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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.

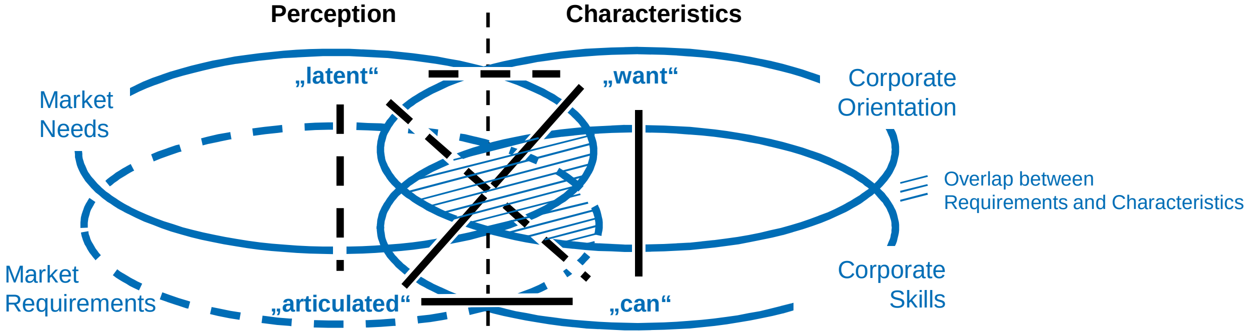

Figure 1: Understanding of Perceived Quality

(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.

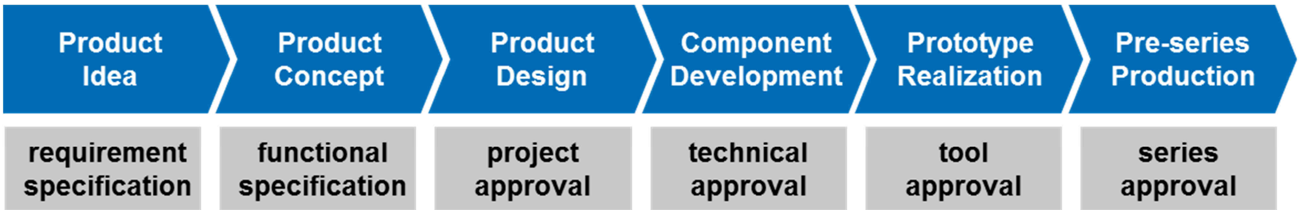

Figure 2: Phases of the PDP (based on Ehrlenspiel, 2009; Beaujean et al., 2011)

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.

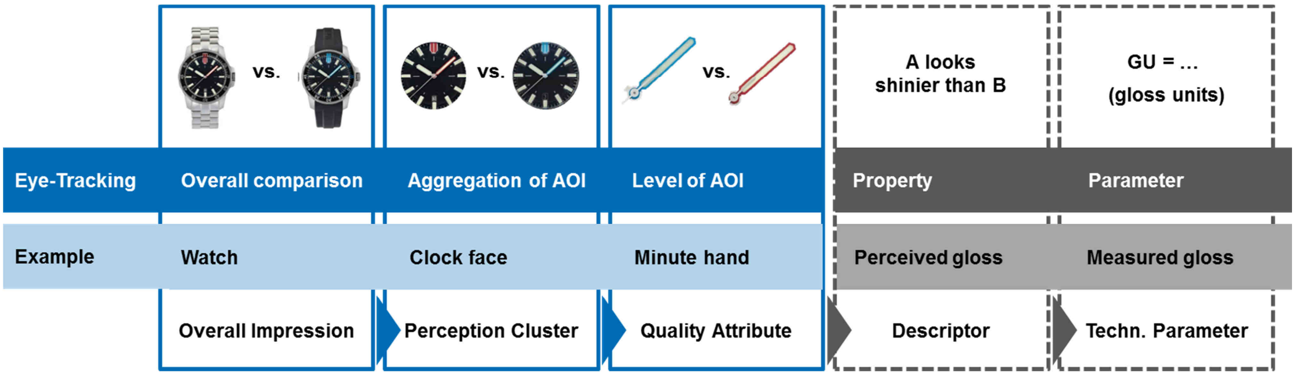

Figure 3: Study design corresponding to the different levels of perception (based on Schmitt & Pfeifer, 2010)

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.

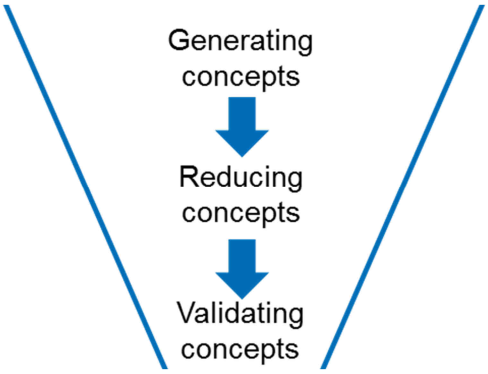

Figure 4: Generating and reducing the semantic framework

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)

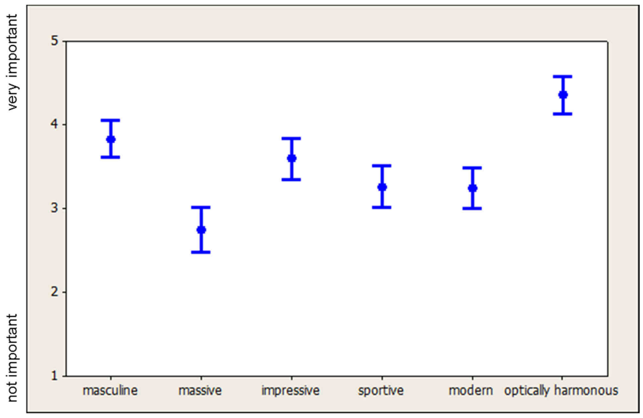

Figure 5: Importance of semantic concepts

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).

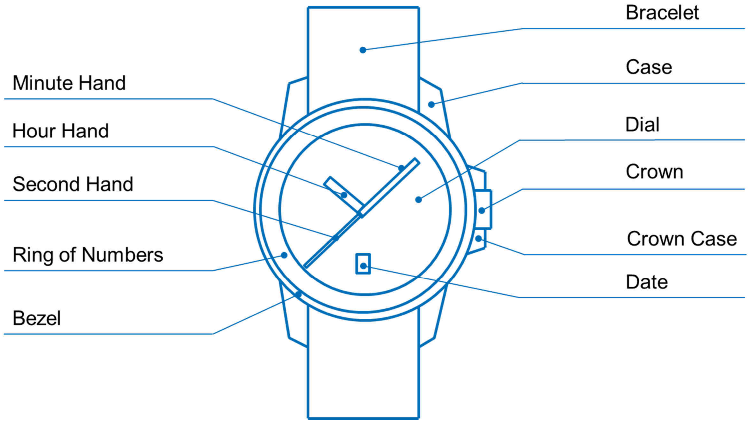

Figure 6: Definition of areas of interest

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)

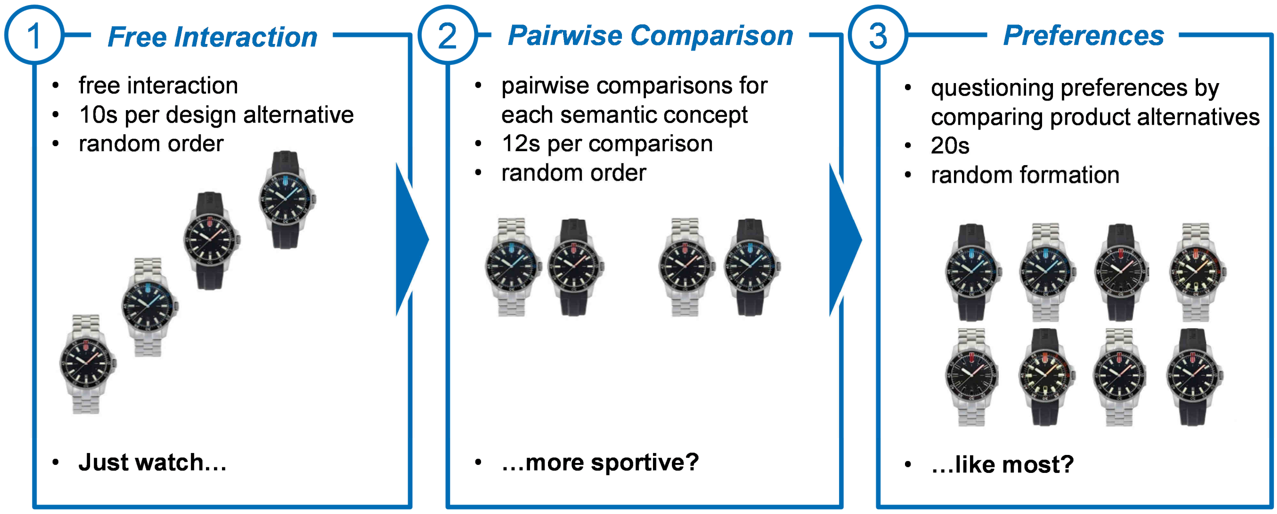

Figure 7: Phases of the Eye-Tracking study

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 ($p_{Greenhouse-Geisser}$ =.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).

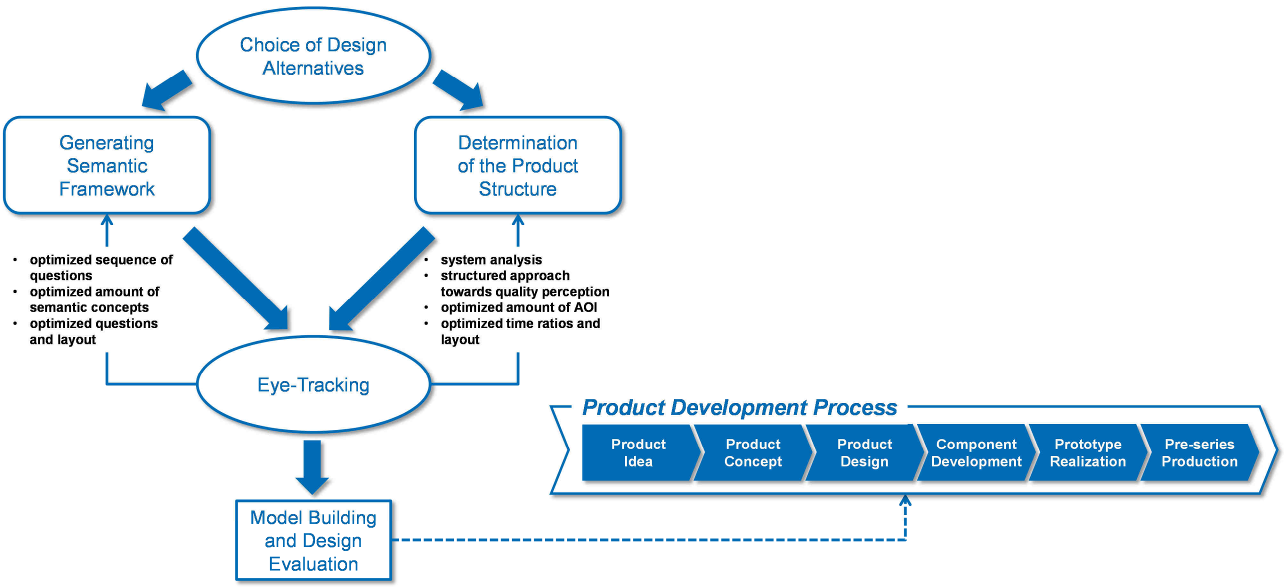

Figure 9: Extending Kansei Engineering for design evaluations in PDP by Eye-Tracking (adapted from Schütte, 2005)

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.

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