic" of Steps 1, 3, and 4, the sample A ranked 1st like comprehensive evaluation. However, sample 2-C ranked 1st at Step 2. In the item of "high-class", it differs from comprehensive evaluation in that the 1st place of Step 1 is sample 1-B and the 1st place of Step 2 is sample 2-C. In the item of "beautiful", since the ranking of the 1st place to the 3rd place has uncertainty, when it is excepted, it differs from comprehensive evaluation in that

sample 3-B ranked 1st at Step 3 Since the evaluation values of three items of the sample A is high on the whole, it is thought that the comprehensive evaluation values of the sample A ranked 1st at all the steps. About "authentic" thought as important especially in this research, the samples of the woodgrain by original new print method were the 1st place in three steps other than step 2.

At Step 2 and Step 4, in spite of having used the same woodgrain, ranking changed. It is thought that this result is because the color of the sample A of Step 2 and Step 4 changed with variations in printing. It seems that this factor is applied also to the difference as the results of the item of the "high-class" in Step 2 and Step 4. From the above thing, it is considered that there is almost no difference between evaluation by the sheets and evaluation with the boxes.

Table 9: Ranking of each step (high-class)

High-class	Step1	Step 2	Step 3	Step 4
1st	D (0.351)	C (0.364)	A (0.422)	A (0.453)
2nd	A (0.283)	A (0.328)	C (0.348)	C (0.280)
3rd	C (0.222)	B (0.308)	B (0.230)	B (0.267)
4th	B (0.145)			

Table 10: Ranking of each step (beautiful)

Beautiful	Step1	Step 2	Step 3	Step 4
1st	B (0.293)	A (0.591)	B (0.407)	A (0.562)
2nd	D (0.278)	B (0.247)	A (0.382)	B (0.254)
3rd	A (0.277)	C (0.163)	C (0.211)	C (0.184)
4th	C (0.152)			

6.2. Difference in Evaluation by Ages

In order to clarify the difference of the result depended on the participant's attribute, analyses were conducted for every age, and the samples of the 1st place of each result were made into the table (Table 11). In addition, when the difference of the value of the 1st place and the 2nd place was 0.01 or less, the sample of the 2nd place was also shown. In order that there may almost be no difference of the 1st place and the 2nd place in the results of Step 3 and 4 of the group of 50's, and the result of Step 3 of the group of over-60, it seems that the 2nd place is equivalent to the 1st place. When the results of every evaluation item were compared, the results of "authentic" and "high-class " had little dispersion, and the dispersion was large to the results of "beautiful". Therefore, about "beautiful" item, the dispersion in participant's judgment is large. Moreover, it is thought that the dispersion has the tendency for the higher age to be stronger. The other difference is the point that tendencies differ in the older age and younger age bordering on 40's in the results of "high-class" (Table 12). It is thought that the sense of values about "high-class" is divided according to age. The clear difference for every age was not seen at the result of "authentic".

Table 11: 1st place sample of each age（comprehensive evaluation）

Comprehensive evaluation	Step1	Step 2	Step 3	Step 4	Step 5
20’ s	A (0.329)	A (0.532)	A (0.488)	A (0.635)	A (0.423)
30’ s	D (0.383)	A (0.486)	A (0.515)	A (0.530)	A (0.378)
40’ s	D (0.342)	A (0.484)	A (0.387)	A (0.550)	A (0.301)
50’ s	A (0.333)	C (0.363)	C (0.369) A (0.364)	A (0.362) C (0.360)	A (0.351)
over-60	C (0.287)	C (0.390)	C (0.372) A (0.369)	A (0.394)	A (0.313)

6.3. Differences in Evaluation by Gender

Analyses according to genders were conducted and the result was compared. The differences between male and female were not seen at the comprehensive evaluation results of Step 1 to Step 4, and the result of Step 5, they were the same as that of the whole participant's results. Male and female results were compared for every evaluation item. The difference with the whole participant's result was not seen at the result of "authentic ". However, the difference in genders was seen about "high-class" at the result of Step 2 (Table 13). Step 2 and Step 4 use the same printings, and only the conditions of the state of sheets and the state of boxes differ. The color of the sample A changed with variations in printing, and the sample A used at Step 2 was printed more brightly than the sample A of Step 4. At Step 4, although there is no difference, evaluation changes with genders about the color of the sample A of Step 2. In Step 2, female evaluated the sample A of the bright color lower than a male. The difference of genders was not seen in the other results.

Table 12: 1st place sample of each age（high-class）

High-class	Step1	Step 2	Step 3	Step 4
20’ s	D (0.388)	A (0.494)	A (0.510)	A (0.580)
30’ s	D (0.460)	A (0.429)	A (0.523)	A (0.443)
40’ s	D (0.347)	C (0.419)	A (0.400)	A (0.481)
50’ s	A (0.300)	C (0.406)	C (0.436)	C (0.433)
60’ s	C (0.367)	C (0.440)	C (0.418)	A (0.418)

Table 13: 1st place sample of male and female（high-class）

High-class	Step1	Step 2	Step 3	Step 4
Male	D (0.391)	A (0.409)	A (0.466)	A (0.511)
Female	D (0.319)	C (0.421)	A, C (0.387)	A (0.407)

7. CONCLUSION

The analyses clarified the following features:

1.The woodgrain patterns printed with the new printing method obtained high score in the “authentic” and overall evaluations; (The difference between 4-color printing and 7-color printing was judged.)

2.Different age groups and genders demonstrated different evaluation tendencies in assessing the “beautiful” and “high-class” features;

3.No significant difference was observed between the evaluations for sheets and boxes;

4.As for the printing method for the box side, participants found it more authentic-looking when the pattern on the top seamlessly continues to the side.

5.The “high-class” evaluation item was found to be prioritized above the “beauty” and “authenticity”.

ACKNOWLEDGMENTS

This research was performed by cooperation of parte gotou co., ltd.

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Analysis of Common Cognition of Impression Among Japanese Fonts and Tea Beverage Packaging

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Abstract: The purpose of the present paper was to investigate the influence of various cognitions regarding package design on consumer behavior. In considering cognitions concerning product preference, we focused on commonalities between impressions of packaging components, especially typeface design and product characteristics. In Study 1, we developed a scale for evaluating the impression of Japanese fonts using the semantic differential method. Exploratory factor analysis indicated that our scale has three subscales: Activity, Aesthetic preference and Legibility. The results revealed that our factor, “Aesthetic preference,” was similar to the “Evaluating” factor in a prior scale. In Study 2, we conducted the principal examination using the scale developed in Study 1. Participants (N = 303) responded to a questionnaire that included 12 pairs of adjectives on a 7-point scale to determine their impressions of four kinds of Japanese fonts and four kinds of tea beverages. Structural equation modeling indicated that there was a partial scalar invariance, with two items having differential item functioning for the evaluation of impressions between Japanese fonts and tea beverages. These findings indicate that people have common cognitions of impressions regarding the shape of typeface design and product characteristics.

Keywords: Typeface Design, Product Characteristics, Semantic Differential Method, Commonality, Simultaneous Analysis of Several Groups.

In our daily life, we often receive a variety of impressions regarding packaging (e.g., “a color which looks warm” or “a logo which looks delicious”). Why do we feel the temperature of a color or sense the taste of a logo? Why do we like it? What is the cause of commonalities regarding cogni- tive interpretations of them? To determine this, we must find commonalities regarding the information derived from the different sensations.

The main aim in the present study is to reveal commonalities regarding components of package design. Bennett (1995) defined packaging as the container used to protect, promote, transport, and

identify a product. Packaging design has been considered an effective tool for marketing strategy (Ampuero & Vila, 2006; Gonzalez, Thornsbury, & Twede, 2007). For instance, it has been indicated that packaging influences consumer decision-making (Butkevičienė, Stravinskienė, & Rūtelionė, 2008; Mishra & Jain, 2012). Moreover, Choi, Koyama, and Hibino (2009) demonstrated that package design influenced the visual attention of consumers. Ishii (2009; 2010; Ishii, Onzo, & Terao, 2008) also determined that the layout of package design was important for the evaluation of products by consumers. Interestingly, Sogn-Grundvåg and Østli (2009) indicated the importance of grocery packaging when consumers buy unbranded products.

Package design includes numerous components, such as logos, pictures, colors, and so on; we specifically focused on typeface design. It has been reported that typeface design in advertisements may evoke a variety of feelings (Henderson, Giese, & Cote, 2004), and an advertisement is remembered better when each component (e.g., picture, copy, and brand name) is related (Schmitt, Tavassoli, & Millard, 1993). Thus, typeface design is regarded as one packaging component, developed to be easily read by consumers and to provide a better impression of the packaging. However, an intention to make typeface designs better does not consistently do well since people's impressions of individual typeface logos differ. We assume that the combination of typeface design and product characteristics is more important in packaging than the independent components of typeface designs.

The semantic differential method (SD), developed by Osgood, Suci, and Tannebaum (1957) to measure commonalities regarding differential stimuli, has been used in many previous studies (Osgood, 1962; Oyama, Takimoto, & Iwasawa, 1993; Oyama, Yamada & Iwasawa, 1998; Suzuki & Gyoba, 2003; Suzuki, Gyoba, Kawahata, Yamaguchi, & Komatsu, 2006). Oyama et al. (1993) revealed a commonality regarding colors, songs, shapes, symbolic words, and projected images using the SD method, and found four factors: "Evaluation," "Activity," "Lightness," and "Dullness.". However, the application of SD to determine the commonalities between typeface design and product characteristics is still unclear. In addition, packaging designers have to depend on their own subjective aesthetic senses or experiences and can use a variety of typefaces in packaging design. However, there seems to be no obvious basis to account for good combinations of typeface design and product characteristics. To fill this gap, we focused on Japanese fonts used in packaging, and developed a scale to evaluate the impression of these fonts (Study 1). Moreover, we investigated the commonalities between typeface designs and product characteristics in Study 2.

1. INITIAL ITEM DEVELOPMENT

We constructed initial items and selected fonts to develop our scale. We conducted a preliminary examination using these items and fonts as follows:

1.1. Constructing initial items

In the first phase of this study, scale development, we used the SD method to review many pairs of adjectives used in evaluating Japanese fonts (Namatame & Ishikawa, 1999), and investigated commonalities in different sensory modalities, such as symbolic words, colors, and sounds (Oyama et al. 1993; Inoue & Kobayashi, 1985). The adjectives were paired to have opposite meanings. In addition to items derived from the review, I added some unique adjectives to our scale (e.g., *Western-style* vs. *Japanese-style*; see also Table 1). As a result, we extracted 46 pairs of adjectives that were likely to be useful in the development of a scale for evaluating the impressions of Japanese fonts. Next, graduate students in psychology removed some pairs of adjectives that were not adequate. Moreover, we omitted adjectives that had similar meanings, so that 36 pairs were selected.

We classified 27 pairs of adjectives into four categories: "Evaluation," "Activity," "Lightness," and

“Dullness” according to Oyama et al. (1993), and the remaining nine pairs of adjectives were based on Ohanian (1990) as “Items added on our own terms” (Table 1).

Table 1: Items and classifications for the exploratory research of study 1

Evaluation	Activity	Lightness	Dullness	Items added on our own terms
Good/Bad	Dynamic/Static	Cheerful/Gloomy	Soft/Hard	Opened/Closed
Like/Dislike	Tough/Tender	Bright/Dark	Relaxed/tense	Creative/Unimaginative
Beautiful/Ugly	Luxuriant/Plain	Light/Heavy	Sharp/Dull	Modern-style
Comfortable	Lively/Quiet	Pleasant	Round/Square	/Old-fasioned
/Uncomfortable	Intense/Calm	/Unpleasant	Obscure	Western-style
Steady/Unsteady	Speedy/Slow		/Well-defined	/Japanese-style
Warm/Cold	Powerful/Pale			Luxury/Austere
Clear/Muddy	Active/Passive			Casual/Formal
Moist/Dry	Complex-shape			City-style/Country-style
Rough/Delicate	/Simple-shape			Childish/Mature
				Mannish/Womanish

Notes. We classified 27 pairs of adjectives into four categories according to Oyama et al.(1993) , and added nine pairs of adjectives on our own terms for reference from Ohanian (1990).

1.2. Selecting fonts

In Phase 2, we conducted a preliminary examination using 27 Japanese fonts to extract the fonts to be used in the main examination.

1.3. Materials

We used 14 typeface design fonts sold by the Microsoft Corporation and 13 handwritten fonts produced by anonymous designers, and the use of these 27 typeface designs were permitted for both private and business use. In constructing the questionnaire, we used 46 hiragana (Japanese cursive characters), 46 katakana (square form of hiragana), and 48 kanji (Chinese characters used in Japan). Kanji characters are ideograms, which remind us of meanings or feelings. We adjusted the size of the 140 characters to look like 42-point font. To standardize the perception of character size, the characters were printed with black ink on white A4 paper.



Figure 1. Schematics of Japanese fonts used in our examination.Three kinds of Characters described in this figure indicated the letter of hiragana “a” , katakana “a” , and kanji “a” , from left to right. We call these as “Chinese Min style” , “Rounded gothic style” , “Angular style” ,” MS Gothic” ,” Semi-cursive style” ,” Pop style” ,” Textbook typeface” ,” Chinese bronze inscription style” , and ” Thick gothic” .

1.4. Procedure

The printed papers were placed on a white cloth over the table. We arranged the order of the fonts so that similar fonts were not placed next to each other. (The similarity of each font was defi-

ned by Namatame et al., 2000). Twelve psychology students at Rikkyo University completed the preliminary five-item questionnaire, with items such as, “Please choose your favorite fonts, and rank them from first to fifth.” We selected nine fonts based on the popularity and impressions of the 27 fonts as follows (Figure 1).

2. STUDY 1

The aim of Study 1 was to develop a scale for evaluating the impressions of Japanese fonts. We conducted the principal examination using nine kinds of Japanese fonts and 36 pairs of adjectives, using the SD method based on the reasons described above (see Section 1).

Table 2: Items and Classifications for the Exploratory Research of Study 1

Scale	Activity	Aesthetic preference	Legibility
Cheerful/Gloomy	**.85**	.09	.07
Casual/Formal	**.83**	-.24	.18
Childish/Mature	**.82**	.08	.03
Relaxe/Tense	**.74**	.06	-.10
Western-style/Japanese-style	**.71**	-.24	-.17
Pleasant/Unpleasant	**.70**	.33	-.04
Opened/Closed	**.59**	.07	.05
Luxuriant/Plain	**.56**	-.15	.26
Soft/Hard	**.51**	.00	-.43
Like/Dislike	.00	**.88**	.15
Beautiful/Ugly	.10	**.82**	.09
Rough/Delicate	.15	**.81**	.04
Comfortable/Uncomfortable	-.27	**.74**	-.06
Creative/Unimaginative	.11	.22	**.73**
Obscure/Well-defined	.07	.13	**.67**
Complex-shape/Simple-shape	.30	-.27	**.53**
Active/Passive	-.30	-.13	**.52**
Correlations Among Response Dimention			1
Activity	1		
Aesthetic preference	-.08	1	.71
Legibility	-.32	-.20	
Cronbach’ s alpha	.90	.87	.71

Notes. Factor loadings > .40 are in boldface. We performed the EFA using major factor method with promax rotation. Activity, Aesthetic preference and Legibility explained 62.99% of the variance in nine kinds of Japanese fonts.

2.1. Participants

Written consent was obtained from each participant before the examination was conducted. The local ethics committee at Rikkyo University approved the examination. A total of 124 psychology students (46 male and 78 female, average age: 20.04 years, *SD* = 5.14) participated in this study. Following the recommendation of Cha (2006), none of the participants had technical experience in visual art.

2.2. Materials and Procedure

We divided the participants into three different groups, presenting each group with a different combination of fonts in order to reduce their burden when answering the questionnaire. The fonts presented to Group 1 were MS Mincho, HG, Maru-gothic M-PRO, and DF Kinbun-tai; to Group 2,

they were MS Gothic, HG Gyosho-tai, and HG Soueikaku-pop tai; and the fonts for Group 3 were DF Reisho-tai, HG Kyokasho-tai, and HG Soueikaku-gothic UB. Thus, 40, 44, and 40 participants were assigned to Groups 1, 2, and 3 respectively. We randomized the order of the questionnaires given to the participants to prevent an order effect. The questionnaire comprised 36 items on a 7-point scale indicating the impression of three kinds of fonts. The structure of the questionnaire was the same as in the preliminary examination (see 1.3). The examination lasted approximately 10 min.

2.3. Results and Discussion

We used the data from 119 participants, excluding the data from five participants due to numerous non-responses and errors. Thus, there were 38 participants in Group 1 (13 male and 24 female), 43 participants in Group 2 (16 male and 27 female), and 39 participants in Group 3 (14 male and 25 female). The analysis revealed that there were no ceiling or floor effects for the calculated means and standard deviations of the response scores for the 36 items. We performed an exploratory factor analysis (EFA) using a principal factor solution with promax rotation. EFA indicated that our scale for evaluating the impression of Japanese Fonts (18 items) had a final three- factor solution that accounted for 62.99% of the variance (see Table 2). Our scale for evaluating the impression of Japanese fonts has three subscales: Activity, Aesthetic preference, and Legibility. There was a similarity, as well as some inconsistencies regarding factor structure, found when comparing our scale to a prior scale. Our “Evaluation” factor was similar to one found by Oyama et al. (1993), which had items related to aesthetic preference, for example, Good/Bad, Like/Dislike, Beautiful/Ugly and so on. In contrast, inconsistencies with Oyama et al. (1993) were as follows: first, Rough/Delicate was included in the factor “Activity” in Oyama’s scale, but was included in our factor of “Aesthetic preference.” In the prior scale, Cheerful/Gloomy was included in the factor “Lightness,” but was included in our factor of “Legibility.” Secondly, our results indicate the new “Legibility” factor, presumably because we used characters on our scale. These results indicate that only the “Aesthetic preference” factor has a similar structure subject to other various stimuli (e.g., colors, songs, shapes, symbolic words, and projected images in the prior study). In conclusion, we suggest that the impression of characteristics has a more unique structure than other various stimuli, which we assume is caused by a related ideogram. In addition, the interpretation of results from the present study may be limited because we included only nine kinds of Japanese fonts based on popularity.

However, the evaluation of impressions regarding each font may be biased because we used three different types of characters (hiragana, katakana, and kanji). It might be assumed that people recognize hiragana as having a roundish shape, katakana as having a square shape, and kanji as having a complex shape. We must make three groups of notion. Moreover, future research should investigate impressions based on other characteristics, such as frequency of use in package design.

3. STUDY 2

The aim of Study 2 was to investigate commonalities of impressions and better combinations of Japanese fonts and product characteristics. Using our scale that was developed in Study 1, we also examined the relationship between individual factors and the “Aesthetic preference” of Japanese fonts or product characteristics. Moreover, we considered the cause of cognitive interpretations regarding Japanese fonts and product characteristics.

3.1. Participants

Written consent was obtained from each participant before the examination was conducted. The

Table 2: EFA Factor Loadings of a Scale for Evaluating the Impression of Japanese Fonts

Scale	Activity	Aesthetic preference	Legibility
Cheerful/Gloomy	**.85**	.09	.07
Casual/Formal	**.83**	-.24	.18
Childish/Mature	**.82**	.08	.03
Relaxe/Tense	**.74**	.06	-.10
Western-style/Japanese-style	**.71**	-.24	-.17
Pleasant/Unpleasant	**.70**	.33	-.04
Opened/Closed	**.59**	.07	.05
Luxuriant/Plain	**.56**	-.15	.26
Soft/Hard	**.51**	.00	-.43
Like/Dislike	.00	**.88**	.15
Beautiful/Ugly	.10	**.82**	.09
Rough/Delicate	.15	**.81**	.04
Comfortable/Uncomfortable	-.27	**.74**	-.06
Creative/Unimaginative	.11	.22	**.73**
Obscure/Well-defined	.07	.13	**.67**
Complex-shape/Simple-shape	.30	-.27	**.53**
Active/Passive	-.30	-.13	**.52**
Correlations Among Response Dimention			1
Activity	1		
Aesthetic preference	-.08	1	.71
Legibility	-.32	-.20	
Cronbach' s alpha	.90	.87	.71

Notes. Factor loadings > .40 are in boldface. We performed the EFA using major factor method with promax rotation. Activity, Aesthetic preference and Legibility explained 62.99% of the variance in nine kinds of Japanese fonts.

local ethics committee at Rikkyo University approved the examination. A total of 228 psychology students (78 males and 150 females, average age: 19.26 years, *SD* = 1.24) and 75 members of the public (50 males and 25 females, average age: 42.49 years, *SD* = 9.62) participated in this study. In accord with Cha (2006), none of the participants had technical experience in visual art.

3.2. Materials and Procedure

We selected Japanese fonts and items from those used in Study 1 to reduce the burden on participants when answering the questionnaire, following a recommendation to the local ethics committee. We calculated the mean scores for the three factors and performed non-metric multidimensional scaling (NMDS) to evaluate similarities between the nine fonts. The results indicated that the nine fonts were mapped into four areas as follows: Area 1 included Pop style; Area 2 included MS Gothic, Thick Gothic, and Chinese Min style; Area 3 included Chinese bronze inscription style and Rounded Gothic style; and Area 4 included Textbook typeface and Semi-cursive style. The Angular style was not mapped anywhere. Since Pop style, MS Gothic, Chinese bronze inscription style, and Textbook typeface could be considered representative fonts of each area, we selected these four fonts for our study. The questionnaire construction method was the same as in the preliminary examination (see 1.3).

Next, to select the items for the questionnaire used in the study, we included items with the top five factor loadings for the "Activity" factor (e.g., Cheerful/Gloomy, Casual/Formal, Childish/Mature, Relaxed/Tense, and Western-style/Japanese-style), the top three items for the "Aesthetic preference" factor (e.g., Like/Disike, Beautiful/Ugly, & Rough/Delicate), and the top three items for the "Legibility" factor (Creative/Unimaginative, Obscure/Well-defined, and Complex-shape/Simple-shape). Accordingly, we used 12 items for our study.

To select the four products used in this study, we focused on five conditions: trade names were written in Japanese font and only the name of raw ingredients was used (e.g., they were not “Sokenbicha” but “Green Tea”) so as not to evoke a variety of feelings in the participants. Products were from a private brand in 500 mL clear plastic PET screw cap drink bottles, and both the shape of bottle and the area of the bottle labels were almost the same. Hence, we selected four kinds of tea beverages sold in Japan: Product 1 (Barley tea), Product 2 (Chinese tea), Product 3 (Japanese green tea), and Product 4 (Japanese green tea with an illustration on the package). A full size picture of each product was printed on white A4 paper. We randomized the order of the questionnaires given to the participants to prevent an order effect. The questionnaire of 12 items using a 7-point scale assessed the impression of four kinds of fonts and four kinds of products. The examination lasted approximately 5 min.

3.3. Results and Discussion

We used the data from 289 participants (118 male and 171 female), excluding the data from 14 participants due to numerous errors and non-responses. The results of the chi-square tests, which were all statistically significant, indicated a poor fit for our model. However, Hoelter (1983) proposed that a model with a sample size of more than 200 respondents is not adequately represented by the results of chi-square tests. Our sample was large (N = 1158; unpaired data), so we used goodness-of-fit indexes (CFI and RMSEA) rather than the chi-square test.

3.3.1. Factor Analysis

We performed an EFA using a principal factor solution with promax rotation to determine common factors between the impressions of Japanese fonts and tea beverages. An EFA of a scale for evaluating the impressions between Japanese fonts and tea beverages (eight items) revealed a final three-factor solution that accounted for 70.52% of the variance. We performed a CFA of our scale with a maximum-likelihood solution using Amos 22.0 (IBM Corporation) to confirm the common factor structure of our scale. The CFA indicated a chi-square = 933.767, df = 37 with a p-value <.001, Comparative Fit Index (CFI) = .953, Root Mean Square Error of Approximation (RMSEA) = .078, with factor loadings from .44 to .91, and all paths were significant.

3.3.2. Structural Equation Modeling

We conducted SEM to consider differences in evaluations of impressions across Japanese font and tea beverages (see Table 3). To compare the fit indexes of the six models, to begin with we allowed all parameter estimates to be freely estimated across groups to test configural invariance in Model 1, which indicated that there was the equivalence of a less restrictive baseline model across groups. For Model 2, we implemented equality constraints on all paths between groups. The results demonstrated that the model fit well (CFI = .968, RMSEA = .071) with no significant difference in comparison to Model 1, so that metric invariance was established. For Model 3, we implemented equality constraints both on all paths and on all intercepts across groups. However, SEM indicated that the model did not fit well, with significant differences compared to Model 1, so that scalar invariance was not established. In identifying items having DIF across groups in Model 3, we implementtttted equality constraints on each intercept for each factor. There were significant group differences in factors 2 and 3, so we conducted equality constraints on each intercept in each factor (Model 3 from (a) to (f)). The results revealed significant group differences for Models 3 (c) and 3 (e). In other words, Items 5 (*Rough/Delicate*) and 7 (*Creative/Unimaginative*) had non-uniform DIF. Finally, we considered the invariance between both factor variance (Model 5) and factor mean variance (Model 6). Therefore, we suggest that Model 4 was the best fitting of the six models (CFI = .956, RMSEA = .068), in which a partial scalar invariance has been established between groups. Table 4

Table 3: Invariance of 8 Items for Evaluating Impressions Across Fonts and Products

Model	X^2	*df*	Comparative Model	ΔX^2	Δdf	CFI	RMSEA
1. Configural invariance	906.563	34				.978	.075
2. Metric invariance	924.558	39	1	17.995	5	.968	.071
3. Scalar invariance	1179.163	39	1	352.519***	5	.874	.089
(a) Equality constraint: item #3	928.131	40	2	2.641	1	.964	.070
(b) Equality constraint: item #4	969.353	40	2	2.641	1	.957	.070
(c) Equality constraint: item #5	1106.519	40	2	139.807***	1	.932	.077
(d) Equality constraint: item #6	916.150	40	2	0.449	1	.966	.070
(e) Equality constraint: item #7	1014.404	40	2	47.692***	1	.946	.073
(f) Equality constraint: item #8	967.162	40	2	0.449	1	.956	.070
4. Partial scalar invariance							
Free intercepts: item #5,7	935.364	42	2	10.806	3	.956	.068
5. Partial Factor variance invariance							
Free variances: item Am, Ch	938.539	43	4	3.175	1	.951	.068
6. Partial Factoral invariance	949.068	46	4	13.704	4	.939	.068

Notes. group identifiers: Am, Ambiguity; Ch, Cheerfulness; CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation.
***p<.001

Table 4: Estimated Value of Factor Means and Standard Deviations Based on Model 4

Item		Metric Invariance		Japanese Font		Tea Beverage	
		Estimated value	*SD*	Estimated value	*SD*	Estimated value	*SD*
Aesthetic preference							
1. Beautiful/Ugly	Path	1.000[a]					
	Intercept	0.000[b]					
2. Like/Dislike	Path	.435	.032				
	Intercept	1.305	.155				
Cheerfulness							
3. Casual/Formal	Path	1.000[a]					
	Intercept	0.000[b]					
4. Rough/Delicate	Path	.553	.024				
	Intercept			1.174	.116	1.832	.111
5. Childish/Mature	Path	.878	.029				
	Intercept	.145	.126				
Ambiguity							
6. Relaxed/Tense	Path	1.000[a]					
	Intercept	0.000[b]					
7. Creative/Unimaginative	Path	.668	.037				
	Intercept			.634	.234	.045	.220
8. Obscure/Well-defined	Path	.695	.039				
	Intercept	.519	.174				
Factor means							
Aesthetic preference				4.265	.031	4.244	.028
Cheerfulness				3.755	.054	3.925	.037
Ambiguity				3.576	.042	3.296	.033

Notes. a, we fixed path coefficient to 1 so as to identify a model; b, we fixed intercept to 0 in order to identify a model.

presents estimated values of factor means and standard deviations (*SD*) based on Model 4. We named each factor as follows: Factor 1, “Aesthetic preference”; Factor 2, “Cheerfulness”; and Fact- or 3, “Ambiguity.” In addition, the Cronbach’s alpha calculated for each subscale was as follows: .70 for “Aesthetic preference,” .60 for “Cheerfulness,” and .70 for “Ambiguity.”

In conclusion, our scale for evaluating the impression of Japanese fonts and tea beverages has three subscales, and a partial scalar invariance was established by two of eight items in our scale

having non-uniform DIF. In Item 5, participants recognized products with a more *Rough* impression (value = 1.832) than for fonts. In Item 7, participants' impressions of products were more *Unimaginative* (value = .045) than for fonts. It could be assumed that the *Rough* and *Unimaginative* impressions were similar to private brand products. Therefore, we believe that future studies with national brand products would have no DIF.

4. GENERAL DISCUSSION

Recent studies suggest that packaging design could be treated as one of most valuable tools in today's marketing communications (Ampuero et al., 2006; Gonzalez et al., 2007). One study demonstrated that each related component of an advertisement (e.g., picture, copy, and brand name) was remembered better than the unrelated components (Schmitt et al. 1993). However, the exact relationship between components was still unclear, so we focused on commonalities of package design components, specifically typeface design and product characteristics. We assume that the combination of typeface design and product characteristics is more important than the independent component of typeface designs in packaging. However, thus far there has been no obvious basis accounting for good combinations of typeface design and product characteristics. To fill the gap, we must find statistically common cognitions among typeface design and product characteristics.

In Study 1, we developed a scale for evaluating the impression of Japanese fonts. Our scale for evaluating the impression of Japanese fonts has three subscales: "Activity," "Aesthetic preference," and "Legibility." Previous studies reported commonalities among differential stimuli (e.g., Oyama et al., 1993). Concurrently, we found similarities between our scale and a prior scale for two factor structures ("Evaluation" and "Aesthetic preference"). In Study 2, we confirmed that there was a partial scalar invariance for evaluating the impressions between Japanese fonts and tea beverages. Previous studies reported that differential stimuli have a commonality. Suzuki et al. (2003) and Takahashi (1995) also reported the interrelation between words and drawings. In line with these findings, we also found a commonality regarding differential stimuli. Therefore, it could be assumed that people have a common cognition of impressions across the shape of typeface design and product characteristics.

Therefore, we believe that our study helps fill the gap by analyzing evaluations of impressions among Japanese fonts and tea beverages. There may be limitations, however. We used only two aspects of components in package design: four typeface designs and four tea beverage products. Future studies should use various typeface designs and product categories.

ACKNOWLEDGMENTS

I thank Harumi Takeda for her support in conducting the examination, Genta Miyazaki at Rikkyo University for his statistical support, and Masakazu Ide at Rikkyo University for his help in constructing the English composition of this manuscript. I am also grateful to an anonymous reviewer for their valuable and insightful comments.

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BIOGRAPHY

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KEER2014, LINKÖPING | JUNE 11-13 2014
INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH

Development of an Affective Sensorial Analysis Method for the Food Industry

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Abstract: Some type of product development method is applied in all industrial branches. In food industry, most of these development methods involve a food designer preparing a number of prototypes to be tested with potential consumers. Several feedback loops allow the designer to improve the product until it is satisfactory. However, it is often not clear to what extend the resulting product is optimized regarding affective aspects. This study presents a method for affective food product development, deeply based in the classical Kansei Engineering model widely used in other sectors, but that integrates ideas presented in the Kansei Food Model suggested by M. Shibata. Basically, the new method incorporates both sensory items and hedonic expressions as Kansei words, and evaluates not only the link between them and the space of properties, but also the relationship between them. The new method is applied in three case studies (two Swedish companies and one Spanish company). Data collection is conducted in both countries, allowing comparisons based on the origin. The method developed worked as expected, and details are given in an applied way based on the case studies. The paper also shows that sometimes results were surprising or unexpected – such as differences and similarities between countries, or the fact that customer preferences ("like it") and desire ("want it") do not exactly match. Difficulties met and advice on how to conduct the proposed method is also given in the text.

Keywords: Affective design in food industry, Kansei Food Model, regression analysis, Quantification Theory Type 1

1. INTRODUCTION

In all industrial branches some type of product development method is applied. In food industry most of these development methods mean that a food designer (or a team of food designers)

prepare a number of prototypes and test them with potential consumers (Meiselman, 2000). Several feedback loops allow the designer to improve the product until it is satisfactory (Meiselman, 2000). One weakness in this process is that the fact that many of the decisions are made by the designer and only the final result is evaluated by customers (MacFie, 2007). Even if the design team is experienced, they still are biased by their own background as well as by corporate culture (MacFie, 2007). This means that products cannot be optimized regarding affective aspects. It is apparent that only measuring sensory preferences using e.g. test panels is not enough (Meiselman, 2000). Food products must today also express certain values (such as luxurious, healthy, etc.) (Jordan, 2001). They must be desirable. Consumer goods industry understood that about 20 years ago and utilizes today methods to cope with those affective aspects in product development (Jordan, 2002). Hence, integration of those methods in food industry can complement traditional methods and lead to superior products.

The research project described in this paper, and funded under the Vinnova program of the Swedish government, develops an affective sensorial analysis method for the food industry. Section 2 of this paper describes the procedure. The method is successfully applied to three companies. Sections 3, 4 and 5 gives detailed explanations on these case studies. Section 6 summarizes the main conclusions of the experience.

2. THEORETICAL FRAMEWORK

2.1. The model for affective product development

The model for developing Kansei Engineering in product development shown in Figure 1 (Schütte, Eklund, Axelsson, & Nagamachi, 2004) has proven very successful in multiple applications.

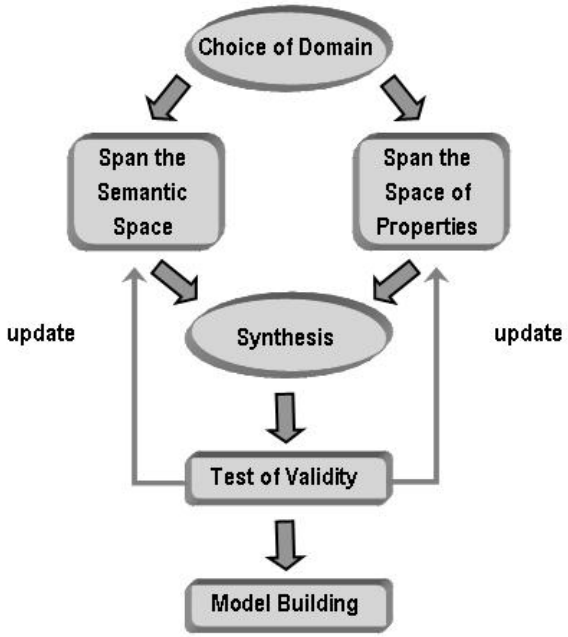


Figure 1: A proposed model of Kansei Engineering method (taken from Schütte, Eklund, Axelsson, & Nagamachi, 2004).

After choosing a domain, two different perspectives are developed: the semantic description and

the description of product properties. These two descriptions each span a kind of vector space. Subsequently these spaces are analyzed in relation to each other in the synthesis phase, indicating which of the product properties evokes which semantic impact. After these steps have been carried out, is it possible to conduct a validity test, including several types of post-hoc analyses. As a result of this step, the two vector spaces are updated and the synthesis step is run again. When the results from this iteration process appear satisfactory, a model can be built describing how the Semantic Space and the Space of Properties are associated.

2.2. A food Kansei Engineering model

Thinking in food, Sagara (1994) defines the term “Kansei” as: 1) the ability to sense and perceive external stimuli through sensory organs; 2) emotional dynamics elicited by all the senses; 3) sensory desires under the control reason and mind. The term “food Kansei” is coined later and defined by the same research group as “an alternative concept of reciprocal relations between foods and humans to proposes an interdisciplinary academic paradigm of Food Kansei Engineering” (Shibata, Araki, & Sagara, 2008)

Ikeda et al. suggested the Food Kansei Model as presented in Figure 2 (Ikeda, Naga, & Sagara, 2004). Its purpose is to correlate physical properties of food and food perception. Ikeda et al. hypothesize that food has both intrinsic and extrinsic attributes. As intrinsic attributes they define physical properties such as chemical compositions and structures. In short all sensory perceptions perceived inside the mouth. Extrinsic attributes, on the other hand, are according to them product properties which are stated externally, in form of package (design and text), ads, commercial, health benefits, etc.

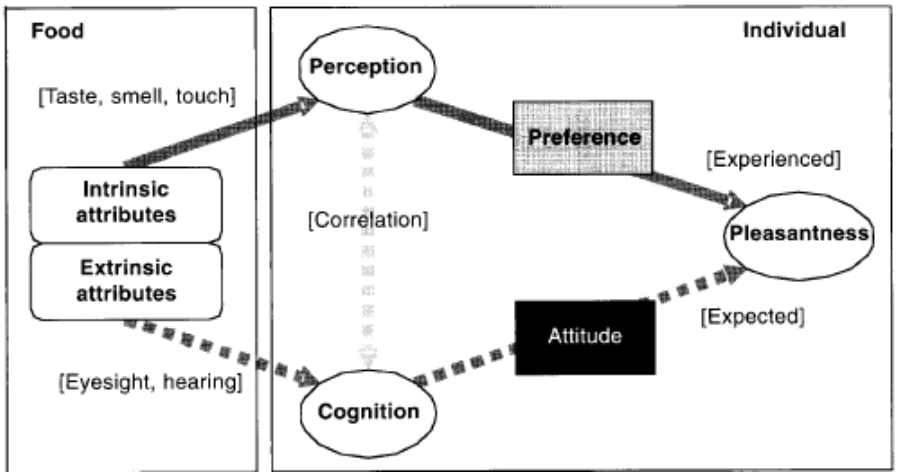


Figure 2: Food Kansei Model (taken from Ikeda et al., 2004).

The Kansei Food model is subdivided into two parts. The left hand part represent the perception, the right hand part the acceptance. It becomes clear that the acceptance part consists out of two paths. The “intrinsic path” deals with the sensory evaluation of the actual product, while the “extrinsic path” generates the exceptions of the product. Both lead ultimately to pleasantness. Pleasantness is in this context defined as the combination of perceptual factors (intrinsic), cognitive factors (extrinsic) and appetitive factors (motivation) (Ito, Umemmoto, Ono, Tokosumi, & Ikeda, 1994).

Ikeda’s model in Figure 2 is rather complex. A number of studies have been carried out by the same research group Ikeda is working in. Going through their publication in chronological order a

development can be seen. After the Kansei Engineering food model was developed their studies focused on the “intrinsic” part only (Ito et al., 1994; Shibata et al., 2006). When they integrated the extrinsic part they apparently discovered that it had to be modified in order to comply with the structure of the intrinsic path (Ueda et al., 2008). First after 2010 the model can handle the intrinsic and extrinsic part (Akiyama et al., 2011) without problems.

All of the publications mentioned in the section above, however, are rather vague on how the Kansei Engineering Food Model can be interpreted and applied. Shibata et al. (2008) present a possible flowchart and suggest a number of tools in order to achieve affective food evaluation. This suggested structure is presented in Figure 3.

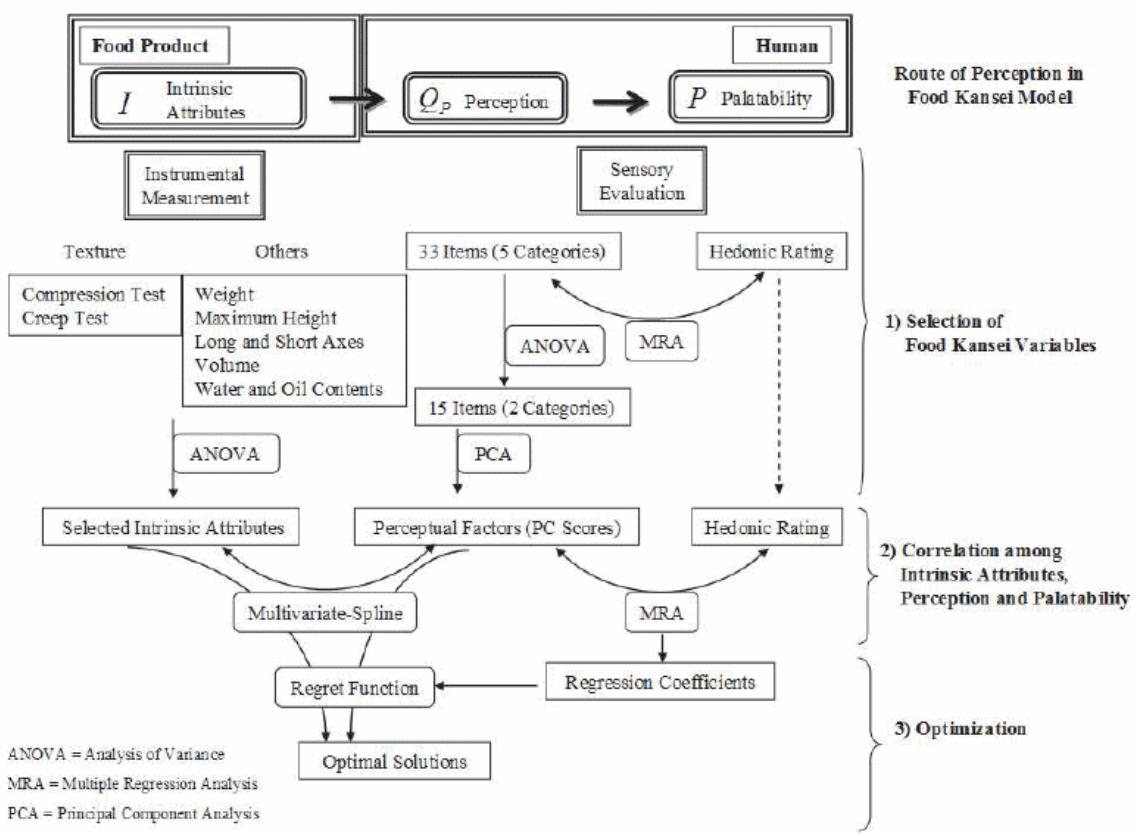


Figure 3: Route of perception according to Ikeda et al. (2004) and Shibata et al. (2008)

As the general Kansei Engineering model in Figure 1; the Kansei Food Model in Figure 3 makes a distinction between product properties (intrinsic attributes/ Space of Application) and human perception (Palatability/ Semantic Space). Both areas are initially explored and then linked together in a synthesis step.

The procedure suggested in this paper is a hybrid between the Kansei Engineering model as it is used for hardware products (Figure 1) and the Kansei Engineering Food model (Figure 2). Comparing those two figures it becomes obvious that they have a lot in common. They create a mathematical relationship between intangible affective values in the user’s minds and physical properties of the product. By matching the activities in the Kansei Engineering Food model with the stages in the Kansei model, it becomes possible to identify separate action and intermediate results. It also makes it possible to replace certain tools used in the Kansei Engineering Food model with other tools with the same purpose.

The hybrid model used here has two main areas. The Identification of Intrinsic attributes which is equivalent to the erection of the Space of Properties. Physically measurable product properties are found and selected according to their ability to create an affective impact of the consumer.

In a parallel step, semantic properties are selected. While hardware products usually only require the evaluation of hedonic values (often verbally expressed adjectives) food has an additional dimension: sensory items. Those are semantic descriptions close related to the physical impression of taste and mastication (i.e. flaky, oliy, crunch, etc.). Accounting for this the spanning of the Semantic Space as it is described by Osgood et al. (1957) is a bit different. Firstly the semantic descriptions are collected and subsequently separated into “Hedonic Expressions” and “Sensory Items”. Outgoing from the data collected on Semantic Visual Scales using KESo software (Schütte & Schütte, 2009), a Principle Component Analysis (PCA) is performed on both sets of terms separately. This step reduces the number of terms and identifies those terms which have the highest impact on the users affect. Regression analysis can be conducted to link the hedonic expressions with the sensory items (something not done in a classical Kansei Engineering study, as this distinction among kansei words does not exist).

Subsequent both sections of the semantic space are linked to the Space of application. In Ikeda’s Kansei Engineering Food model this was done using multiple regression analysis (MRA). However, other methods have been used in consumer industry such as Quantification Theory Type 1 (QT1) (Komazawa & Hayashi, 1976b), Rough Sets Analysis (RSA) (Nishino, Nagamachi, & Ishihara, 2001), Ordinal Linear Regression Analysis (OLR) (Marco-Almagro, 2011) and others.

The suggested procedure will become apparent in the following three Section, which present three case studies. Two of them (Cloetta, a confectionary manufacturer, and Espuña, a charcuterie manufacturer) strictly follow the modified Kansei Engineering food model presented previously. The third one, Lantmännen, which produces breakfast cereals, presents some particular characteristics.

3. THE CLOETTA CASE STUDY

Cloetta AB is a leading confectionary manufacturer, which produces chocolate products, sugar confectionary, pistils and chewing gum in Scandinavia, The Netherlands and Italy. Their products are sold in more than 50 countries. Cloetta’s R&D department identified a new trend for product development: “power bars”, i.e. chocolate bars providing energy. Amongst other products they produce two sister power bars containing out several layers of wafer covered with chocolate (Figure 4).



Figure 4: Cloetta Kex-Choklad (left) and Sportlunch (right).

Both products are very similar, but Kex choklad has a thinner chocolate cover and is selling better to a wider market. Sportlunch suggests a closer connection to physical activity and is therefore consumed at more limited occasions. Also Sportlunch is preferred by male consumers.

Having this in mind the Cloetta development team is eager to differentiate these products further.

3.1. Aim of the Cloetta study

In this particular case study, the aim was to determine a filling with an emotional profile corresponding to the brand image of Sportlunch of being sporty and refreshing (Swedish: uppiggande). More concrete, a suitable combination of ingredients shall be found which at the same time is preferred ("like it") and desired ("want it") by the consumers. A secondary aim is to find a combination which works most likely in both Sweden and Spain.

3.2. Study structure of the Cloetta study

The study was carried out in accordance to the modified Kansei Engineering food model suggested. Firstly, a domain was chosen. From this the Semantic Space and the Space of Application were determined. For erecting the Semantic Space, emotional words were collected. These words derived from previous studies ((Schütte, 2013)(Prithivirat & Grzechnik, 2011)), competing product ads consumed at sport occasions and Cloetta's own development team. In order to complement these data pilot study was performed, asking 25 consumers to semantically describe their impression when eating Sport Lunch. These words were then screened manually and separated into hedonic expressions and sensory items. After applying affinity diagram technique the number of semantic terms was reduced and expressions with overlapping meanings eliminated.

In parallel the product development division of Cloetta identified key ingredients and combinations thereof with high emotional impact. In cooperation with LiU an experimental plan was established and the selected prototypes produced.

Kansei Engineering Software (KESo) (Schütte & Schütte, 2009) was used for establishing a data collection homepage. The consumers were provided an assortment box containing samples of individually numbered chocolates containing different samples. Despite the different taste the samples looked identical. Using the website, the consumers were asked to take a specified sample and test it, giving a rate on a visual analogue scale (VAS) in a position which "felt" right (Figure 5, left). The data collection was carried out in 2 stages. In the first stage Swedish chocolate consumers, with medium to high chocolate consumption answered the survey. In the second stage, the survey was answered by Spanish chocolate consumers. Additional data was provided by two chocolate experts in a third group, which however was too small to include in the final evaluation.

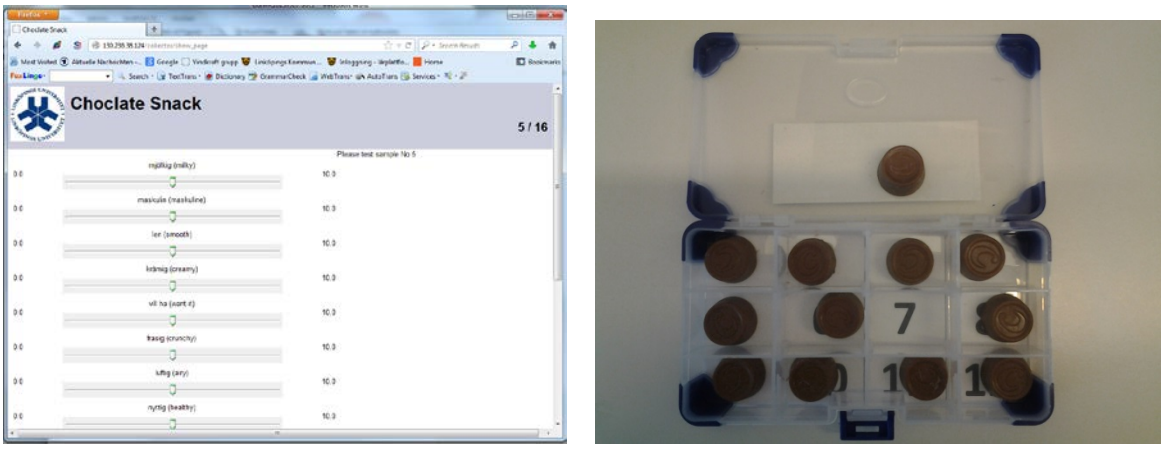


Figure 5: Data collection using KESo software (left, data collection site; right: samples provided in an assortment box).

KESo provided instant results by applying QT1 analysis (Komazawa & Hayashi, 1976a) and Rough Set Analysis (Nishino et al., 2001). The data was also checked for data quality and consistency.

3.3. Results of the Cloetta study

As a result of the semantic data collection a total number of 151 expressions were collected. Of those 55 expressions were hedonic expressions, 32 were sensory items (20 described the texture and 12 the taste). The rest were either variants of expressions (sweet, sugary, sugar, etc) or deemed irrelevant. After the affinity analysis the following words remained and were used in the following data collection (Table 1).

Table 1: Kansei Words used in the Cloetta study and their translations.

Type		Svenska	English	Català	Español
Hedonic expressions		Vill ha	Want to have	Ho vull	Lo quiero
		Nyttig	Healthy	Sa	Sano
		Energi	Energy	Energia	Energía
		Maskulin	Maskuline	Masculí	Masculino
		Tycker om	Like it	M'agrada	Me gusta
Sensory items	Texture	Len	Smooth	Suau	Suave
		krämig	Creamy	Cremós	Cremoso
		Frasig	Crunchy	Cruixent	Crujiente
		Luftig	Airy	Flonjo	Ligero
	Taste	Mjölkig	Milky	Lletós, amb llet	Lechoso, con leche
		nötigt	Nut-like	De nous	De nueces
		uppiggande	Refreshing	Refrescant	Refrescante

As mentioned above, different recipes of combinations of ingredients were prepared. In order to get best results a reduced factor table with dummy coding was developed. The ingredients chosen were caffeine, three different flavours, yoghurt and chilly spice (to produce a hot feeling). **Error! Reference source not found.**2 shows the 12 combinations which were tested by the participants.

Table 2: Set of stimuli used in the Cloetta case study.

Sample No.	Caffeine	Flavour	Yoghurt	Spice
1	Yes	Salt	No	Chilli
2	Yes	Salt	No	None
3	No	Salt	Yes	Chilli
4	No	Salt	Yes	None
5	No	Nut	No	Chilli
6	No	Nut	No	None
7	No	Nut	Yes	Chilli
8	No	Nut	Yes	None
9	Yes	Fruit	No	Chilli
10	Yes	Fruit	No	None
11	No	Fruit	Yes	Chilli
12	No	Fruit	Yes	None

The data collected in KESo software were checked according to its quality. A K-S test was performed to check whether the data was normally distributed. That was the case for all Kansei words used. Also, it was checked if the gender, the age and the nationality (Swedish, Spanish) made a difference in how the test samples were perceived. As for the gender significant differences were found only for the word “smooth in sample 1”. Otherwise no significant differences were found for man and women. The age range of the participants was quite narrow. That might be the reason that no significant difference could be observed. For the nationality the Levene’s Test show 3 significances regarding the variances. However, no significant differences were found for the means of the nationality rankings in the t-test. As a consequence all data was pooled for further evaluation.

Figure 6 shows the average rating values plotted in a radar chart. These presentations are commonly known as emotional profiles of the samples.

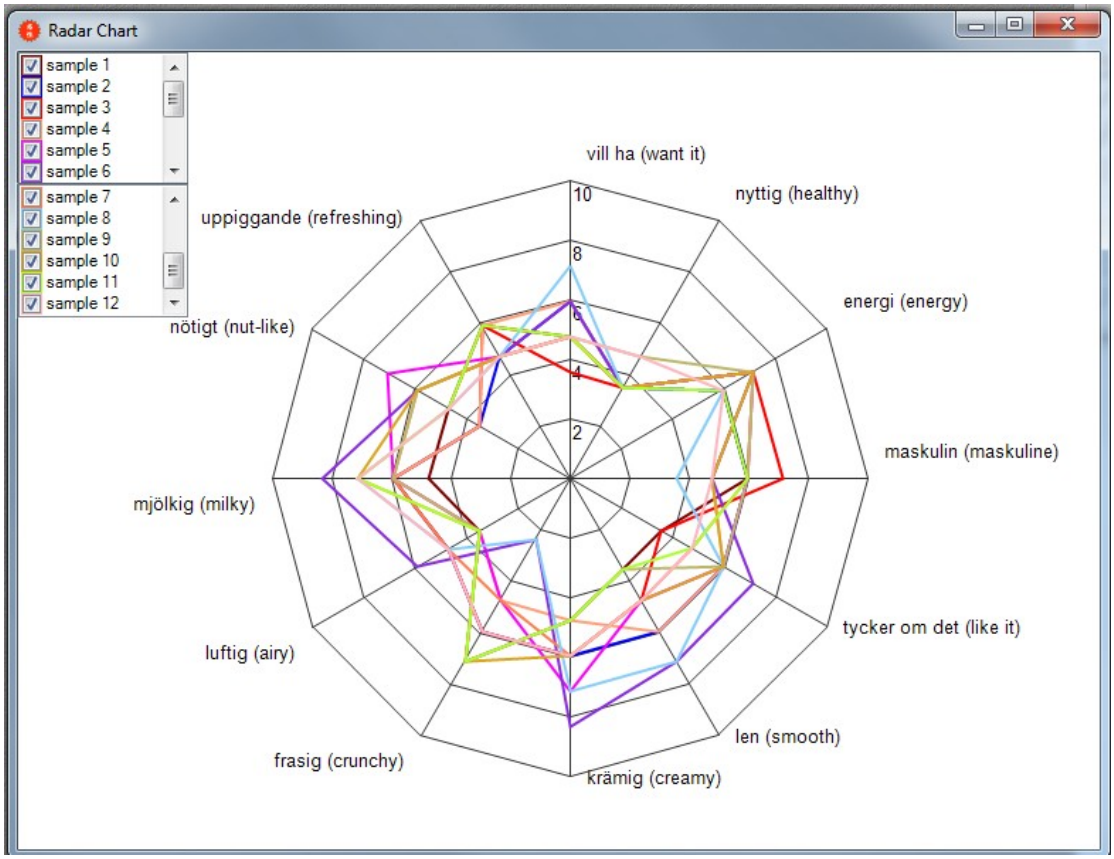
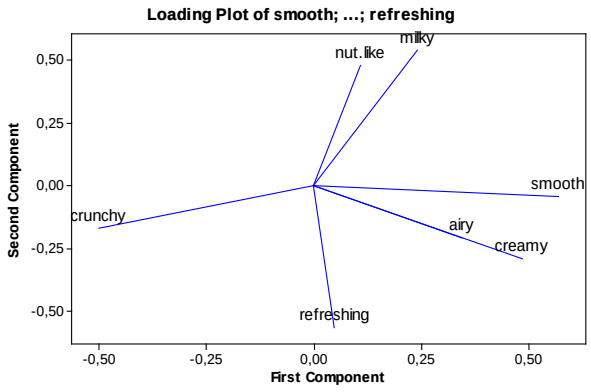


Figure 6: Emotional Profiles for each sample; all participants’ average.

3.3.1. Principal component analysis (semantic space)

A principal component analysis (PCA) has been conducted separately on sensory items and hedonic expressions for both Swedish and Spanish results. The results are incredibly similar for both countries when dealing with sensory items (Figure 7).

Sweden



Spain

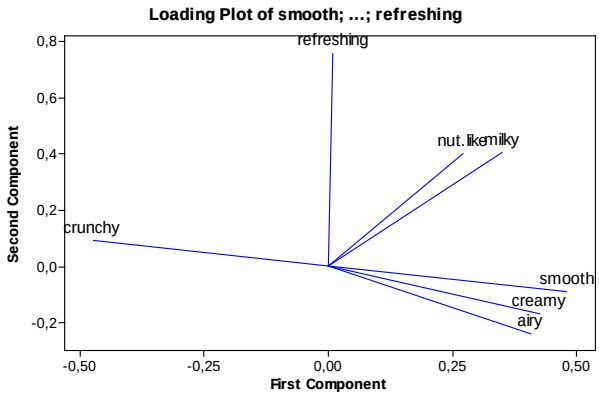


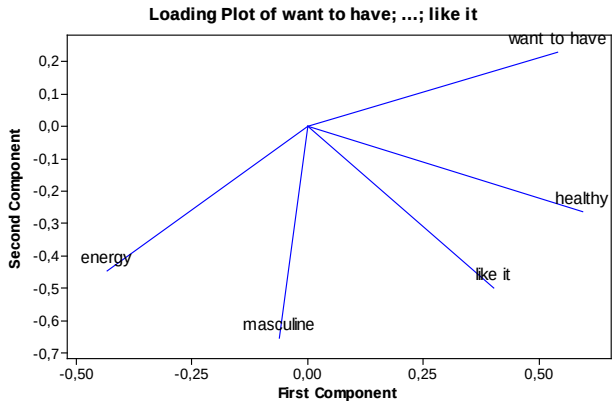
Figure 7: Principal component analysis (PCA) for sensory items in the Cloetta study.

Creamy, smooth and airy fall very close in the semantic space; and these three sensory items are perceived as contrary to crunchy. Nut-like and milky are also close together. Refreshing falls quite alone in the semantic space, and this is the only word with a different location depending on the country.

The fact that the deployment of this semantic space of sensory items is very similar to both countries makes sense. Participants in the study seriously rated all sensory items and arrived to similar conclusions in both countries, as these sensory items are intrinsic attributes of the chocolates, easier to “objectivize”.

The PCA for the hedonic expressions (Figure 8) show more dissimilarities between both countries. Basically, all hedonic expressions fall far away one from the other. The exception is for expressions “want to have” and “like it” for the Spanish results, where both words are quite close.

Sweden



Spain

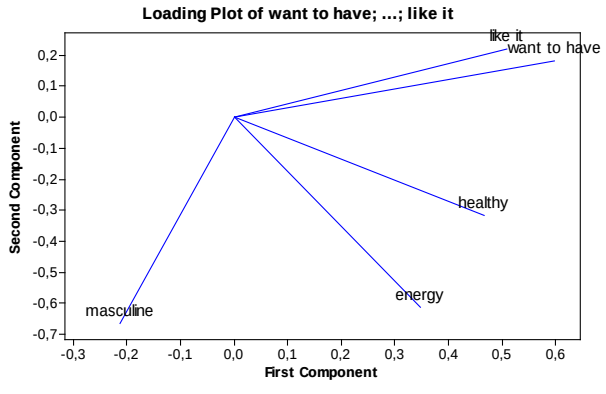


Figure 8: Principal component analysis (PCA) for hedonic expressions in the Cloetta study.

3.3.2. Regression analysis

A linear regression analysis has been done using each one of the hedonic expressions (want to have, like it, healthy, energy and masculine) as responses, and the sensory items (smooth, creamy, crunchy, airy, milky, nut-like and refreshing) as possible regressors.

The selection of the best model for each response has been done using a best subsets procedure (doing all possible regressions and choosing the best one based on adjusted squared R^2 and Mallow's Cp indicator).

Figure 9 summarizes the results for both Swedish and Spanish data collections. The figure % response explanation is the value of adjusted R^2 in the linear regression analysis. It represents the percentage of variability of the response that can be explained by the given variables.

Sweden

	Smooth	Creamy	Crunchy	Airy	Milky	Nut-like	Refreshing	% response explanation
Want it	+	–						54
Like it				–		–		39
Healthy				–		–		54
Energy	–	+						30
Masculine			+		+		+	69

Spain

	Smooth	Creamy	Crunchy	Airy	Milky	Nut-like	Refreshing	% response explanation
Want it	+				+			61
Like it			–		+			76
Healthy		–		+		+		57
Energy			–		–	+		29
Masculine	–	–				+	–	77

Figure 9: Relationship between hedonic expressions and sensory items based on regression analysis for the Cloetta study.

3.3.3. Quantification Theory Type 1

The evaluation using QT1 yielded a great amount of data. An example of a QT1 output is displayed in Figure 10. It compares the results for the terms "want it" and "like it". The diagrams in each figure can be interpreted in the way that the combination of caffeine, nut taste, Yoghurt and no chilli spice will maximize the rating for "want it". The picture is similar for "like it" where the combinations of no caffeine, nut or fruit taste, no yoghurt and no chilly spice produce the highest ratings. This means that a product which people like AND want need to have nut flavor, and no chilli spice. It also shows that liking and wanting are different concepts when it comes to food products.

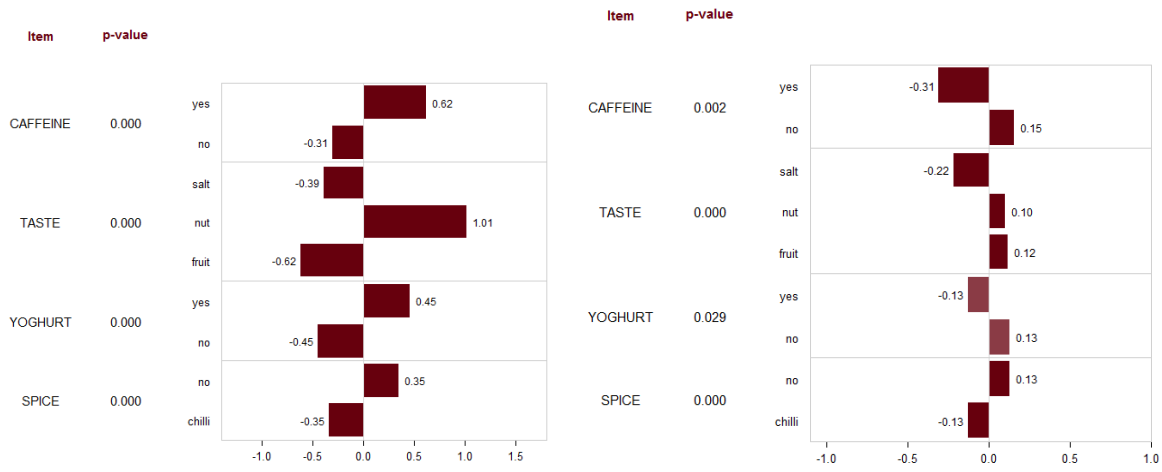


Figure 10: QT1 output from all pooled data for "want it" (left) and "like it" (right).

Figure 11 displays all the QT1 result in only one table. It can be seen that in some points there are differences in the ratings of the Spanish and Swedish groups. However, it can also be seen that despite those differences it is possible to find a common pattern for both groups. This implies that a chocolate product designed for either market probably will be perceived similar on the other market as well.

		Kansei word	Dataset	Caffeine		Taste			Yoghurt		Spice	
				Yes	No	Salt	Nut	Fruit	Yes	No	no	chilli
Hedonic expressions (Kansei Words)		Want it	Sweden	+	-	-	+	-	+	-		
			Spain			-	+	-	+	-	+	-
			All	+	-	-	+	-	+	-	+	-
		Like it	Sweden	-	+	+	-	+			-	+
			Spain	-	+	-	+	+	-	+	+	-
			All	-	+	-	+	+	-	+	+	-
		Healthy	Sweden	+	-	+	-	-	+	-		
			Spain	-	+		+	-			+	-
			All	+	-	+	+	-	+	-	+	-
		Energy	Sweden	-	+	+	-	+	-	+	-	+
			Spain	+	-	-	+	-	+	-	-	+
			All	-	+	-	+	-	-	+	-	+
		Masculine	Sweden	+	-	0	-	+	+	-	-	+
			Spain	-	+	+	-	-	-	+	-	+
			All			+	-	0	-	+	-	+
Sensory items	Textures	smooth	Sweden	+	-	-	+	-	+	-	+	-
			Spain	-	+	-	+	+	-	+	+	-
			All	+	-	-	+	-	+	-	+	-
		Creamy	Sweden			+	+	-	-	+		
			Spain			-	+	0	-	+	+	-
			All			0	+	+	-	+	+	-
		Crunchy	Sweden	+	-	-	-	+	-	+	-	+
			Spain	+	-	+	-	+	+	-	-	+
			All	+	-	+	-	+	+	-	-	+
		Airy	Sweden	+	-	-	+	-	+	-	+	-
			Spain	-	+						+	-
			All			-	+	-	+	-	+	-
	Taste	Milky	Sweden			-	+	-	+	-	+	-
			Spain	-	+				-	+	+	-
			All	-	+	-	+	-			+	-
		Nut-like	Sweden	-	+	-	+	0	-	+	+	-
			Spain	-	+	-	+	+	-	+	-	+
			All	-	+	-	+	+	-	+		
		Refreshing	Sweden			+	-	-			-	+
			Spain			-	-	+	+	-		
			All			+	-	-	+	-	-	+

Figure 11: Assembly of all QT1 results. "+"/"-" means positive impact of the respective category on the average rating. Empty boxes mean that the data is not significant.

3.4. Conclusions of the Cloetta case

When collecting data also a number of demographic questions were asked. This was meant in order to be able to stratify the data afterwards. Except for the citizenship, it was difficult to find

subgroups regarding age or chocolate eating habits. The reason for this might be twofold. Partly, the low number of participants did not allow clear results. Partly, the group of participants was deliberately chosen as homogenous as possible (for instance, age range was very narrow).

Most important kansei words for the company were the terms “want it”, “like it”, to ensure that consumers will repeatedly buy the product. Also the words “masculine”, “healthy” and “refreshing” were chosen by Cloetta to be prominent for this product group. The rest of the words were chosen in a way that they had positive influence on the product.

The best compromise with those prerequisites was:

- Sweden: Caffeine: yes, Taste: fruit (or possibly salt), Yoghurt: Yes and Spice: No (only to emphasise masculine chilli can be added)
- Spain: Caffeine: No, Taste: nut (or possibly fruit), Yoghurt: Yes and Spice: No (except for masculine)

Considering those selections it is not impossible to find a combination which works for both countries. It can be speculated that such product might work for more than just the Swedish and Spanish market.

4. THE LANTMÄNNEN CASE STUDY

The conglomerate of Lantmännen is entirely owned by Swedish farmers. Founded in 1924 and reorganized in 2001 their goal is to refine agricultural raw products and market them using their own brands. This case study was carried out for the branch Lantmännen cereals. A research project started in January 2013 evaluated different recipes of rye based breakfast flakes. The aim was to determine the physiological effects on the feeling of satiating (Isaksson, 2011). For this the participants would consume a number of pre-fabricated product variants. Consecutively, physiological measurements (blood sample, breath hydrogen measurements) but also subjective measurements of appetite registration using VAS scales were taken. As a final result an optimized mixture of ingredients should be determined. The hypothesis was that if consumers of breakfast cereals feel satiated for a longer time after consumption they will consume less food leading to a healthier life style. It is however known that food products’ visual appearance (structure, colour, etc) and physical properties (such as taste, consistence, etc.) have a major impact on the acceptance of the product (Ueda et al., 2008). These affective properties were not being tested in the study carried out at Lantmännen themself.

4.1. Aim of the Lantmännen study

The aim with this case study was to determine the affective impression of the visual sensation and compare it to the actual impression when consuming the product.

Particular questions to be answered were:

- Does the degree of satiation vary over time and is it possible to determine the degree of satiation visually before consumption?
- Is there an association between personal taste preference (like it) and desire (want it)?

This will be done by defining a Semantic Space, and emotional profiles of the five products selected.

4.2. Study structure of the Lantmännen case study

The study is carried out in accordance to the modified Food Kansei Engineering model presented previously.

The Semantic Space was determined using brainstorming technique, as well as gathering semantic descriptions from sources such as adds, TV spots, Internet representation and popular scientific health magazines. These words and terms were manually separated into hedonic expressions and sensory items. Unlike in the other studies the time since consumption were deemed important. Hence both the hedonic descriptions and the sensory items were ordered into three groups of “before consumption, during (or directly after) consumption and 3 hours after consumption”. Affinity analysis grouped the terms in clusters and together with sensory experts the final set of Kansei rating words was selected.



Figure 12: Taste samples for Lantmännens protoyptes.

21 selected customers participated in the data collection. They were provided a data collection form, and five product samples. They were supposed to prepare one sample every morning as a replacement of their normal breakfast. Then they evaluated the dish visually on affective visual analogue scales (VAS). During or directly after consumption they evaluated the product again on a second set of scales. A third and final evaluation was done 3 hours later the same day. After one week the collection sheet was returned.

4.3. Results of the Lantmännen case study

The set of products to be evaluated were picked from an on-going study at Lantmännen. Table 3 depicts the products given. It can be seen that two of the samples were for control purposes (C40 and C55). They are identical, except for the weight. The other three products varied in the content of Inulin and Gluten. In fact all products varied in their visual appearance and sensory texture.

Table 3: Set of products for the Lantmännen study

Product sample	Weight per portion	Inulin per portion	Gluten per portion
C 40	40g	-	-
C 55	55g	-	-
6:6	40g	Medium	Medium
3:9	40g	Low	High
9:3	40g	High	Low

The words on which the products were evaluated on are presented in Table 4. The participants were asked to evaluate a different set of words at different times as seen in the columns. The word “satiating” appears in all three columns in order to evaluate the progression over time. The terms “like it” (personal preference) and “want it” (desire) are asked with a 3 hour gap inbetween.

Table 4: Selected words for evaluation of Lantmännens products with Swedish word in parenthesis.

Words for visual evaluation (before consumption)	**Words for sensory evaluation (during or short after consumption)**	**Words for residual evaluation (3h after consumption)**
Tasty (god)	Smooth (len)	Satiating (mättande)
Appetizing (aptitlig)	Creamy (krämig)	Want it (vill ha)
Satiating (mättande)	Healthy (nyttig)	
Energy giving (energigivande)	Satiating (mättande)	
	Like it (Tycker om det)	

Of 21 Participants who received samples one participant obviously mistreated the data collection, 2 data sets were merely incomplete and 2 were not returned. In total 16 participants finished the study and returned the completed data set. The mistreated and incomplete answers were not taken in account for further evaluation.

Analysing the data, no significant differences were found regarding gender or age group.

A paired samples t-test revealed that all ratings for C40 and C55 were not significantly different. Since they are basically the same product in a different quantity this was expected and insured that the data had good quality. In the following only the data from C40 were compared to the rest of the products, since they had the same quantity of 40 grams.

Paired samples t-tests were carried out checking whether the three different ratings of “satiating” (visual, at consumption and three hours after consumption) were similar. This was done for all products separately. Some significant differences could be observed. All of them were in the comparison between visual and at consumption as well as visual and 3 hours after consumption. This meant that it was difficult for the participants to estimate the degree of satiation just from visual inspection. However it was also found that for the samples 6:6, 3:9, 9:3 the differences were bigger which might mean that the products with additional hunger damping ingredients (Inulin and gluten) were easier to estimate visually.

4.4. Conclusions of the Lantmännen case study

The visual sensory perception yielded different ratings of the products. Some of the properties such as the texture and partly even the taste could be estimated just from looking at the product.

One question Lantmännen was particularly interested in was how consumers evaluate satiation. This case study showed clearly that it was more difficult to estimate the degree of satiation from visual inspection alone. Samples with more ingredients (all but the control) were apparently easier to estimate than those with only one ingredient (C 40 and C 55). It was significantly easier for the participants to estimate the satiation they would feel after 3 hours already directly after consumption.

Regarding for the semantic terms expressing personal taste preference (“like it”) and desire (“want it”) high correlations were found. But since those terms were not entirely rated alike, it can be assumed that the mental picture is not entirely the same, i.e., products that customers like are

not necessarily those they want. Hence, more studies should be conducted to clarify this point.

5. THE ESPUÑA CASE STUDY

Espuña was founded in 1947 in Olot (Spain) as a manufacturer of charcuterie products. Espuña has a presence in European countries (France, Portugal, UK, Germany) and in the South American and Japanese markets. Although serrano ham slices are the most successful product, Espuña has launched two new totally innovative product ranges over the last years: the Minute Tapas range (in 2002) and the "Cañitas" range (in 2011). Both products are quick and easy to prepare and have attractive packaging. The case study presented here is focused on the “Cañitas” range. The aim is discovering the effect of new tastes and shapes on the sensations conveyed by the products when viewed and tasted.

Currently, there are three main flavours of *Cañitas* in the market: chorizo, fuet and salami. All these are products coming from pork, but with different additives and preparation. Salami is a common product in many European countries. Chorizo is popular in the whole Spain, whereas fuet is much more linked to Catalonia, and especially to the counties of Osona and La Garrotxa (the motherland of Espuña).



Figure 13: Two different tastes and lengths of *Cañitas* (fuet, short, on the left; and chorizo, long, on the right)

Cañitas is a product sold in Spain and other European countries. It is now being introduced in Asia, particularly in Japan. Espuña experts were very interested in experimenting with the tastes in the market, together with new “more extreme” ones.

5.1. Aim of the Espuña study

In this case study, the aim was to study the emotional profile conveyed by *Cañitas*. Both the visual impression before being eaten, but especially the taste, had to be evaluated. Some hedonic expressions were of high interest: the perception of an innovative and cool & trendy product, a convenient product, easy to eat everywhere and at any time; and the idea that it is a product for everybody.

5.2. Study structure of the Espuña study

The study was carried out in accordance to the modified Kansei Engineering food model previously presented. Firstly, a domain was chosen. From this the Semantic Space and the Space of Properties were determined.

For erecting the Semantic Space, emotional words were collected. An initial list of 103 words was collected by Espuña experts. The list was made based on personal work by each team member in the company, followed by a brainstorming session to share all the ideas. This initial list of emotional words was reduced using an affinity diagram (Figure 14).



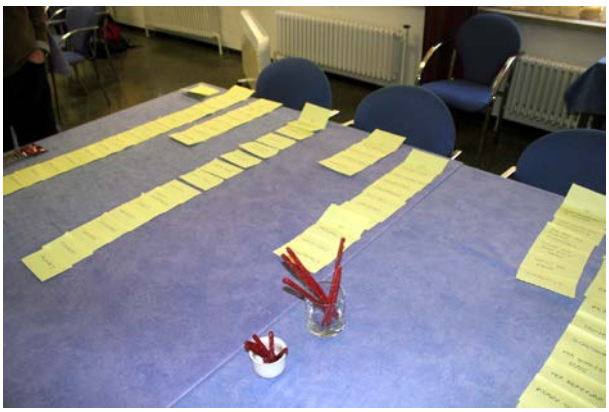


Figure 14: Espuña team working with the affinity diagram

Two properties were used to prepare the set of stimuli: different flavours (the three existing flavours plus two new ones and the shape

So, the items and categories to be used for the study were:

- Taste: salami, chorizo, fuet, ginger pork, curry chicken.
- Shape: long sticks, short sticks, balls, slices.

Some combinations of taste and shape were not feasible (or at least, not easy to produce in the short period of time – a few weeks – allocated for the preparation of all samples). These were not included in the set of products to be evaluated. Table 5 shows the set of products that were prepared.

Table 5: Set of products prepared for the data collection

	Taste	Shape		Taste	Shape
1	Curry chicken	Short stick	9	Salami	Sliced
2	Chorizo	Ball	10	Fuet	Long stick
3	Salami	Long stick	11	Chorizo	Short stick
4	Ginger pork	Short stick	12	Ginger pork	Long stick
5	Fuet	Sliced	13	Salami	Short stick
6	Chorizo	Sliced	14	Fuet	Ball
7	Fuet	Short stick	15	Curry chicken	Long stick
8	Chorizo	Long stick	16	Salami	Ball

Data collection was organized in a different way in Sweden and Spain (Figure 15). In Sweden, Kansei Engineering Software (KESo) (Schütte & Schütte, 2009) was used for both building the

data collection homepage and for actually collecting the data. So each participant was seated in front of a laptop, tasted each sample, and gave ratings moving a slider on the website. In Spain, and to avoid the difficulties of having many computers in a room that was not excessively spacious, the data collection was done on forms printed on pieces of paper. Each participant had 16 pieces of paper (one for each product that had to be rated). To make results from the Spanish data collection totally comparable with those from Sweden, visual analogue scales (VAS) were drawn in the form of 100 mm long lines. Participants, instead of moving a slider on the computer screen, had to write a vertical mark on the VAS (later on, we measured distances with a rule, and extracted all figures, in an easy but time consuming task).

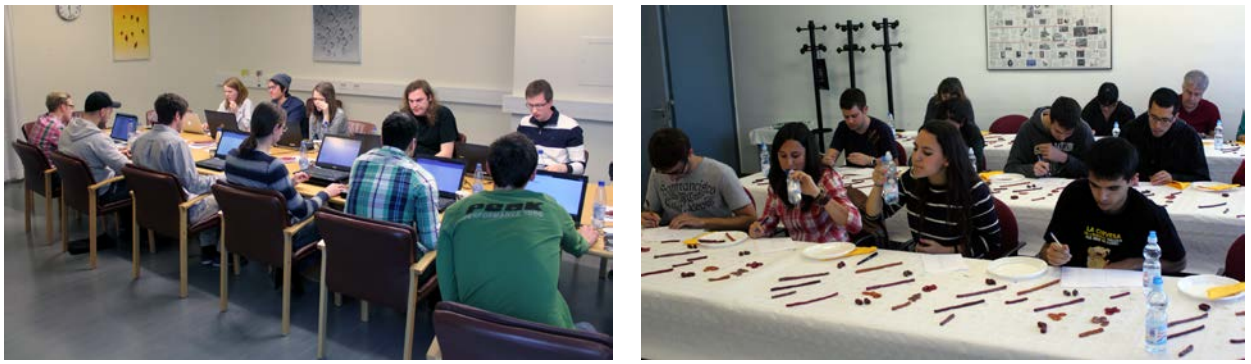


Figure 15: Data collection in Sweden (left), and in Spain (right)

As usual in these studies, and besides the actual ratings, participants also provided personal information such as age and gender.

5.3. Results of the Espuña study

Each product sample was rated on 13 different kansei words, divided into hedonic expressions and sensory items. Table 6 shows the list of words used. Swedish participants were shown the Swedish and English version of the words. Participants in Spain were shown the Spanish and Catalan version of the words.

Table 6: Kansei Words used for the Espuña study, and their translations.

Type		Svenska	English	Català	Español
Hedonic expressions		Cool och trending	Cool & trendy	*Cool & trendy*	*Cool & trendy*
		Innovative	Innovative	Innovador	Innovador
		Bekvämt	Convenient	Convenient	Conveniente
		Närande	Nutritive	Nutritiu	nutritivo
		För alla	For everybody	Per tothom	Para todos
		Närhelst varhelst	Whenever wherever	Per qualsevol moment I lloc	Para cualquier momento y lugar
		Vill ha	I want it	El vull	Lo quiero
		Tycker om det	I like it	M'agrada	Me gusta
Sensory Items	Texture	Len	Smoot	Suau	Suave
		Tuggyg	Chewy	Gomós	Gomoso
	Taste	Köttig	Meaty	Amb gust de carn	Con gusto de carne
		Fetty	Greasy	Greixós	Graso
		Kryddig	Spicy	Picant	Picante

A descriptive analysis of all data collected was performed in order to assure its quality. No outlier participants were detected. Furthermore, there were no significant differences based on gender or age. Although great differences were expected between the Swedish and the Spanish group (basically based on knowledge and familiarity with this kind of product), this was not the case. All data analysis has been done separately for Sweden and Spain. However, as results are very similar for both countries and for the sake of simplicity and facilitate understanding, the analysis of all data together will be offered in this section.

5.3.1. Principal component analysis (semantic space)

A principal component analysis (PCA) has been conducted separately on sensory items and hedonic expressions. In this case, the semantic space was better summarized using not only the first two principal components, but three of them. To achieve this, words have been represented in three dimensional scatterplots.

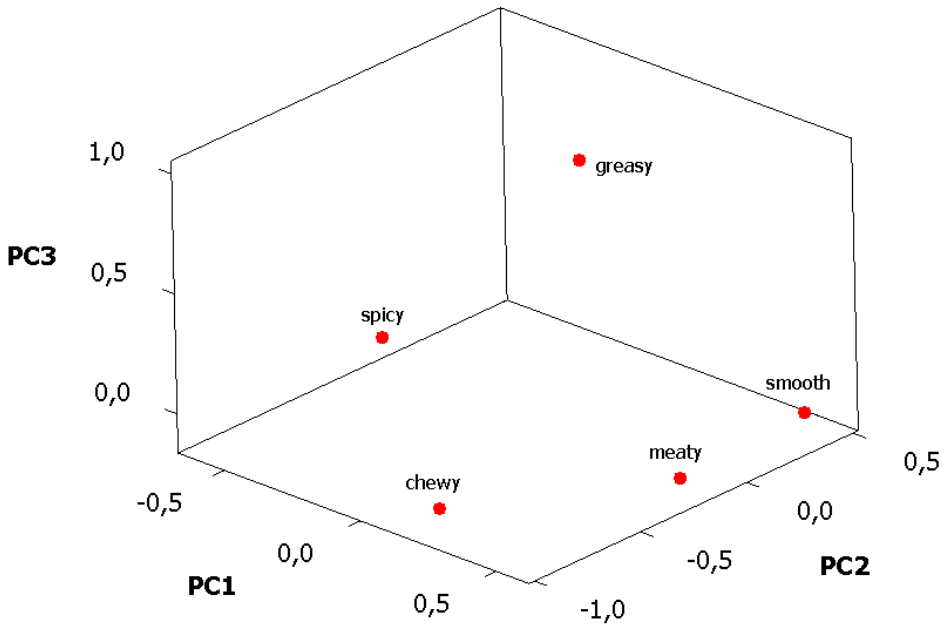


Figure 16: Principal component analysis (PCA) for sensory items in the Espuña study.

As can be seen in Figure 16 the five sensory items are spread on the whole spectrum of semantic space. There is no word perceived as very close to another one. This is not bad; on the contrary, it shows that the selected sensory items cover well all the spectrum of possible sensory items.

The PCA for the hedonic expressions does show words in groups (Figure 17).

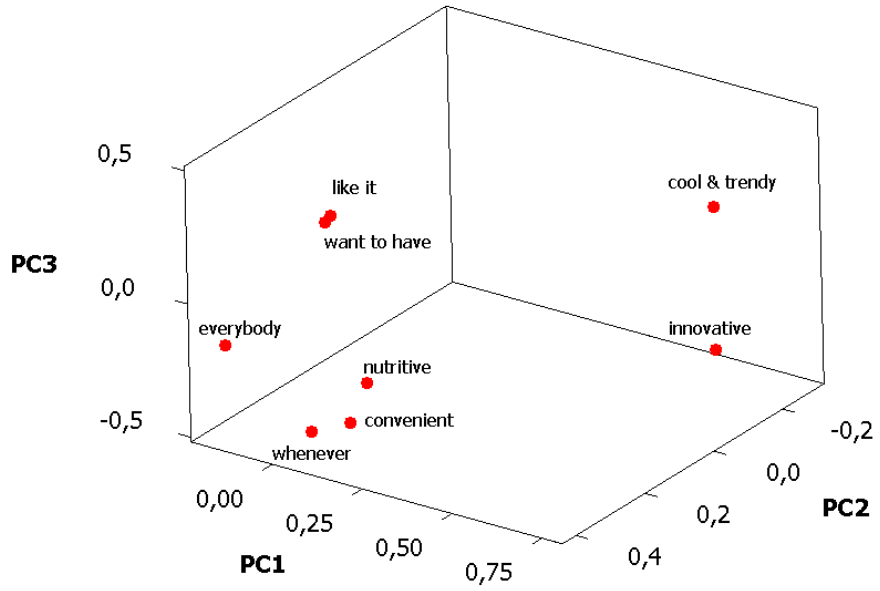


Figure 17: Principal component analysis (PCA) for hedonic expressions in the Espuña study.

These groups are quite logical. “Like it” and “want to have” are very close one to the other. Although this is not always the case (remember the Cloetta study, where this fact did not happen), in this occasion both concepts are perceived as the same: the desire for the product is linked to the preference for that product. “Cool & trendy” and “innovative” are another group, something that can be easily justified by the semantics of both hedonic expressions. “Nutritive”, “convenient” and “whenever-wherever” form another group. “For everybody” is, basically, alone.

5.3.2. Regression analysis

A linear regression analysis has been done using each one of the hedonic expressions as responses, and the sensory items as possible regressors. As in the Cloetta study, the selection of the best model for each response has been done using a best subsets procedure.

Models have been built with data from Sweden and Spain altogether. Figure 18 summarizes the results. The figure % response explanation is the value of adjusted R^2 in the linear regression analysis. It represents the percentage of variability of the response that can be explained by the given variables. Those models having this figure higher than 50% are shown shaded on the table.

	Greasy	Meaty	Smooth	Chewy	spicy	% response explanation
Want to have	–	+		–		73
Like it		+				60
Convenient	–	+			–	74
Cool & trendy	–	+			+	47
For everybody	–	+		–	–	93
Whenever wherever	–	+			–	80
Nutritive	–	+	+			78
Innovative	–				+	72

Figure 18: Relationship between hedonic expressions and sensory items based on regression analysis for the Espuña study.

A quick inspection of the table above shows that greasy affects negatively in almost all hedonic

expressions, whereas meaty affects positively. Smooth and chewy affect very few hedonic expressions, whereas spicy affects positively or negatively depending on the hedonic expression.

5.3.3. Ordinal logistic regression analysis

Data from the Espuña case study was analyzed using QT1 and ordinal logistic regression (OLR), as suggested in Marco-Almagro (2011). The analysis with OLR is able to detect more clearly how each category affects each kansei word. Results from OLR are shown using bars that represent the odds ratio, with the category acting as reference level having the value 1.

Results for Sweden and Spain are very similar. Therefore, results are offered for the whole dataset, with data coming from both countries.

Analysis was conducted for both sensory items and hedonic expressions.

Figure 19 shows the OLR output for some hedonic expressions. Some relevant conclusions are that the preferred tastes are fuet, salami and chorizo. Curry chicken is perceived as the most innovative flavour.

Related to shape, short sticks are seen as the most convenient format.

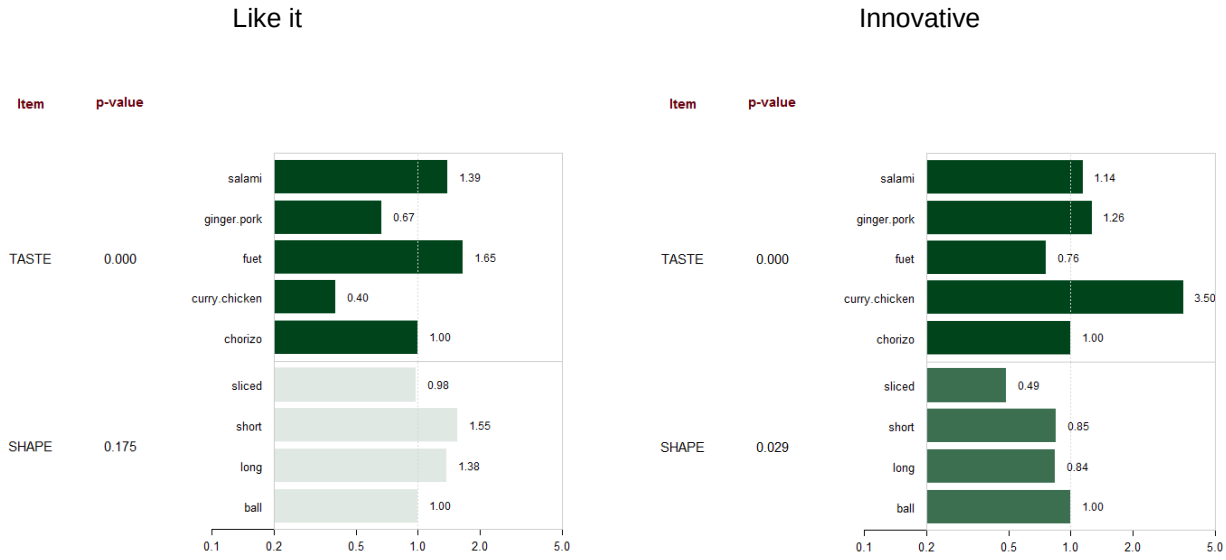


Figure 19: OLR Output for some hedonic expressions in the Espuña study

5.4. Conclusions of the Espuña case study

Very interesting results from the methodological point of view derive from the Espuña case analysis. The principal component analysis (PCA) for sensory items shows that the selection of these five words has been appropriate to cover a good spectrum of sensory perceptions in charcuterie products (all five words fell far apart one from the other). The PCA for the hedonic expressions made it possible to establish groups of words. These groups of hedonic expressions have been later confirmed by the regression analysis, as results from the regression for words in the same group are very similar.

Regarding the products, main conclusions from the Espuña case study, are the following:

- Contrary to what initially was expected, results from Sweden and Spain are very similar.
- In general, the most preferred flavours are the ones already in the market (fuet, salami, chorizo).
- Shape affects the perception of convenience and innovation (with slices being the least convenient and innovative, a quite logical conclusion).

6. CONCLUSIONS

A methodology capable of integrating affective consumer needs into food products has been developed and explained in this study. The methodology is based on Kansei Engineering technology and combines parts of the Kansei Engineering model developed by Ikeda et al. (2004), together with the model suggested by Schütte (2004), leading to an integrated model of Kansei Engineering for food products. A major addition to this model is the separation of Kansei words (Semantic Space) in sensory items and hedonic expressions.

The model was applied in three European companies, Cloetta AB (confectionary), Lantmännen AB (breakfast cereals) and Espuña (charcuterie products). The method can map the specific product affective properties into an emotional fingerprint and link each of the hedonic and sensory attributes to one or a combination of physical product attributes. The results of the case studies also show that the method is working equally well for both Swedish and Spanish consumers. They also show that Spanish and Swedish consumers in many ways have similar preferences. This means that the cultural background and local food habits do have an impact on the consumer's experience of food products, but that common preferences can be found in order to develop products aiming for international markets.

The terms "like it", expressing individual preference, and the term "want it", expressing desire, were used on all studies. As expected, they show high correlation but also differences. This means that some products might be liked but not wanted and vice versa. Also, it is possible to find products which are wanted and liked. Using the suggested methodology, combinations of attributes can be found increasing preference and making products more desirable at the same time.

ACKNOWLEDGMENTS

This research study was founded by the Vinnova program of the Swedish government.

The authors are very grateful to:

- All the staff from the participating companies, who enthusiastically collaborated with the study. A special thank you to Anita Storm from Cloetta, Christan Malmberg from Lantmännen and Neus Quintana from Espuña.
- All the participants in the studies, both in Sweden and Spain.

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BIOGRAPHY

Simon Schütte Short biography has a degree of mechanical engineering and a PhD in Human Systems Engineering. Currently, he is an associated professor at the division of machine design at Linköping University. He has been working with Kansei Engieering since 1999 and proposed the first European model on the method in 2004. Since then he has been working in many projects with companies such as Volvo, Scania, Cloetta, Danone, etc.

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