Integration of Affective Engineering in Product Development Processes

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Abstract

Due to globalisation and strong development of emerging markets today's buyers have the choice of an almost infinite number of similar products with comparable performance and function. Products in these markets must be innovative and at the same time recognizable by the customer. Most manufacturers therefore use customer research instruments for integration of affective values in products. However, in many companies this process is unstructured and unorganised. This brings a couple of risks in lauching these products. In this paper an integrated approach is presented for objective-subjective co-design. A model will be presented how technical and emotional attributes interact with each other. Moreover, opportunities will be presented how affective method can be integrated in common product development processes in European industry.
Also examples will be given for successful products in these sector.

Introduction

Due to globalisation and strong development of emerging markets today's buyers have the choice of an almost infinite number of similar products with comparable performance and function. In order to be successful in these markets manufacturers must ensure that their brand(s) and products are recognizable by the customers. At the same time products have to be innovative and attractive to the customer. Weighing these two points against each other is crucial since products with a lack of innovativeness as well as products with too many new features are likely to fail.
Most manufacturers therefore use customer research instruments in order to find out what features to include in new product generation and how the potential customer group feels about those alterations. The purpose is to value add the products and make them worth of its price to the customer.
Adding value to products can in principle be done in different ways. One possibility is to add physical value e.g. enhanced functionality, new features etc. to the product, i.e adding objective attributes. This is a reliable method to attract customer attention. On the other hand it makes the product more complex and expensive. Another possibility is to add affective attributes to the product. This can be done by a more modern design, using novel technical solutions and orient the product towards up-to-date lifestyle. Such a product hitting the market on the right time can be tremendously successful. However, there is a certain risk involved, since not many methods are in existence which can cope with affective customer needs. In this paper an integrated approach is presented for objective-subjective co-design.

Figure 1: Example of Products with physical an affective value adding (source: Electrolux)

Product development methods usually can cope with adding physical value in a structured way, however, adding affective value is often based on subjective intuition of a few specialists in the company. This can work, but not involving everybody in the product development team can lead to reduced consensus about the affective value of the product. Moreover, in case the product fails due to a lack of affective value it is difficult to trace back the failure and modify the product accordingly. Consequently, it is necessary to introduce methods able to cope with affective values and introduce those methods into existing product development processes.

Aim

The aim of this paper is to present methods which can handle integration of affective values in new products and suggest possibilities how to integrate affective customer needs in product development processes.

Affective Product Development

The academic approach started in different disciplines in the 1990ies. Industrial design, mechanical engineering, psychology and ergonomics are some of them. Consequently, many different names evolved. Such are: Emotional engineering/design, Design for pleasure, affective design/engineering, Kansei Engineering etc (ENGAGE, 2005). In 2004 a European network (ENGAGE) was started. One of its purposes was to gather all these approaches under one umbrella in order to form one single research area. The most common names today might be Emotional/Affective Engineering/Design and Kansei Engineering. The ENGAGE network had originally some 21 organisations from 9 countries in Europe, mainly universities, research institutes and multi-national industries.

with a joint focus of incorporating users' emotional needs into product design. Presently The outcome was the formation of a knowledge community under the roof of the Design and Emotion Society homepage (www.designandemotion.org). More then 50 tools for affective evaluation have been collected reaching from simple data collection tools to sophisticated design strategies. Linköping university contributed with a computer software able to collect raw data and perform Kansei Engineering evaluations. All tools have in common that they aim to bridge over the gap between user design and manufacturing (Park- Dahlgaard, 2007).

Integration of Affective Methods in Product development processes

From a more general perspective each product can be seen a function f that transforms the design parameters x_d into the system characteristics y, as in f (see **Error! Reference source not found.**).

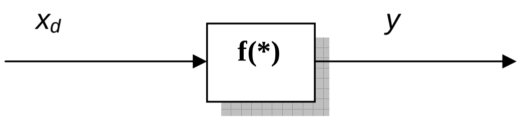

Figure 2. The product as a function that transforms design parameters into system characteristics.

One example could be a hydraulic braking system. The design parameters such as piston size, line parameters, etc. are be chosen by the product designer. Based on this choices the system produces a certain response such as braking force, pedal force, time delay, etc. The designers task is to chose the design parameters in a way that they comply as good as possible to target values stipulated in a product specification document. This is usually an iterative process requirering experience and professional skill.
However, the system response has only to meet both functional demands but also and affective customer demands. In case of the hydraulic braking system functional demands could be stopping distance of the vehicle. One affective demand of the driver could be good control of the breaking force and the impression of safety. Hence, the system characteristics can be divided into traditional technical characteristics and subjective affective charateristics (see **Error! Reference source not found.**).

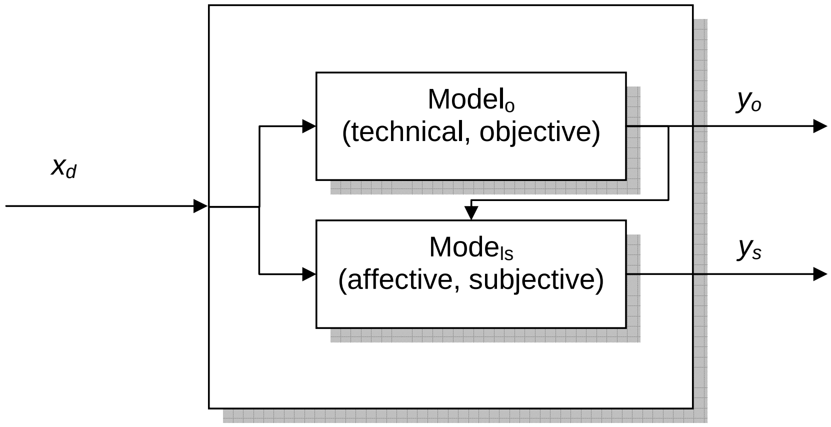

Figure 3. The model decomposed into a objective and a subjective part.

The figure above shows how the function presented in **Error! Reference source not found.** can be decomposed into a technical model and an affective model. Both parts together fulfil the target. Also the technical attributes of the product have a certain impact on the affective attributes. For the breaking system this means that choosing an actuator piston with a wider diameter (design characteristic) will decrease the breaking force (system characteristic). This does not only change the technical model of the system but also the affective model since the resulting higher break paddle force is experienced as less safe and providing less control.

Identification of Affective Model

The area of integrating affective values in artifacts is not new at all. Already in the 14th century philosophers such as Baumgarten and Kant established the area of aesthetics. In addition to pure practical values, artifacts always also had an affective component (Baumgarten, 1961; Kant, 2004). One example is jewellery found in excavations from the stone ages. Also the period of renaissance is a good example of that.
In the middle of the 19th century, the idea of aesthetics was deployed in scientific contexts. Charles E Osgood developed his Semantic Differentials Method in which he quantified the peoples' perceptions of artifacts (Osgood et al., 1957). Some years later, in 1960, Professors Shigeru Mizuno and Yoji Akao developed an engineering approach in order to connect peoples' needs to product properties. This method was called Quality Function Deployment (QFD) (Akao, 1990). Another method, the Kano model was developed in the field of quality in the early 1980s by Professor Noriaki Kano, of Tokyo University. Kano's model is used to establish the importance of individual product features for the customer's satisfaction and hence it creates the optimal requirement for process oriented product development activities (Kano et al., 1984). A pure marketing technique is Conjoint Analysis. Conjoint analysis estimates the relative importance of a product's attributes by analyzing the consumer's overall judgment of a product or service (Green and Rao, 1971). A more artistic method is called Semantic description of environments (Swedish: Semantisk Miljöbeskrivning, SMB). It is mainly a tool for examining how a single person or a group of persons experience a certain (architectural) environment (Küller, 1975).

Although all of these methods are concerned with subjective impact, none of them can translate this impact to design parameters sufficiently. This can, however, be accomplished by Kansei Engineering. Kansei Engineering (KE) has been used as a tool for affective engineering. It was developed by Professor Mitsuo Nagamachi in the early 70ies in Japan and is now widely spread among Japanese companies. In the middle of the 90ies, the method spread to the United States, but cultural differences may have prevented the method to enfold its whole potential (Nagamachi, 1989).

Kansei Engineering

The expression Kansei has its origins in the Japanese language. It was used when Kant's work was translated from German into Japanese and it means roughly "sensitivity/sensibility". When in the 1970ies research was conducted in Japan on integration of affective values in products, this research was mainly referred to as "Emotional Engineering" (compare: e.g. (Nagamachi, 1989). In the 1980ies the method spread rapidly in the Japanese car industry and in 1986 the president of Mazda called the technique used "Kansei Engineering" (Nagasawa, 2002). Under this term the methodology spread to Western industry.
In Europe, there had been some development in this area too. However, there is a major difference how Kansei Engineering is used in European context. In Japan integration of affective values is a product development philosophy. Often it is a top-down process where the intended affective impression is a center part of the design requirements (Nagasawa, 2002). In Europe companies often apply bottom- up processes in order to achieve the "right" impression. In this way Kansei Engineering is used as one tool out of a number of different other tools. This makes it possible to easier integrate it in already existing European product development processes (Schütte, 2007).
Figure 4 shows how Kansei Engineering works in principle.

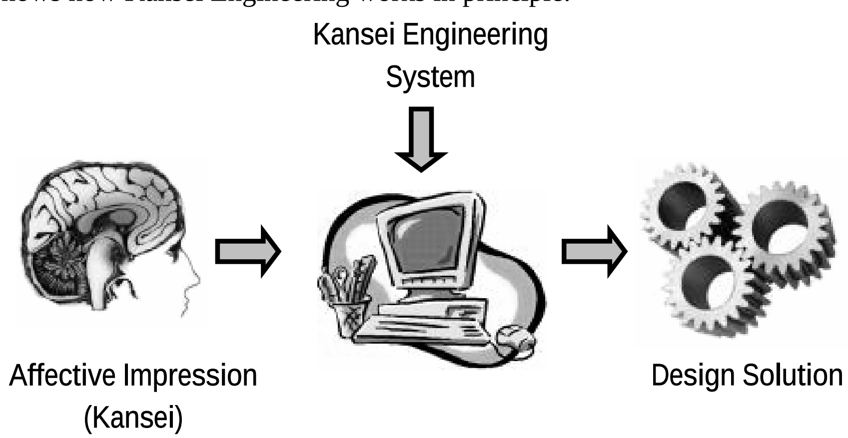

Figure 4: Kansei Engineering System (KES) adapted from (Nagamachi, 1995).

Kansei Engineering can collect the affective information of a tangible of intangible product. It then uses mathematical statistical methods in order to identify design solutions which correspond to the intended affective value. In Japanese publications, different types of Kansei Engineering are identified and applied in various contexts. Schütte

(2005) examined different types of Kansei Engineering and developed a general model covering the contents of Kansei Engineering. This model is presented in Figure 5 below.

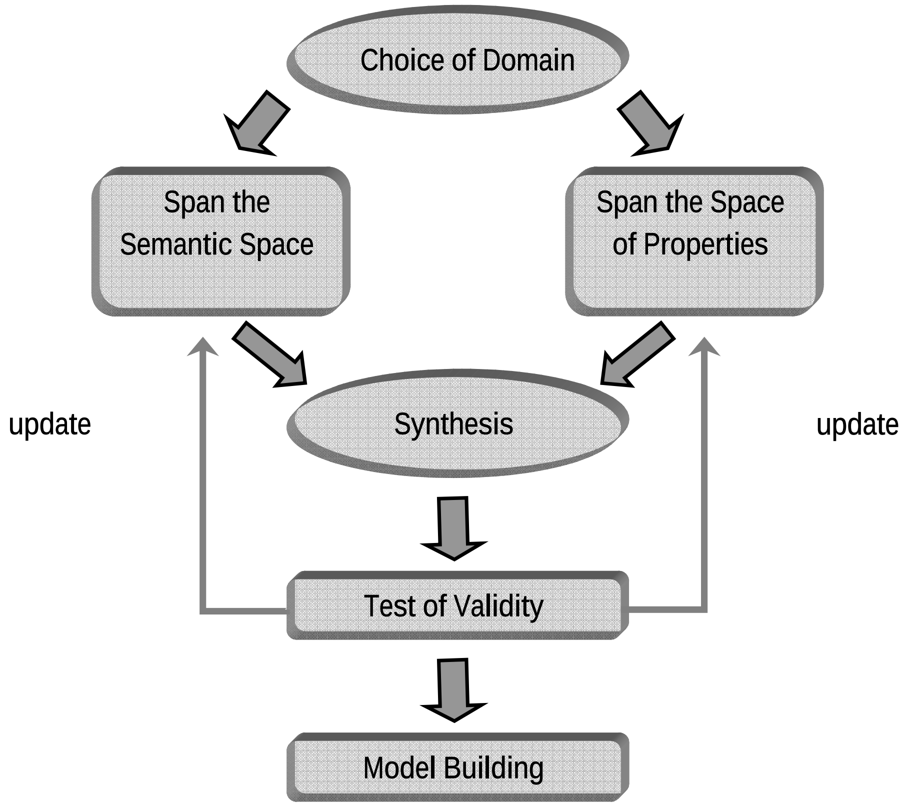

Figure 5: A general model on Kansei Engineering (Schütte, 2005).

Based on a chosen domain the idea behind the product can be described from two different perspectives: The semantic description (Osgood et al., 1957); and the description of product properties (Schütte, 2006). These two descriptions each span a kind of vector space. Subsequently these spaces are analysed in relation to each other in the synthesis phase indicating which of the product properties evokes which semantic impact and vice versa. After these steps have been carried out, is it possible to conduct a validity test, including several types of post-hoc analyses. The two vector spaces are updated and the synthesis step is run again if necessary. When the results from this iteration process appear satisfactory, a model (qualitative or quantitative) can be built describing how the Semantic Space and the Space of Properties are associated.

Integration of Affective Models in Product Development Processes

Application of Affective Methods in Coopers Stage Gate model

Many companies use a Stage-Gate model. As a standard product development stage gate model Cooper (1998) can be quoted with his model portrayed in Figure 6. Within each stage an exactly defined part of the product development process is carried out and subsequent reviewed by the project steering committee. If the result is sufficient the project may pass the gate and continue, otherwise it is sent back for revision or rework. The Stage-gate process model allows an identification of point in time when Affective Engineering data has been found to be most useful for the product development process (Antoni and Schütte, 2002).

In particular the Kansei Engineering methodology has been applied on the product at different levels and at different stages in the product development process. A macro-level investigation was used on whole product concepts, whereas micro-level examinations are used for detailed studies on product parts after the concept is specified and follow-up investigations, which give feedback to the earlier stages of the process. These three types can be recognized in the stage-gate model in Figure 6.

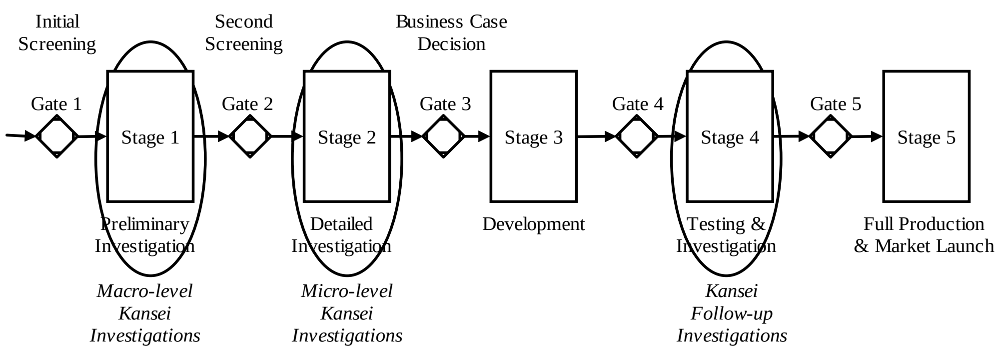

Figure 6: A Stage-Gate process for product development, adapted from (Cooper, 1998).

During the Preliminary investigation stage a quick investigation can be conducted, which will result in a large number of potential Kansei Engineering projects. This is based largely on desk research and therefore inexpensive. Kansei Engineering data from rough macro-level examinations on different competing products can be a valuable information source for the pre-selection of product concepts.

In the second stage a more detailed investigation is carried out. Typically market studies are included and Kansei Engineering can support the forthcoming decisions by focusing more carefully on selected product parts (micro-level investigations). After this point the actual development process is started. Kansei Engineering data can even support this process by making the designers aware of the Kansei their work may evoke.

In the following testing and investigation stage (follow-up investigations) Kansei Engineering is able to reveal whether the new product will fulfill the requirements regarding emotional impact or not. At this point small changes like color setting, tuning parameters or changing minor modules can still be made (Antoni and Schütte, 2002).

Affective Data in QFD

"Quality Function Deployment" (QFD) is a common method used in product development processes. It if often performed in the early stages for concept generation. QFD uses customer demand data as an input. It than can connect the customers needs to the product properties. In this way it is possible to prioritize the product properties, make competitors comparisons and allocate production resources (Cohen, 1995). The central part of QFD is often called the "House of Quality"

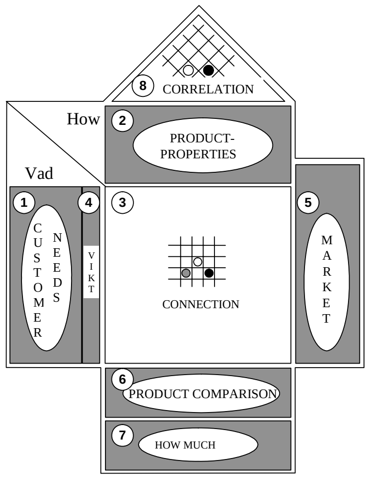

Figure 7: House of Quality.

Firstly, customer needs are identified using different types of customer surveys (field 1) and weighted according importance (field 4). Than relevant product properties are found and inserted in field 2. A group of experts than establishes the connection between both groups by setting no, weak, medium or strong connection. Using simple arithmetic the importance of each property can be calculated.

Both KE and QFD have a role in product development. By using QFD customer needs can explicitly be integrated in the product development process leading to innovative solutions. The goal is the same, whereas the input data are different. Whereas QFD input data derived from objective customer needs such as ergonomics, functionality, durability etc., Affective data is more abstract. However, it has been shown that combination of QFD and Kansei Engineering is possible. The "backward" Kansei Engineering, a special type of KE can provide a feedback loop, evaluating if the generated concept is acceptable or not (Kammerlind and Schütte, 2001). Also Kansei Engineering output data can be fed it into the house of quality as customer needs can reduce required resources (Kammerlind and Schütte, 2001).

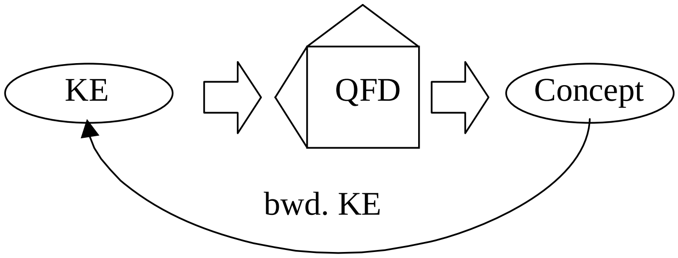

Figure 8: A combination of Kansei Engineering and QFD.

Discussion and Conclusions

Most consumer products are competing in difficult markets. Users demands are steadily increasing. One of the more recent customer demands are affective values as an ingegral part of the products. However, the integration of those affective values in product design processes is often unorganized and spontaneous and reduced to artistic design. Many engineering designers do in fact care more about functionality then affective value
The different groups within the product design group often use jargon and technical terms differently due to their different educational background. Even if they think they understand each other this is not always the case. Many engineers prefer to communicate using diagrams, and figures, managers emphasise the human organisational side of product development, marketers focus on sales and customer demands. Hence it is necessary to use methods which can grasp and document affective values of products and communicate it to all different groups.
Companies can win from integration of affective methods in product design. An organized approach can enhance communication by reduction or elimination of confusion and thereby shorten development times and consequently costs. Moreover, it can significantly help to avoid unsuccessful products and reduce the risk of failure for new products based on novel technology.. Improved communication and documentation of the affective features in products will also shift work forces' attention more towards customer focus
Although Affective Engineering and customer focus is an integrative part in product development these methods are in Europe only a supplement in product design. Concrete steps to be taken for successful integration of Affective Engineering methods are presumably based on already existing procedures in companies. As shown, these methods can be closely connected to already existing process parts such as QFD, Conjoint Analysis etc. Also, using these methods in the right stages of product is crucial for the success of the product. Affective Engineering methods are proven to be most effective if they are used in the early stages of product development. Also verifying studies just after product launch can give useful information for follow-up and new concept generation.

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