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).

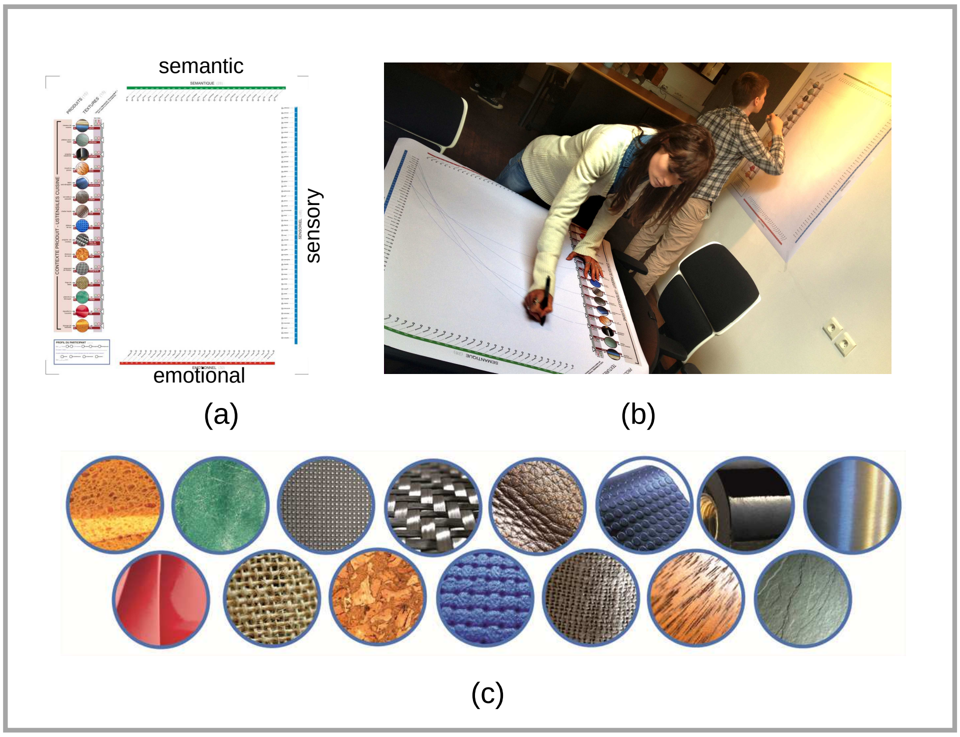

Figure 1: Materials: (a) Panel A0 - Textures vs. Descriptors, (b) Hand draw line – population, (c) 15 selected tactile textures.

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.

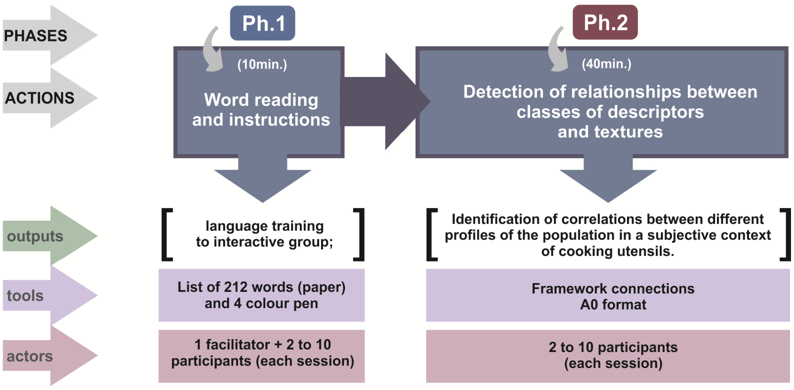

Figure 2: Schema of the experimental protocol.

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).

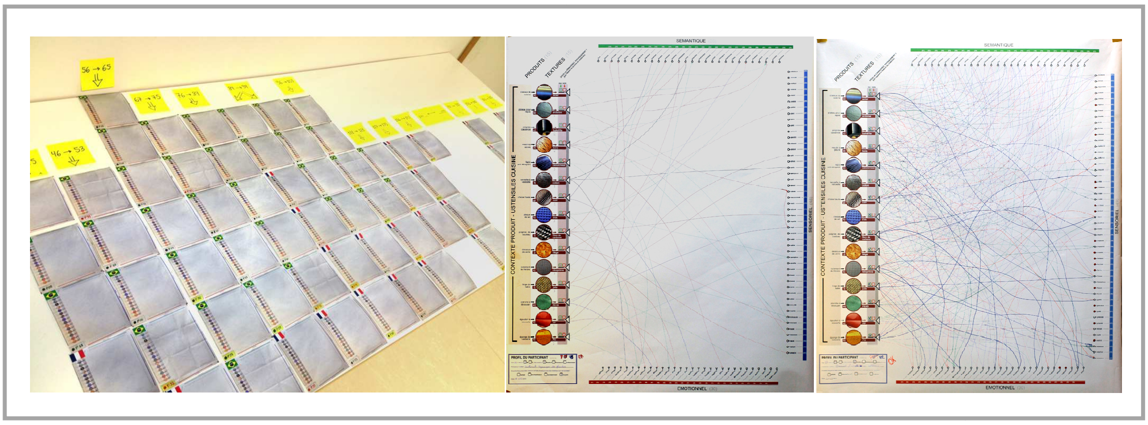

Figure 3: Visual analysis of the line density in the miniature panels on the table.

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.

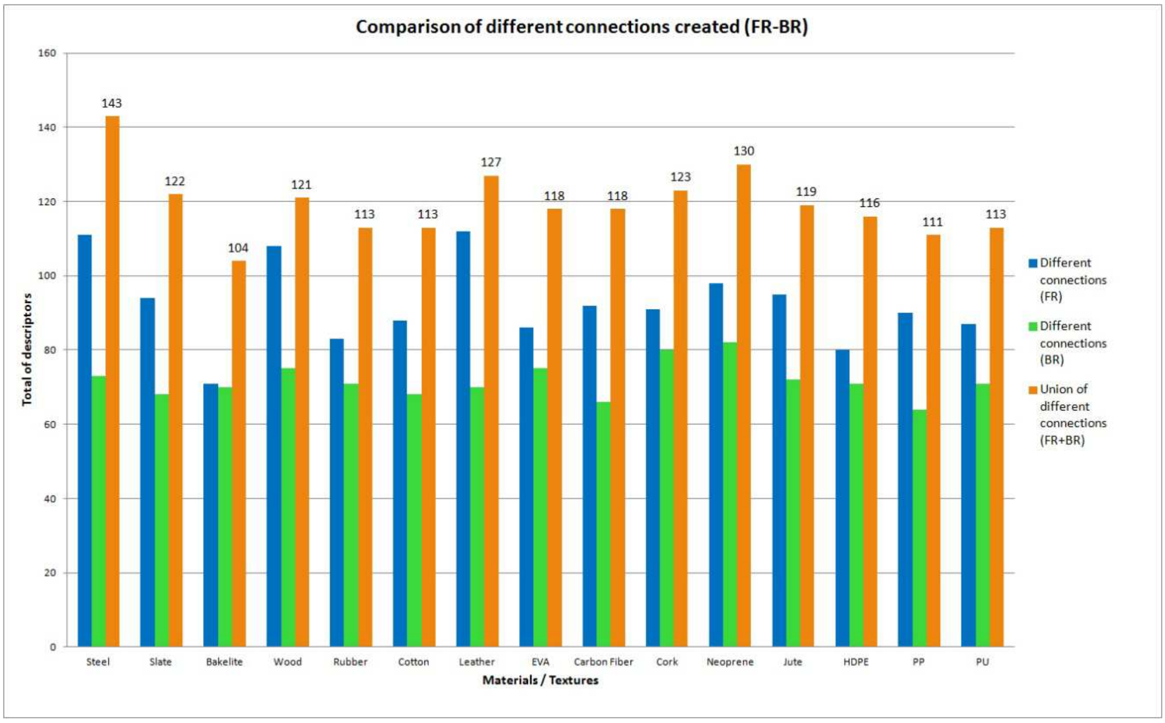

Figure 4: Total number of different connections created for each texture.

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).

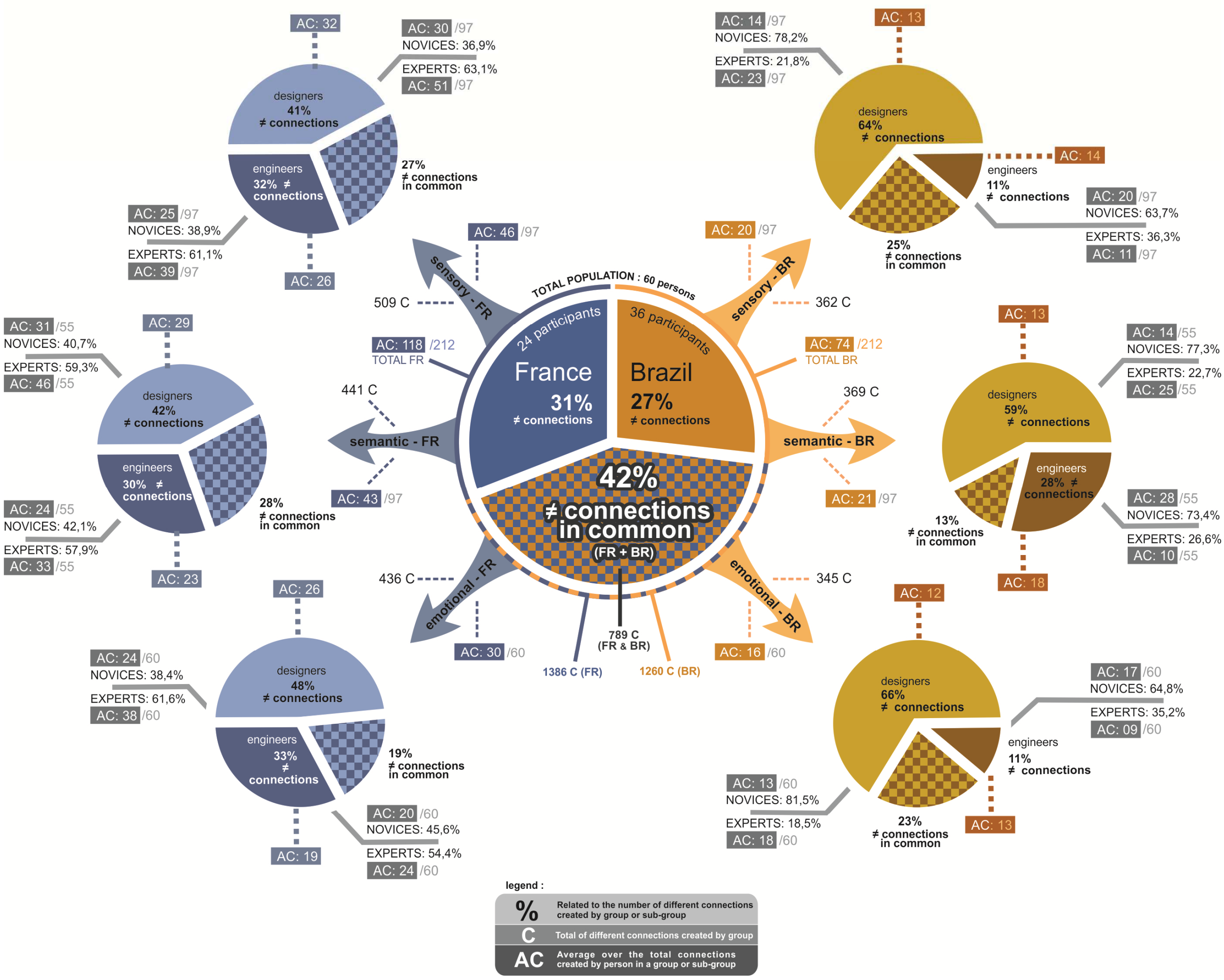

Figure 5: Subjective assessment of Kansei – Texture connections – established due to the occupation and the expertise of a population in a kitchen utensil context.

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.

Frequency of positive and negative emotions																
Materials ►	Steel	Slate	Bakelite	Wood	Rubber	Cotton	Leather	EVA	Carbon fiber	Cork	Neoprene	Jute	HDPE	PP	PU	
Textures ►																
FRANCE	negative	positive	negative	positive	negative	positive	positive	negative	positive	positive	positive	negative	negative	negative	positive	
Σ ►	24	22	19	26	28	20	27	25	20	24	26	33	25	31	27	► (max. 60 emot.)
BRAZIL	positive	negative	negative	positive	negative	positive	positive	negative	positive	positive	positive	positive	negative	negative	positive	
Σ ►	18	19	22	18	19	13	16	23	15	20	21	25	19	21	21	► (max. 60 emot.)

Legend: positive = rather positive emotions; negative = rather negative emotions; Σ number of diff. emotions (pos. and neg.)

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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