Engineering Emotional Values in Product Design

-Kansei Engineering in Development

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Abstract

Feelings and impressions of a product are important for the decision of purchasing it or not. Designing attractive products therefore requires knowledge about the feelings and impressions the products evoke on the customer and the user. Integrating such affective values in product design requires the introduction of suitable methods into companies' product design processes, methods which can capture and convert subjective and even unconscious feelings about a product into concrete design parameters. This is sometimes referred to as 'Affective Engineering'. One methodology in this context is Kansei Engineering, which has been developed in Japan in order to design feelings into products. The aim of this thesis was twofold: Firstly, to improve understanding of the nature of products making emotional impact on the users and customers. Secondly, to identify and improve methods capable of grasping those affective values and translating them into concrete product design solutions. This thesis presents three empirical studies and two methodological papers, relating to warehouse trucks and laminate flooring. The first study was made on user impact of warehouse trucks in three different European countries. A second study dealt with affective values of rocker-switches in work vehicles, such as warehouse trucks. A third study on this truck type compared the old manoeuvring panel evaluated in the previous studies with a newly introduced manoeuvring panel in order to validate the impact of the design improvements made after the first study. Further, a conceptual model on Kansei Engineering methodology was proposed in a methods paper based on the experience from the studies performed in order to provide a structure for performing Kansei Engineering studies. The fifth paper had the purpose of validating and improving the proposed model using laminate flooring as research object. More structured ways of identifying design parameters and relevant product properties was given high priority in the improvement work of the methodology. A model for spanning the Space of Product Properties was presented and applied. This thesis also deals with other improvement areas in the methodology and proposed new developments, including the use of scales, experimental design and validation methods. In conclusion, Kansei Engineering is a concept and a methodology in strong development, a framework in which tools and methods are continuously developed, added and integrated.

Acknowledgements

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Linköping June, 2005

Simon Schütte

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Appended Papers

Paper A: ***Comparing the User Impact of Warehouse Truck Design in Europe***

SIMON SCHÜTTE AND JÖRGEN EKLUND

Published in 'Arbete Människa Miljö' 1/2003, pp. 38-50, and presented in an earlier version at 'Conference on Human Affective Design', Singapore, 2001.

Paper B: Design of Rocker Switches for Work Vehicles

SIMON SCHÜTTE AND JÖRGEN EKLUND

Accepted for publication in 'Applied Ergonomics', 2005 and presented in an earlier version at 'NES-Conference', Reykjavik, Island, 2003.

Paper C: Affective Values of Lift Trucks - an Application of Kansei Engineering

SIMON SCHÜTTE, RILDA SCHÜTTE AND JÖRGEN EKLUND

Accepted for publication in the 'Proceedings of QMOD Conference 2005', Palermo, Italy.

Paper D: Concepts, Methods and Tools in Kansei Engineering

SIMON SCHÜTTE, JÖRGEN EKLUND, JAN AXELSSON AND MITSUO NAGAMACHI

Published in 'Theoretical Issues in Ergonomics Science', (2004), Vol.5 (3), p 214-232, 2004

Paper E: Developing the Space of Product Properties Supporting Kansei Engineering Procedure

SIMON SCHÜTTE

Submitted for international publication

List of Abbreviations

AI	Artificial Intelligence
AVI	Analogue Visual Scale (compare VAS-scale)
BT	BT Industries AB. One of the worlds leading manufacturer of warehouse trucks.
CA	Conjoint Analysis (see Appendix C)
CS	Category Score (compare QT1)
EEG	Electro-Encephalo-Gram (Measurement of brainwaves)
EMG	Electro-Myo-Graphy
HMU	Human Machine Unit. Mazda concept (see Appendix E).
KE	Kansei Engineering
KES	Kansei Engineering System (see Appendix E).
KEW	Kansei Engineering Word (see Section 7.3.3)
KW	Kansei Word (see Section 7.3.1)
MCC	Multi Correlation Coefficient. Similar to R value in linear regression (compare QT1)
PCC	Partial Correlation Coefficient (compare QT1)
PD	Product Development
PSI	Physical Structure Identification (see Section 7.4 and Appendix B)
PI	Proximity of Interaction (see Appendix B)
RI	Relationship Identification (see Section 7.5 and Appendix B)
SD (Scale)	Semantic Differential (Scale). Invented by Osgood (see Appendix C).
SMB	Semantik Miljö Beskrivning, Semanic decriptions of environments. Method within Affective Engineering (see Appendix C)
SSI	Semantic Structure Identification (see Section 7.3.3 and Appendix B).
VAS	Visual Analogue Scale (compare AVI-scale) (see Section 8.2.1)
QFD	Quality Function Deployment. Method within affective quality work (see Appendix C)
QT 1	Quantification Theory Type 1 (see Section 7.5 and Appendix B)

Before Reading

This thesis is one of the first works written in English addressing the field of designing affective values into products and Kansei Engineering. It is assumed that some readers wish to make quick reference to certain parts of the thesis. Hence, the thesis is structured ‘modular’ in order to allow easy access. Some comments regarding the disposition might therefore be useful in order to facilitate the reading of this thesis. It consists of two main parts: a compilation and summary of research findings, and appendixes including published articles.

The purpose of the first part is to present a holistic picture of the research and to relate the research findings to theory. In chapter 1 and 2, the reader is introduced to the research field of integrating affective values in products. Methods in the field are presented briefly, followed by the aims of the thesis in chapter 3, and methodology for the research in chapter 4. Kansei Engineering methodology is explained more in detail in chapters 5-6. Chapters 7 and 8 are summarising the research findings from the authors’ publications including a proposed model on Kansei Engineering methodology and experiences from applying the methodology in Swedish industry. Chapter 9 discusses the findings and conclusions are drawn in chapter 10.

The second part, the appendixes, include complementary material giving a more detailed background picture of the area of knowledge. It is divided into five parts:

- Appended papers published by the author
- A guide to tools in Kansei Engineering
- Other methods for measuring affective values in products
- A guide to literature within the field of Kansei Engineering
- An in-detail description of the different Types of Kansei Engineering

Since the area of research is rather new and yet not clearly labelled, many sources are difficult to find through keywords. Also, many important sources are published in Japanese or Korean language. Hence, the appendixes are relatively voluminous in order to guide also readers with a deeper interest.

1.
Introduction
はじめに

This chapter introduces and makes the reader familiar with the topic. It explains why it is necessary to integrate affective aspects into product design and presents existing tools and methods in short. The field of research is quite new, and a part of this chapter also deals with today's definition of it. Finally, affective aspects in the field of quality are shown and the research partner, BT Industries AB is presented.

1.1. Customer Needs in Future Products

During the recent decades the production capacity of consumer products has increased in a never before seen scale. New national and international actors arise and world's markets are globalizing at high speed. Changes therefore play a more important role leading to shorter life cycles of products than before, see Brown and Eisenhardt (1998). Shorter life cycles mean shortened development time of new products and in combination with hard competition it also entails an increased focus on cost reduction (IVA, 1999).

At the same time occurring new techniques such as Internet and mobile communication, flat TV-screens etc., allowed the development of previously unthinkable products but also forcing manufactures to fast adaptation of product development and production methods (IVA, 1999). Also, new customer demands arise due to improved cognitive ergonomics and education for highly advanced products. Another effect is that new products also become mature more quickly and must be followed up more frequently starting the Plan-Do-Study-Act (PDSA)- circle, a tool for constant improvement in the sector of quality over and over again (Deming, 1986).

Together with an increasing demand for higher product quality the situation becomes even more complicated; products must have higher performance, better function and they must be developed faster.

Another challenge for companies is even more crucial for companies in these markets. Strong 'supertrends' such as hedonism, spirituality, downsizing and individuality

(Jordan, 2001) abandon the traditional focus on functionality and concentrate on 'softer' issues such as Hedonic Ergonomics in design and Pleasurable Products and Interaction (Helander, 2001)

Even if it seems so, today's market situation is not completely new. Industry has been challenged many times before and adapted by adopting new ways of working. One way of improving market shares on markets full of mature and similar products is to make their product 'edgy', i.e. easily recognisable and typical for the brand.

Industry coped with these demands though more active integration of the customers opinions in the designing phase. In the 1950ies and 1960ies the quality movement was born. Although functional aspects were in focus in the beginning, usability and intangible product characteristics soon became more important the early 1980ies (Childs, 2004).

Today's development probably goes towards integration of emotional values in products. Products must appear independent reflecting an individual life style. Also, if the customer has the choice between products from different manufacturers, which are equivalent in price and performance a consciously build in 'good feeling' can trigger the final purchase decision.

Consequently, it is the customer's emotional needs which primarily must be taken care of. For integrating the voice of the customer different methods exist for industrial use (Bergman and Klefsjö, 1994), but when it comes to measurements of emotions, impressions and pleasure, methods are very rare. So research is needed and in the recent years new research directions such as 'Emotional Design', 'Affective Design', 'Affective Ergonomics', 'Pleasure with products' etc. have appeared (ENGAGE, 2005). All these research directions have in common that they try to grasp the customer's and users' personal impression and make it describable or even measurable in order to evaluate product solution according to their emotional impact.

However, as these research directions are not interconnected, one could say that there is a great need for methods, but the research is still in its infancy. It is surprising that there is not more research done on this area since we as human beings apparently have quite little knowledge about how we interact affectively with products (ENGAGE, 2005).

Helander (2001) identifies the most urgent research needs. Firstly, the measurement issues and theory formation must be addressed. Secondly, it must be possible to predict user/customer needs for affect.

In 2004 a European project was started under the name ENGAGE for just these purposes. Its goal is to form a knowledge community involving all research directions in order to define the content of the new research field to be formed.

1.2. Labelling the Field of Knowledge

The emerging research field is currently addressed by many names. The ENGAGE network lists and define some of the labels which have been used in the area:

- Emotional Engineering
- Affective Design
- Affective Engineering
- Affective Ergonomics
- Design for experience
- Pleasure with products
- Design of metaqualities
- Design for human senses
- Kansei Engineering
- Sensorial Engineering

(ENGAGE, 2005)

The discussion is currently not finished about what the new area will be called but it is clear that the current lack of agreed terminology must be overcome in order to promote it properly. When looking on the definitions behind the denominations above it becomes clear some are more general than others and therefore more suitable. Within the ENGAGE network also the hierarchy of the different labels will be defined in order to identify suitable candidates.

The Keyworth Institute in Leeds/GB attempt a definition. ‘Affective engineering is the study of the relationships between physical and rational products features and their subjective cognitive or emotional influences on the people interacting with them, and the use of the knowledge gained to design more satisfying products’ (*www.keyworth.leed.ac.uk,* 2005). Using the term ‘engineering’ implies a ‘systematic approach that aims to integrate engineering, scientific and artistic approaches for the design and delivery of products’ (ENGAGE, 2005)

1.3. Methods in the Area of Affective Product Design

The idea of integrating values related to user impression into products is not entirely new. It developed gradually since the early 1970ies after an almost 20 year long period of economic growth in Europe which started when the damage from the Second World War was repaired.

New competitors emerged foremost from outer-European countries. Since markets were saturated the strategy of producer-controlled supply did not work any more and the need for new product development strategies became obvious.

Hence, in the late 1970's companies began integrating customer-oriented techniques into their product development processes. Companies made their production more efficient and spent more effort on quality management. As a consequence the variety of products increased and the quality of the products improved driven mainly by competitive pressure from Japan (Juran et al., 1974).

Measuring the customers voice in combination with highly flexible production-systems made it possible from the early 1990's onwards to satisfy the wants of even selective customers with individual taste and high demands on quality, adaptability and personalisation.

Constantly shifting trends in customer demands require new or improved tools integrating even affective aspects into product development. Such methodologies are e.g.:

- Semantic Differential Methods (Osgood et al., 1957)
  The Semantic Differential Scales SD- Scales are a political instrument for measuring the affective impact of political streams on the citizens mind. This tool can also be used in a modified version for product development.

- Conjoint Analysis (Green and Srinivasan, 1978)
  Conjoint Analysis is a monetary tool. It is designed to ascertain how much money the members of a target group are willing to spend on certain product features.

- Semantic Description of Environments (SMB) (Küller, 1975)
  Semantic Description of Environments (in Swedish: Semantisk Miljö Beskrivning) designed as a method for evaluating architectural structures

according their aesthetic appearance. This method originally addressed artistic non-commercial interests.

- Quality Function Deployment (QFD) (Akao, 1990)
  QFD is an engineering tool developed in by Japanese Quality technology experts. It identifies relations between customers' (functional) needs and engineering characteristics.

- Kansei Engineering (Nagamachi, 1989)
  Kansei Engineering is an engineering tool. It collects the users' emotional needs and establishes mathematic prediction models of how the emotional needs are connected to selected product properties.

In particular the last methodology mentioned, Kansei Engineering is of special interest, since it is the only tool especially designed for quantifying emotional customer needs and develop them into products. Kansei Engineering has probably come furthest in the pursuit of introducing engineering methods into implicit customer needs.

In contrast to other methodologies Kansei Engineering has the ability to collect and prioritize the customers' feelings and distinct customer groups with different 'tastes'. It also can collect the product properties which are most important to the user. However, what distinguishes Kansei Engineering from the method above is its ability to build mathematical prediction models on how feelings are connected to product properties.

1.4. Affective Quality Work

1.4.1. A Short History on Quality

The modern history of quality began in the 1920ies in the USA. Sheward and Radford stand for a systematic research on this area (Axelsson, 1999). They recognised, that good quality products supports sales. However, it was in Japan that the ideas were applied in full scale.

Quality thinking was introduced in Japan after the Second World War. Japanese society had been isolated for many decades before the Second World War and struggled with social problems caused by the new open society. Japanese industry saw itself confronted with the competition from the global market. A bad reputation and bad quality of the products made in Japan made them difficult to sell. However the Japanese learned quickly to take advantages of the changed situation and were open to new impulses from abroad. They began to manufacture foreign products under license and tried to improve their quality. Two Americans, W. Edward Deming and Joseph. M Juran played an important role in quality development.

In the middle of the 1970's Japanese companies had not only survived the challenges, but had grown stronger and produced products that were attractive to customers. The world depression made it possible for Japanese products to enter European and American markets, since customers ranked quality products at a reasonable price higher than brand-fidelity. It was mainly cars and cameras, which sold best but soon Japanese brands took over even big shares of the electronic market. European and American companies were forced to react, but the Japanese competitiveness could not be broken, even with increased import taxes on Japanese products. Many companies in the West became insolvent, the survivors adapted and integrated quality thinking into their organizations (Bergman and Klefsjö, 1994).

1.4.2. Evolution of the Concept 'Quality'

The word quality originates from the Latin word 'qualitas' and means 'of what'. In general usage it describes the property or the nature of things (Cicero, 2004). In an industrial context the definition of quality shifts depending on the context. Moreover, the expression 'quality' also underwent significant changes during the time of its existence. Originally, the word was strictly bounded to the area of production control. Nowadays it has become an everyday word in everybody's mind indicating everything from 'quality vacation' to 'quality time'.

In the 1950ies when the quality movement started the expression 'Quality' was used as a means of insuring good quality of goods in industrial production. Famous researchers in this era were names such as Crosby, Deming, Juran. They saw the task of quality in the following ways.

'*Conformance to customer requirement*' (Crosby, 1984)
'*Fitness for purpose or use*' (Juran et al., 1974)
'*A predictible degree of uniformity and dependability at low cost suited to market*' (Deming, 1986).
Later, the expression quality was also applied in other areas in industrial activities such as product development and after-sales. Moreover it was not only restricted to tangible products but also to intangibles (compare Section 2.4). The original ISO 9000 definition provides a direct connection between quality and the properties of a product:

Quality is '*the totality of those properties and characteristics of a product or an activity that relate to its suitability to fulfil stated requirements*.'

In the late 1980ies and 1990ies a new way of thinking was added, apart from the controlling tasks in industrial production. This was the customer perspective. A new expression occurred: 'perceived quality' (compare Zeithaml (1988)). For the first time it became possible to measure if the objective quality in production was perceived in the same way by the customer. With this, even the definitions had to be extended. Garvin (1988) drew eight dimensions of quality work, of which the first six were consistent with traditional quality work. New were the last two dimensions: aesthetics and perceived quality. These were new areas, where almost no tools existed.

1.Performance
2.Features
3.Reliability
4.Conformance
5.Durability
6.Serviceability
7.Aestetics
8.Perceived quality

Garvin summarised the two new dimensions in a single sentence:

'Quality is in the eye of the beholder!' (Garvin, 1988)

Others followed and definitions including affective values occurred and revealed connections to the field of ergonomics:

'*A product/service is of quality when it makes a maximum contribution to the health and happiness of all people involved in its production, use, destruction, and reuse*' (Aune, 1999)

Tribus defines quality in even more emotional terms: '*Quality is what makes it possible for a customer to have a love affair with your product or service. Love is always fickle. You must be ever on the alert to understand what pleases the customer, for only customers define what constitutes quality*' (Tribus, 1990).

Focusing on product development processes two aspects of the above presented definitions are of importance:

- Affective aspects (emotional impact of the new product)
- Design aspects (product properties)

It is hypothesised that affective impact on the user is consequently a result of the composition of the different product properties. Hence, the goal must be to choose the best combination possible in order to maximize the customer satisfaction. Figure 1 lists some quality dimensions of an article as it is seen by Bergman and Klefsjö (1994).

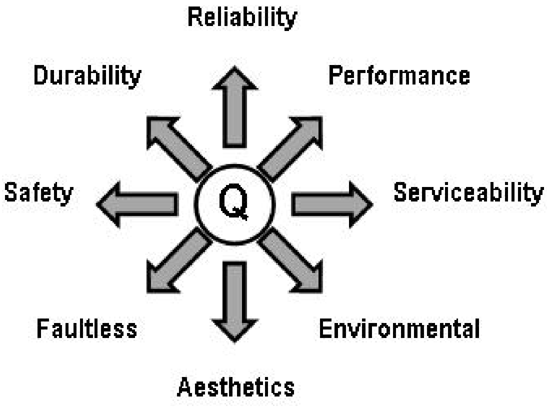


Figure 1: Some quality dimensions of an article (adapted from Bergman and Klefsjö (1994)).

1.4.3. The Kano Model as a Tool for Attractive Quality Creation

When Kano, Seraku and Takahashi carried out investigations on customer needs in the early 1980's, they discovered that customer needs could be grouped into different categories on different levels. This discovery led to the introduction of the basics of the model later called the Kano Model (Kano et al., 1984). Figure 2 shows the Kano model in its later version. The x-axis displays the degree of achievement and the y-axis the degree of customers' satisfaction with the certain type of achievement. Depending on the product property being considered, different function-characteristics can be obtained.

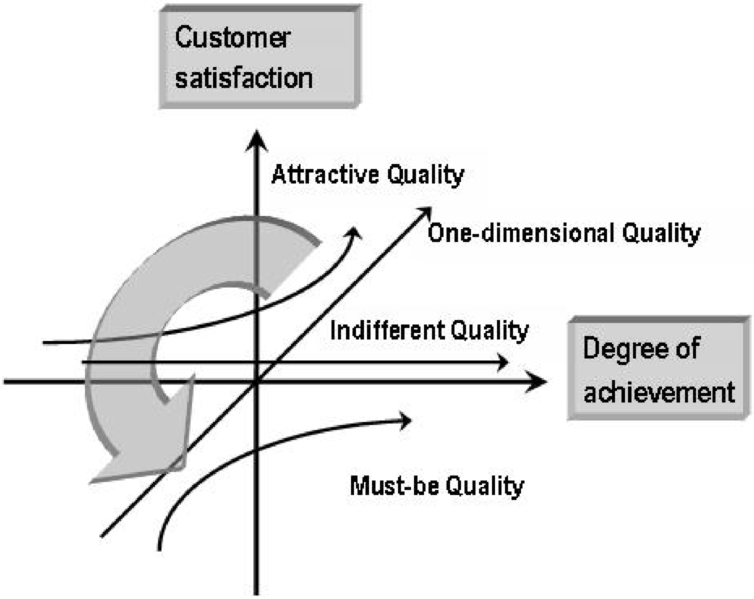


Figure 2: The Kano model (adapted from Kano et al. (1984)).

For example, basic demands like the electrical start of cars or automatic warming system in houses are considered a *must-be quality*. Often customers do not express these demands, since it is self-evident to them. Usually *one-dimensional* quality is expressed, i.e. special light metal rims or CD-player in cars, tiles in the bathroom, etc. The customer is aware that this type of equipment is not standard and expresses a desire for it. Manufacturers try to surprise the customer by adding a feature, which was not expected like a sponge for body gel, electrical heated side windows in a car, etc. This product property might be decisive for the customer buying the product. Particularly common products manufactured by many different companies can be made recognisable to the customer as common in this way. This is called an *attractive quality*.

Kano points out that almost every product property traverses a certain life cycle. When the property is newly introduced to the product the customer considers it an attractive quality. After a certain time the customer gets used to it and expresses it when purchasing a new product. In the end the feature becomes common and it can be found in almost every product. Then it has become ‘must-be quality’. Take the remote control for a TV-set as an example. In 1970 this feature was probably considered very attractive. Several years later practically all manufacturers could offer a remote controlled version of their TV-sets and the remote-control became a desirable feature (one-dimensional quality). Since the number of TV sets sold equipped with remote control was relatively low, it became a kind of status symbol too. Nowadays remote controls are standard. No TV set is sold without them any longer, since it has become an expected must-be quality. This is called the life cycle of product features and is indicated in Figure 2 with the bold arrow. As a consequence manufacturers must find new attractive features in order to make their products distinctive (Kano et al., 1984).

In the context of integrating feelings into products the Kano model is highly relevant. Most product properties have an emotional impact on the users mind and the producer's goal is to make it positive. Especially interesting in this context is attractive quality creation meaning that the user should become positively surprised about a certain feature. This of course is closely connected to the affect.

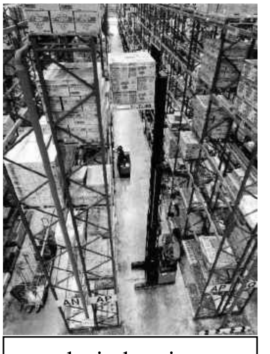
1.5. Industrial Partnership

In order to conduct the research presented in this thesis a number of studies have been carried out within the time period between spring 2001 and winter 2004/2005. However, only the minor part i.e. the most significant studies are presented explicitly in this thesis. Many minor studies have been conducted in cooperation with companies such as Electrolux, Hörnell International, Saab Automobile, Scania, , Volvo Tech (see www.ikp.liu.se/kansei).

However the majority of studies was done in cooperation with BT Industries AB. BT also financed a considerable part of the authors work.

1.5.1. BT Industries AB

BT Industries AB is located in Mjölby /Sweden. It is one of the leading manufacturers of industrial handling equipment and the worlds biggest manufacturer of electrically driven warehouse trucks.



www.bt-industries.com

BT was founded in 1946 as a construction and transportation company. Among others BT also imported industrial handling equipment and started one year later fabricating hand pallet trucks. Soon the manufacturing of handling equipment became the main focus for the new company. From this moment the company started a period of continuous growth. After a major reorganization in 1990 BT acquired Raymond, one of USA's biggest truck manufacturers. In June 2000 BT was bought by Toyota Material Handling Company and is now a part of the world's industrial handling equipment manufacturer.

1.5.2. Product Range

BT's product range stretches from hand pallet trucks to 5 ton diesel fork trucks. Moreover, it includes applications for horizontal transport, stacking, order picking, very narrow aisle, and combinations of these items (BT-Industries, 2003).

The product program is complemented with surround services, which include prophylactic and emergency maintenance in different forms, spare part supply, short- and long time rental, financing and driver education. These parts account for around 50% of BT's turn over, which is typical for this branch. (BT-Industries, 2003).

Trucks and services can be composed into individual packages adapted to particular purpose. Consequently, BT delivers in most cases not only the truck itself, but the combination of tangible and intangible sub-products.

1.5.3. Meeting Customer Demands at BT

BT Industries AB has experience in designing the customer's demands into their products; i.e. trucks and surrounding services. Adapting the services to the customer's demands is possible by tailoring the rental and service contracts individually.

Product development methods such as Quality Function Deployment (QFD) make it possible to collect the voice of the customer regarding a tangible product. Modularisation contributes to an easy change of components in order to suit the customer's demands. In addition, prototypes or parts of the new trucks are tested in field tests under real conditions, which gives valuable feedback from the actual users. Also BT works according to Toyotas product development system which at its core includes the concept of 'go and see', i.e. the staff visits places where BT products are used and can observe the usage and talk to the users (Schill, 2005).

1.5.4. BT REFLEX

The BT REFLEX is an electrical driven warehouse reach truck. Technically the REFLEX is a reach truck which is characterized by a seating position oblique to the driving direction in order to reduce the length of the vehicle. Together with a single wheel in the back this design allows better manoeuvrability than in conventional designs e.g. counter balanced trucks. Consequently, a narrow isle width in the warehouse can be realized. Another contribution to this is the retractable mast. The driver can move the truck in front of the stack lift the forks to the intended level then slide the forks into the pallet by extracting the mast and pick the load. This leads to an efficient handling and reduces the risk for damage of good or injuries. The REFLEX is on of BT's most technically advanced products and is manufactured in high volumes with good profitability.

1.5.5. Market Segmentation

The market for industrial handling equipment is strongest in industrialized countries. The total volume of this market was estimated to 600000 units in 2000, of which circa 40% are electrically driven warehouse trucks and around 50% are counter weight trucks. According to BT, the market for reach trucks can be divided into three main categories as shown in Table 1.

Table 1: Market segments for Reach Trucks (source: BT Industries).

Group	**I**	**II**	**III**
Frequency of use	Low	Medium/High	High
Ownership	Purchase	Rental	Rental
Lifting Height	Low/Medium	Medium/High	High
Driver Qualification	Layman/Professional	Professional	Professional
Operating Time	<700 h/Year	1000-3000h/Year	2000-3000h/Year
Sales in %	15%-20%	80-85%	

Group I is characterised by trucks with low frequency of use, used in small warehouses with a small number of employees working with various tasks. Material handling equipment in this sector must be easy to handle by everybody and universally applicable. Since the majority of these trucks are owned by the company the purchasers are relatively price sensitive. Group II and III are rental trucks with medium to high frequency of use. Those are typically operated in big warehouses under single or multiple shift conditions. In these cases the operators are professional truck drivers, requiring an adaptability to their personal working situation.

1.5.6. Productivity through Ergonomics

BT Industries supports joint long-term research in the field around productivity and ergonomics (PRODERGO). The founders of this project were Eric Berg, BT-Industries AB and Professor Jörgen Eklund, LiTH. Today this project includes three forms of cooperation.

The central pillar is cooperation largely based on the work of Ph. D. student, which also is the basis for this thesis. Often the projects are an integral part in the ongoing research work. Further, the cooperation includes project work by undergraduate students and 'learning laboratories' where the researchers and personnel from BT have joint seminars in topics relevant for PRODERGO at regular intervals.

2.
Definitions
定義

This chapter includes definitions of the most important expressions and concepts used in this thesis work. Several different sources are quoted and compared to each other, followed by a motivation of the authors choice.

This work is written in a way that it would not require pre-understanding of technical specialised expressions. However, the author is aware that parts may be hard to understand even for the initiated reader. In these cases a special dictionary can be of assistance.

On the other hand, certain expressions might be common and seem easy to understand, but in the context of this work they are used in a restricted sense, with a different perspective or focus than in other contexts. In order to prevent misinterpretations, misunderstandings or simply to make the reader aware of unusual nuances within certain expressions, some of the most central and most frequently used terms are defined here. Moreover, a list of abbreviations is also provided in the beginning of this book, hopefully facilitating reading.

2.1. Affect

Within the scientific area 'Affective Engineering' and 'Kansei Engineering' respectively the expressions 'affect' and 'affective' are used frequently and therefore hold significant importance. Hence, it is opportune to explain the expression itself and define its usage for this thesis.

A dictionary definition states that 'affect is an emotion or subjectively experienced feeling, or the involvement of such processes…'. Moreover, in abnormal psychology affect can also refer to 'emotional expressiveness' (Encyclopaedia Britannica Online, (2005).

The American psychologist Edward Titchener uses the term in a more specific way outside the mainstream. He refers to the concept of affect to a pleasantness-unpleasantness dimension of feeling (Titchener, 1998). This definition comes closer to the meaning the term is used in this context since also Osgood uses the assumption of a one-dimensional affect in his Semantic Differential-Scales (Osgood et al., 1957).

In his openscource project 'Passionate Engines' The researcher DeLancey, (2002) illuminates the concept of affect from a pragmatic angle. His concern is to utilize the findings for building an affective engine using Artificial Intelligence (AI). According to him, affect is a superior expression embracing all so called states. As states he defines desire, emotion, pleasure, moods, etc. He also disagrees with Titchener's concept of affect as bivalent and mono-dimensional. Instead he suggests an amorphous structure. DeLancey also makes a distinction between what he calls occurrent affect and disposition to affects. According to him occurrent affect is a current state, whereas a disposition to an affect is a description of which occurrent affect is caused in a certain context. Therefore he concludes that disposition to affect is derived from the concept of occurrent affect (DeLancey, 2002). This assumption can be strengthened by the discussion of another AI researcher. Rosalind Picard, says that emotional states can not be maintained over a long time (Picard, 1997) but can be stored latently in form of moods.

The expression concept of affect in this thesis is seen as an occurrent state, because the customer's immediate reaction on the products in question is of interest. Moreover, the author chooses to utilise Titcheners view on affect as a mono-dimensional variable in order to be able to use Osgood's SD-scales.

2.2. Affect vs. Emotion, Feeling and Mood

As mentioned before the expression affect and affective respectively are used frequently in this thesis. However, this expression automatically leads to associations or even overlaps with other expressions which also will be used in this work. A short discussion is required in order to avoid possible misunderstandings. The way the expressions are defined is not always the most common definition.

One major expression is the word 'emotion'. When trying to find a proper definition the author found many different ones, each of them context defined and more or less generally expressed. Kleinginna and Kleinginna (1981) did an intensive search on this topic and identified and categorised about one hundred different definitions. However even if it is not possible to present all definitions here, it is possible to define the differences and joint possessions of the concepts of 'affect' and 'emotion'.

'Emotion' is often described as the antithesis to reason (Damaiso, 1996). It was also he who proved this empirically and showed in his studies the importance of emotion for decision-making. In the context of affective engineering and AI, the term 'emotional' is often used equivalent with the term 'affective' (Picard, 1997). However, some specific definitions see emotions placed on an instinctive basic level, comparable to the sexual drive (DeLancey, 2002). This is not what is meant in this thesis. In order to avoid confusions the term emotion is mostly replaced by the term 'affective'. If the instinctive basic level of emotions is explicitly addressed the term 'sentic' is used. This term originates from the latin term sentire and emphasizes physical mechanisms of emotion expression (Clynes, 1977).

Another term appearing rather frequently within this research area is the word 'feeling'. Feelings can be seen as less subjective phenomena than emotions which rather evoke emotions than are emotions themselves (Damaiso, 1996). Feelings are on a lower level of consciousness and are connected to anatomical physical properties. However there are different types of feelings, depending on in which way an emotion is triggered. Those types are:

- internal (physical) feelings
- external (social) feelings

(Encyclopaedia Britannica Online, 2005)

Picard, (1997) defines 'feelings' strictly as a physical sensory input although she is aware that they sometimes are used equally with emotional experience. This is not necessarily the most common definition but in order to avoid confusion the term feelings is defined in this way for this thesis.

The third expression to be defined in this context is 'mood'. It is certainly less common in the research on affective topics, however it plays an important role in subjective experience. A 'mood' is a long term affective state and is triggered by a combination of emotions (Picard, 1997). The difference to the other concepts presented above is that people are more aware of their state of mood and therefore can express it. So if it is attempted to measure the affective values this can preferably be done indirectly by measuring the mood, which in turn is evoked by external events (Encyclopaedia Britannica Online, 2005).

2.3. Design vs. Engineering

In the field of affective product development two expressions occur frequently naming the process itself: ‘Design’ and ‘Engineering’. In some cases they even together appear as ‘Engineering design’. These terms are important, since they are considered as name for an entirely new field of knowledge.

In literature about affective products the two expressions are sometimes used equally, sometimes there is a distinction between the expressions. Also the names of the scientific approaches (Emotional design (Nagasawa, 2002a), Affective Engineering (Barnes et al., 2004, ENGAGE, 2005), Affective design (Helander, 2003)) show that Design and Engineering are closely related to each other, because they indicate the same area of research. Despite that they are not completely identical.

Engineering is according to a dictionary definition ‘the application of science to the needs of humanity. This is accomplished through knowledge, mathematics and practical experience applied to the design of useful objects or processes.’ Encyclopaedia Britannica Online, (2005). From this it can be concluded that design is a tool in the area of engineering.

The definition of ‘design’ supports this thesis: ‘Design is the process of originating and developing a plan for an aesthetic and functional object…It is used in the areas of applied arts, engineering, architecture and other such creative endeavours’. Despite the fact that design both has an aesthetic and functional dimension the expression is understood by Swedish and German people almost exclusively (aesthetical) industrial design.

Concluding both design and engineering are creative actions deployed in e.g. product development processes. The main differences are that ‘design’ tends more to the artistic side whereas ‘engineering’ is closer related to natural science and mathematics. This is also the way the expressions are used in this thesis.

2.4. Products

The word ‘product’ is derived from the Latin word ‘productum’, which means result or gain. Initially it had a strongly limited usage in mathematical science. However, during the industrial revolution it extended its significance even to the commercial sector and it became synonymous with industrially manufactured commodities. Traditionally, these types of goods are tangible products i.e. physical objects.

With time even non-physical products e.g. services were considered as products, but it took time until this point of view became accepted. Nowadays the expression product naturally also includes intangible products (Röstlinger and Goldkuhl, 1999).

Later a third form of product emerged, which were tangible products combined with intangible features such as delivery, installation and sometimes even maintenance of i.e. a washing machine. However, the focus hitherto is mostly on the physical part.

With emerging new techniques new trends appear. Quite recently the focus shifted for many new products from the mentioned third form towards the intangible part i.e. these products are foremost as services which necessarily requires tangible components (IVA, 1999). Examples are mobile telephones, rental TV or household machines, etc.

Figure 3: Product Definition used.

Extrapolating this trend a vision could be that future products whether they are tangible or intangible, are owned by the company producing them and customers pay for the access of using it. The driving forces for such change are sometimes external. For the person transportation sector Toyota predict a model where the company owns the vehicle and all peripheral services and the customer pays for the transportation alone.

2.5. Expressions in Subjective Assessment

As many methodologies dealing with qualitative data, also the methods within Affective Engineering such as Kansei Engineering utilise subjective assessment methods (compare Section 8.2). These methods require a certain type of jargon. Although these expressions are internationally recognised Kansei Engineering researchers sometimes use different words.

Entity/ Concepts

According to Sinclair, (1990), entities are the products to be scaled, for example the fork-lift trucks in the study for BT Industries (compare Appendix A, Paper A). In Kansei Engineering also the expression 'concept' is used in the same context.

Attribute/ (Product) Property
An attribute is the property of the entity which is scaled. This can be an ability of the product as for the trucks mentioned above, the lifting speed, the colour or the height. Both terms are common in Kansei Engineering literature.

Item
The item is a term used mainly by Nagamachi. It means Product attributes/ properties chosen for Kansei Evaluation. A attribute/ property is called an item when it has passed the 'Spanning of the Semantic space' and is chosen for evaluation with Quantification Theory Type 1 QT1, a type of linear regression using dummy coding (compare Appendix B)

Category
Displays the variety of an item. This is also a Kansei Engineering term. An item has a number of different categories which can vary. For example the colour of a truck can be orange, red, yellow, etc. These are called categories. The introduction of the expression category is mainly used for Quantification Theory Type 1 (QT1)

Subject/ Participant
The people used for scaling. In some of the appended papers they are referred to as participants.

Respondent
The subjects/ participants used in questionnaires. Sinclair (1990) makes a distinction between subjects and respondents. However since this work deals with data gathered from questionnaires there is no difference between subjects, participants and respondents here.

2.6. Data, Information, Meaning, Knowledge

Using scientific methods means that models of the reality are built from a noisy and fuzzy environment. So from the decision on which raw data to collect in order to describe or measure a certain phenomenon until the underlying mechanism is properly understood, the data has to be reduced. Otherwise the human mind cannot cope with it. In this context three expressions are of interest, indicating the different stages of 'purification of the raw data'. These phrases are: 'data', 'information' and 'knowledge'.

'Data' is derived from the Latin term 'datum' which means 'a statement accepted at face value' (Encyclopaedia Britannica Online, 2005) i.e. 'to give' or 'given value'. In computing and scientific contexts with ‘data’ is meant ‘raw data’ which are numbers, characters, images or other outputs with no mutal structure.

‘Information’ is a type of non-material input into an organism or device. Information is often carried by a weak stimuli which requires special equipment for amplification in order to be visible. In contrast to data information is a result of data reduction by elimination of noise.

‘Knowledge’ is defined by Plato as ‘justified true belief’. In other words: Knowledge is the ‘awareness and understanding of facts, truths or information gained in the form of experience or learning (Encyclopaedia Britannica Online, 2005). Although ‘knowledge’ and ‘information’ consist of true statements it is not equal. Knowledge exists in the human mind or collective theoretical human mind like the ‘body of knowledge’. However it can simultaneously exist in other forms as information. Knowledge is perhaps the human means of storing information, facts, skills, experiences etc.

Data on its own does not have any meaning. However it can be interpreted and conditions in data processing systems and become information. Through learning processes the information is understood and gets a meaning which then results in knowledge.

2.7. Semantics

In general semantics can be explained as the study of meaning. The expression itself is derived from the Greek term ‘semantikos’, which means ‘significant meaning’ (Encyclopaedia Britannica Online, 2005). So via meaning semantics is connected to knowledge.

In the area of linguistics semantics is traditionally the study of meaning of parts of words, phrases, sentences and texts. A newer application is in the area of mathematics and computer sciences, semantics stands for the meaning of logic linkages. The neighbourhood to knowledge here becomes even more visible.

In this thesis the term is used mostly in connection with Semantic Differential Scales technique (SD-scales) (compare Appendix B and C,). Semantic Differential applies both on linguistic expressions and product semiotics, i.e. the language of signs and sign-systems.

2.8. User, Customer, Purchaser

New products must fit the market's demand in order to be economically successful. Hence, in the area of (affective) product development the customer is (or should be) the focus of each process ensuring that new products will fit her needs.

By definition a customer is somebody who buys a product in order to achieve a certain goal with it (compare Figure 4). So there are two aspects in the expression customer; an economical and a functional. The economical aspect focuses on the purchasing process whereas the functional describes the usage of the product.

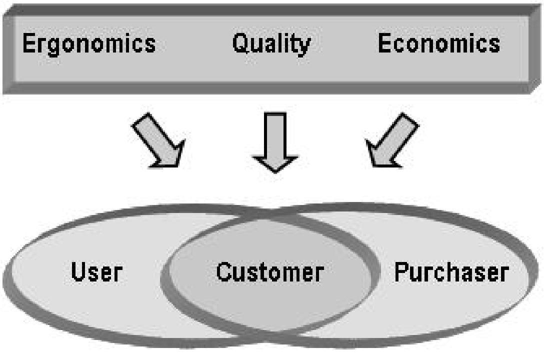


Figure 4: Definition of 'customer'.

In certain situations it is possible that the purchaser and the user are the same person: the customer and in other cases not. Products for private consumption are probably mainly purchased by the future user in person, while the buying decision for products dedicated for use in a work company environment is often done by a professional employed purchaser. However, the rules above do not always apply. Sometimes products for private consumption are bought by another person e.g. as a gift; sometimes factory-workers may choose between different machines that they are supposed to use.

Companies often know much about 'their' customers, but little about the users behind them. However for integrating affective values in products exact knowledge about the user and user behaviour is needed.

In this thesis the expressions 'user' 'consumer' and 'customer' are equally used in the sense of the person who really interacts with the product in a functional manner. If explicitly an economical perspective is meant the term 'purchaser' or 'buyer' is used.

3.
Aims and Delimitations
研究の目的と限界

3.1. Aims of the Research

As pointed out in the previous chapters, the area of research addressed in this thesis is not entirely new. Affective values in products and attractive products have always been an issue for customers. However, the questions that have been asked recently are what makes products desirable on an emotional basis and how this newly gained knowledge may contribute to the improvement of affective product properties.
In order to answer these questions the aim of this thesis was twofold:

- Firstly, to improve understanding of the characteristics of products making affective impact on the users and customers
- Secondly, to identify and improve methods capable of grasping affective values and translating them into concrete product properties

More specifically, the aim was to improve the understanding of the field of knowledge by giving an overview of Affective Engineering and Kansei Engineering in particular. This included the application of Kansei Engineering in concrete projects in Swedish industry.

An important aim was also to analyse and improve Kansei Engineering methodology, to summarise the findings, and on the basis of this to propose a general model on Kansei Engineering methodology.

3.2. Delimitations

Kansei Engineering is in general possible to apply for both artefacts and services. However, the studies in this thesis are made on physical products only. Hence, the conclusions are mainly valid for this type of product.

Kansei Engineering methodology deploys different methods found in other fields of research. In this thesis, these methods did not receive any further development. They were, however, adapted with the purpose of being applied in Kansei Engineering.

Also, Kansei Engineering includes a number of statistical evaluation tools which originate from other areas or knowledge fields. These were not developed further, except necessary changes for adaptation.

The focus of this thesis has not been to suggest or improve specific product development processes, but to use Kansei Engineering in product design for improving existing products and product concepts

4.
Research Methodology
研究方法

This chapter gives a brief overview on the segmentation of the research area. Also some of the main research activities carried out for this thesis are presented. Finally, a structure of the research is given and its phases are explained in detail.

4.1. The Area of Research

Integrating affective values in products is essential to many different areas of research. This includes consumer research, ergonomics and quality research for identifying customer needs via the product design and engineering marketing and surround services.

Examples of research in Europe in the areas of product design and (affective) engineering topics are found at e.g. the University of Leeds (Barnes et al., 2004, *www.keyworth.leed.ac.uk,* 2005). Research on affective design is carried out at Delft University of Technology (Hekkert, 1999). Customer research is performed in Sweden at Chalmers University of Technology in Göteborg (Rosenblad, 2000). Research on affective impact of buildings is conducted at Lund University (Küller, 1991). Kansei Engineering research at Linköping University covers the areas of ergonomics, industrial design, mechanical engineering, psychology and quality.

4.2. Research Activities

Different activities were part of the 4 years of research finalised in this thesis. Beside his own studies the author also supervised a number of projects carried out by undergraduate students. A highlight was also the 3 month visit as a guest researcher at Hiroshima International University.

4.2.1. Author's Studies

The first steps were to understand the ideas and the basics of Kansei Engineering properly. Based on this knowledge, several small case studies could be evaluated including few Kansei Words and a limited number of product properties. Kansei Engineering literature mentions a number of different evaluation tools which were tested in this context. In parallel, the author conducted a study on BT fork lift trucks in order to find out how the products are perceived by the actual users in different European countries. Kansei Engineering could be developed in a way that met BT's demands on efficiency and time.

The next step was to find support for the gathered result in the BT's organisational structure and its development process. In Japanese companies, Kansei Engineering is often run separately from other development procedures and is able to deliver the result independently from the actual company philosophy. However, the author chose to introduce Kansei Engineering as an integrated part in product development. Hence, the approach here was to inspect the different methods used in product development processes and find entry points for Kansei Engineering data. This task was accomplished by an in depth scrutiny of common product development processes and related methods for gathering customer information. Once again BT offered the opportunity to conduct studies and the author joined the pre-planning phase of a new forklift-truck model in order to provide and condition the data gathered from the previous study to the on-going project.

4.2.2. Student Projects

A number of projects were carried out by students in co-operation with industrial companies. The author acted as supervisor and coordinator for these projects. Together with BT, Saab, and Scania the manipulation feeling with switch keys was evaluated (Rydman and Sandin, 2000). Another study dealt with the driving feeling of BT warehouse trucks (Elsmark, 2000). In cooperation with Electrolux AB a study on affective impact of vacuum-cleaners was done (Skogman, 2002). In the same period also the opinion of welders on auto-darkening welding visors were tested for Hörnell International (Burkhardt, 2001, Arnold, 2002). At Volvo Tech a group of students evaluated the presentation of textile surfaces in vehicle environment using VR-technique (Frisk and Järleskog, 2003). Also, a project was done on laminate flooring together with Pergo AB (Lindberg, 2004).

4.2.3. Visit in Japan

After finishing the Licentiate thesis the author visited the Institution of Kansei Ergonomics at Hiroshima International University as a guest researcher for a three-month period in the autumn of 2002. The purpose of the visit was to intensify the exchange of experience on the area of Kansei Engineering and learn about tools and their application in the area. Moreover, BT Industries had an interest of extended exchange with its parent company; the Toyota Material Handling Company in Aichi prefecture in central Japan.

Initially orienting conversations with the researchers at Hiroshima International University took place. The author presented problems, which occurred in the European Kansei Engineering studies done at Linköping so far. New approaches were prepared to be tested back in Sweden. This was also the start of a series of regular seminars throughout the period. Before the author had left Sweden, data was collected for a joint study on cultural differences in affective impression of the form ration (ratio of high to width) of kitchen furniture elements e.g. refrigerators. Together with data collected at the same time in Japan, an analysis was carried out where the newly learned tools were applied. The result was presented in the form of a report (Garcia and Schütte, 2002). In the final stage the author visited Toyota's Takahama plant in Aichi prefecture several times and learned about their production system as well as the tools used for affective product development. These results benefited the PRODERGO project (see Section 1.5.6).

4.3. Research Structure

In the following the research plan used for this thesis work is presented. It follows the PDSA circle used in quality management (Deming, 1986). Knowledge about Kansei Engineering is developed gradually by literature research, followed by case studies, and finally deployed in real products and retested. The planning of the following studies was based on the results of previous research sets using an evolutionary process where more knowledge about the Kansei Engineering methodology was gained. This approach is corresponds to the concept of 'Kaizen', a Japanese method insuring that results learned are sustained (Imai, 1991). Figure 5 presents the resulting research structure for this thesis work.

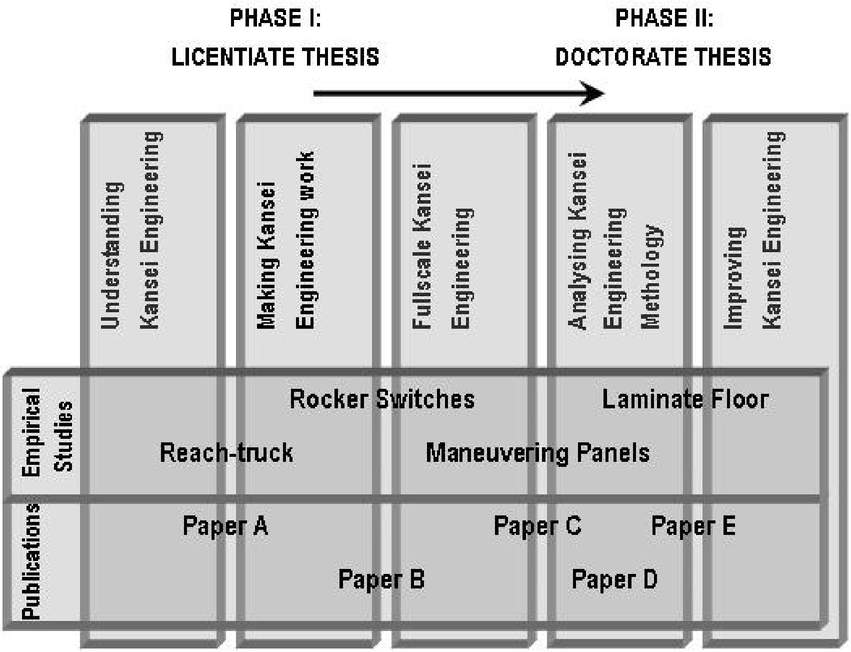


Figure 5: The research process of this thesis.

In the Swedish academic world the doctoral studies are divided into two parts. The first part includes basic studies about the research topic and is usually completed with the Licentiate thesis. In the second part more depth is gained and finally the Doctoral thesis sums the findings up.

4.3.1. Phase I, Licentiate Thesis

The aim of the Licentiate thesis which was roughly identical to the first phase was 'to understand and apply a methodology, measuring and translating the psychological feeling that customers have about a certain product' (Schütte, 2002). Hence it seemed to be suitably subdivided it into thee parts:

- Understanding Kansei Engineering
- Making Kansei Engineering work
- Application in full scale on Kansei Engineering

The first stage was characterised by an intensive literature study on areas related to affective methods in product development. In particular the studies of Elsmark (2000) and Nolimo-Solman, (2001) were important bases. The purpose was mostly the

understanding and testing of the method. Research objects were chosen due to their simplicity e.g. soaps and wristwatches.

Making Kansei Engineering work was a challenge, which was not expected from the beginning. Some of the tools used in Japanese Kansei Engineering studies were not applicable due to different reasons and had to be replaced by other alternatives. This was done in several studies made by masters students closely followed and supervised by the author. Examples here were the studies on vacuum-cleaners, welding visors and on textile surfaces in vehicle environments as earlier mentioned.

Bringing together all the experiences collected in the first year, a **Full scale study** on reach trucks was carried out in three different European countries (see Paper A in Appendix A). This was the first study using Kansei Engineering alone.

The Licentiate thesis was then finished by proposing a general model for conducting Kansei Engineering Studies. At that time the model was only built on the very limited experiences from the European studies. It was up to further research to validate and refine it.

4.3.2. Phase II, Doctorate Thesis

The second phase of the research presented in this thesis is based on previous results from both phase I and the Japan visit. The proposed model of Kansei Engineering procedure as developed in the Licentiate thesis, and the new and refined tools from Hiroshima International University played a significant role. Like the first phase the second phase is subdivided into stages:

- Analysing Kansei Engineering Methodology
- Improving Kansei Engineering Methodology

In the first stage of the second phase, the previously gathered information is **analysed** and partly revaluated. New studies were made on e.g. rocker switches (Appendix A, Paper B) among other things in order to verify deductively derived findings. Other studies were carried out by undergraduate students supervised by the author. Beside the results the studies also tended to confirm the model suggested in the Licentiate thesis. The new data significantly underpinned the assumption in the paper on tools and methods in Kansei Engineering (see Paper D in Appendix A). In parallel a small book was written summarising the ideas of Kansei Engineering in the first book in English language (Schütte and Eklund, 2003).

In the last stage, conclusions about the knowledge gained were drawn and **Improvements of Kansei Engineering** methodology were done. Firstly, a theoretical framework was proposed which later was confirmed by a study in co-operation with PERGO AB (Appendix A, Paper E). Another study on manoeuvring panels in fork-lift trucks was done with the same purpose. This study was at the same time a follow up of the first full-scale Kansei Engineering study made on the previous model of fork-lifter. Its purpose was to determine whether the new model really was improved on an affective level. Two papers summarise the findings (compare Appendix A, Paper A and C).

4.4. Scientific approach

4.4.1. Streams in Scientific Philosophy

The history of science shows mainly two streams. On one side the rational-empirical approach which refers to the early Greek scientists like Aristotle, on the other side the intuitive-theological approach, which refers to the early forms of biblical studies. During the following centuries the dominance of the two forms shifted, depending on the regime in power and spirit of the age, but both forms existed in parallel and influenced each other. Today these mainstreams are called positivism and hermeneutics.

Positivism

The positivism grew from Aristotle's logic which was based on empiricism. Around 1930 Comte (1979) recognised that different scientific methodologies were used in different scientific fields. He pleaded for a homogenous methodology, '*which could guarantee positive knowledge*'. This was the starting point for positivism.

One of positivism's most essential assumptions is that existence of a *true reality*- a reality, which is independent of the researcher's beliefs and convictions. Knowledge can only be gathered from observations and has to be documented in a logical, analytical or mathematical way in order to give the statements a universal character and make the observations repeatable.

Scientific knowledge is according to Comte, an instrument for predicting future events. These predictions can be based on probability terms, which in turn have to be based on sensory data. Useful scientific data must be measurable and express observable laws. This make the positivistic approach suitable for natural sciences.

Hermeneutics

Hermeneutics is a Greek expression and refers to Hermes, the messenger of the gods. During the Middle Ages, Protestant priests were called Hermeneutics, since they could interpret the Bible. These priests were representatives of the above mentioned intuitive-theological approach.

A Hermeneutic perspective assumes that human expressions follow a universal pattern, which is expressed by actions, language, gestures, etc. Since humans live in the context of the present their actions will be based on history and controlled by previous experience. The Hermeneutics state that no fact is static, but everything can (and has to be) interpreted. This is valid even for material things. Reality is what humans consider to be real and consequently subjective. The basis of human thinking is language, which forms the way of thinking, clarifying standpoints and evaluating as well as understanding and having a perspective on life.

Hermeneutics strives after an understanding and an interpretation of the human context rather than 'hard' measurements and establishing of laws. Moreover, according to the Hermeneutic perspective it focuses on the overall impression of things. Whereas positivism examines a phenomenon in its parts, hermeneutics considers that the sum of the parts results in a greater meaning. Hence, hermeneutics is especially suitable for human science approaches.

4.4.2. Quantitative vs. Qualitative Measurements

In recent years much has been written manifesting the distinction between qualitative and quantitative research methods. It appears as if one rules out the other in a research approach. In practice this is not the case. Both methods can be used within the same research problem (Patel and Tebelius, 1987). The choice of which method is most suitable depends on what kind of information is required.

If the purpose of a study is to reduce the facts gathered to mathematical figures, and formulas to provide a measurability of the investigated phenomenon: a quantitative approach should be chosen. Among practitioners, quantitative measurements are often considered to be more objective (Black, 1999). On the other hand qualitative methods suffer from a lack of detailed description, especially in poorly developed research areas (Strauss and Corbin, 1990). Since these are the demands the positivistic view makes on its investigation methods, hermeneutics often rejects the use of this method.

Qualitative measurements are mostly used in hermeneutics. The research question aims for a deeper understanding and interpretation of a phenomenon. With a holistic view upon the settings, and the humans involved, the context becomes important (Taylor and Bogdan, 1984). The strength of qualitative methods lays in their ability to support understanding of details and correlate them to the context. Overlying patterns becomes detectable (Patel and Tebelius, 1987). Findings on the other hand are not arrived at by means of statistical procedures or other means of quantification (Strauss and Corbin, 1990).

4.4.3. Building a Bridge between Customers and Feelings

Starting from an easy experiment, Fibonacci developed a series of numbers, nowadays known as Fibonacci-numbers. This series is commonly used in art i.e. for determining the ‘golden section’ and can be seen as a link between mathematics and art, and qualitative and quantitative science (Liedman, 2001).

Market research utilises social scientific theories in order to reveal customers’ demands and attitudes. Whereas product design is primarily based on natural science’s mathematical terms. Integrating the findings from market research into product design requires a bridging of the different areas. The main task is to translate feelings, perceptions, individual experiences and understandings into ‘hard’ measurements and mathematical models which in turn have to be falsifiable using both qualitative and quantitative methods. Figure 6 shows this graphically.

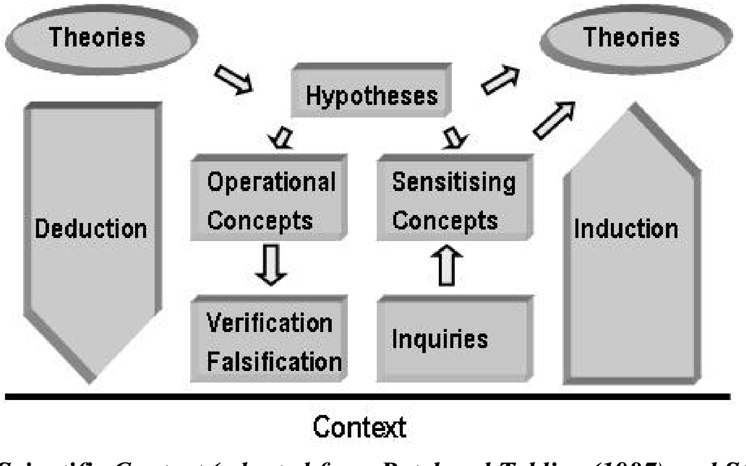


Figure 6: Scientific Context (adapted from Patel and Teblius (1987) and Starin et al. (1991)).

Starting at a hermeneutics-context data about the emotional impact of products is gathered. Using induction hypotheses theories are built describing the relations either quantitative or qualitative. The models which had been gathered in that way are a linkage between a certain impression and e.g. a product property which has to be verified using deduction methods. This means that the bridge between customer feelings and product properties has to be double tracked.

5.

What is Kansei?

感性とはなにか?

The term Kansei is a Japanese expression which with no direct corresponding term in English. This chapter makes an attempt to explain the concept to the reader. After a brief illustration the etymology of the Japanese term is presented as well as several eminent definitions. This is followed by a more detailed explanation of the concept. Finally measurement methods are presented, among them the Semantic Differential Scales Method.

5.1. The Nature of Kansei

The Japanese word Kansei is a multi-facetted expression which is not readily translated to other languages. This is a result of the fact that it is so closely connected to the Japanese culture.

However, the use of the expression Kansei requires a proper understanding of the underlying concept in order interpret and translate crucial aspects. This chapter will give definitions and explanations for the phenomena starting with an example. A few moments of concentration on the painting below will give a Kansei.

Looking at the painting on the following page may make some people feel the warm sun on the skin and a soft breeze in the hair. Perhaps there is a butterfly dancing in the sunlight coming through the tight leaves of the mighty trees? And perhaps there is the smell of summer and a taste of fresh strawberries.

That is what Kansei is about!

Figure 7: 'Frukost' by Carl Larsson.

'Kansei is an individual's subjective impression from a certain artefact, environment or situation using all the senses of sight, hearing, feeling, smell, taste [and the sense of balance (annotation by the author)] as well as recognition' (Nagamachi, 2001). Of course, this might seem irrational but in most cases even your personal Kansei may not be so unique and it can be grouped, categorised and measured in order to use it for e.g. product design.

In the following the expression Kansei and its background is illuminated from different angles finishing with a concluding definition used by the author in this work.

5.2. The Etymology of Kansei

Japanese language possesses two different types of alphabets (Hiragana, Katakana) and Kanji characters. The Kanji has its roots in the Chinese culture and each character expresses a whole meaning. However, a Kanji character usually has multiple meanings and only the combination and arrangement with other signs creates a definitive meaning.

The Japanese term 'Kansei' consists typically of two different Kanji- signs 'Kan' and 'Sei', which in combination means sensitivity or sensibility (Lee et al., 2002, Nagasawa, 2002a). But first in a technical or psychological context, the expression receives its final meaning which is used here. Etymologically the term Kansei splits into two signs of which the second sign derivates from two other signs (compare Figure 8 below)

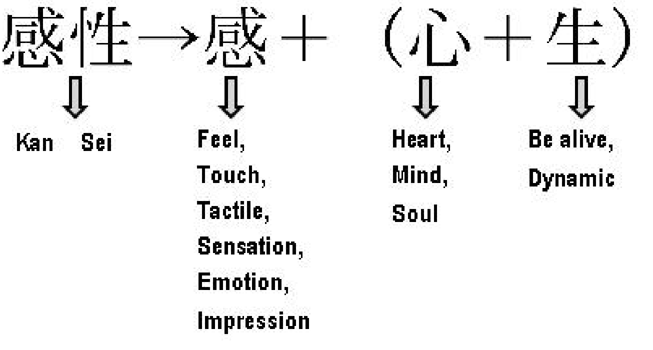


Figure 8: Etymology of Kansei (Lee et al., 2002).

5.3. Dictionary Definition

According to the 'Dainihon Japanse Dictonary', Kansei apparently is the abbreviation of the word 'kanjusei' which means translated to English 'sensitivity'. Moreover the dictionary also provides a more accurate definition:

> *Kansei: Sensitivity of a sensory organ where sensation or perception takes place in answer to stimuli from the external world.*

In this context Nagasawa (2002a) states that according to his understanding there is an enhanced meaning beyond the pure word of sensitivity; Kansei also includes a part of sentiment in the meaning as in classical literature of the old days. He quotes an old

Japanese source from Ukiyozoshi entitled ‘Ten-Inch-Diameter Mirror of Homoerotism’, where Kansei adopts the meaning of ‘feeling the core’.

5.4. Philosophical Definition

According to Lee et al. (2002) the problem field of ‘Kansei’ was originally addressed by the German philosopher Baumgarten. In 1742 Baumgarten gave an initial lecture on aesthetics which was followed up eight years later when he published his unfinished Latin book ‘Aesthetica’ in 1750, in which he introduced the philosophical theoretical framework and expression of Aesthetics (Schweizer, 1973). Baumgarten did not only want to give a theory of fine arts, but also intended to enhance philosophy with a ‘Wissenschaft der sinnlichen Erkenntis (cognitio sensitiva)’ (Science of sensual awareness) (Baumgarten, 1961). He argued in favour of two aspects in Aesthetics: the sensitive-theoretical and the more common artistic-rhetorical, i.e. the receptory and the productive meaning of Aesthetics.

Even another famous German philosopher, Immanuel Kant, picked up this topic about 20 years later when he wrote his main work ‘Die Kritik der reinen Vernunft’ (Kant, 2004). When the manuscript was translated of Teiyu Amano in 1921, the word Kansei was used as translation for the German expression ‘Sinnlichkeit (cognitio sensitiva)’ (Nagasawa, 2002a). As a German, the author immediately understands that the word Sinnlichkeit, as the expression Kansei, does not have a direct translation in English. What Kant meant is ‘the perception based on senses in contrast to the abstract perception of the mind without sensory input’ (*Brockhaus Universallexikon,* 2000). In other words ‘Sinnlichkeit’ is what enables a human being to receive an image of an object (or situation), which can not be grasped by reason. E.g. a sunny warm spring day can trigger impressions (e.g. happiness) which can not be processed by reason alone. According to Kant the Kansei/’Sinnlichkeit’ plays an important role when a human subject comes in contact with the real world (Nagasawa, 2002a). The Kansei therefore is a basic part of a complex combination and reciprocal effect of cognition and emotion.

Originally Kansei is a term from the Japanese epistemology, which is a branch of anglo-saxon philosophy. It is the science of knowledge that tries to find principles and rules about how knowledge it gained (*Brockhaus Universallexikon,* 2000). Kansei is considered to be a ‘passive mental process’ activated by the external world. According to Nagasawa (2002a) the epistemological approach distinguishes between the concepts of sensitivity (Kansei), understanding and reason. Human beings receive the outer world by *Kansei*; carry out analysis, integration and extraction activities on it by *understanding* and systemize and unify it by *reason*.

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. He states that the Kansei is processed by the right half of the brain, processing analogue and fuzzy data whereas the understanding possessing logical speculative nature is (reason) treated by the left brain side, whose specialisation is digital data processing.

5.5. Psychological Definition

The expression Kansei itself did not exist in Japanese Psychology at all until recent years. It is connected to concepts such as sensation, perception and cognition which are accepted psychological terms. They belong to a sequential process called the cognitive continuum. In this context, sensation, perception and cognition are processes which generally are independent but can be interconnected. Nagamura, (1991) illustrates this in an example. He says that a light stimulus can be sensed and perceived without cognition. No cognition is required if somebody is asked whether she sees the light or not. If one is asked how it looks like even cognition is required and the three processes work together in the cognitive continuum, previously mentioned.

5.6. Definitions by R&D Kansei Researchers

When dealing with Kansei for practical use the theoretical definitions can be useful in order to put the basics of the work on solid ground. However, to some extent they contradict each other and may be imprecise regarding certain practical details, making Kansei difficult to handle. On the other hand researchers using the concept of Kansei for different reasons cannot assume that the expression is commonly known. Consequently, some of them documented their own view on Kansei according to their purpose and context.

According to Lee et al. (2002) Kansei incorporates the meaning of the words: sensitivity, sense, sensibility, feeling, aesthetics, emotion, affection and intuition (see Figure 9 below).

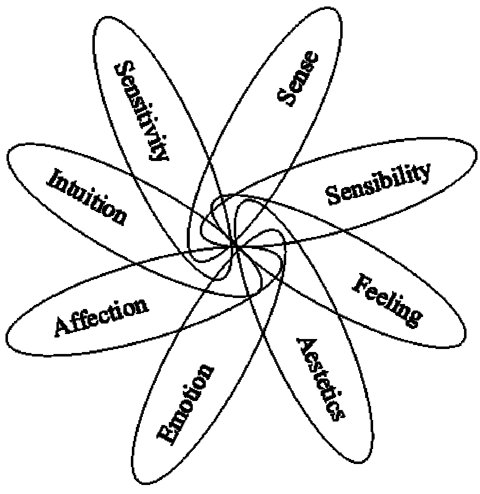


Figure 9: The meaning of Kansei inspired by Lee et al. (2002).

Shimizu et al. (2004) sees Kansei closely related to 'sophisticated human abilities such as sensibility, recognition, identification, relationship making and creative action…'. This definition does not only include the sum of the meanings of words translating Kansei to English but they see Kansei also as a part of a process binding together these concepts. Kansei is defined as an internal concept with three basic pillars of taste/ sentiment, Feeling and Emotion. These basics continuously interact with each other by triggering certain actions. His model is presented in Figure 10.

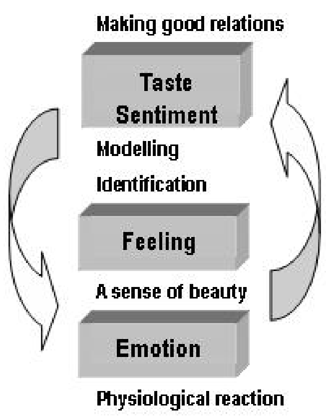


Figure 10: A model of the Kansei according to Shimizu et al. (2004).

According to the Japanese Society of Kansei Engineering (JSKE) 'Kansei is the integrated function of the mind, and various functions exist during receiving and sending [signals]. Filtering, acquiring information, estimating, recognizing, modelling, making relationship, producing, giving information, presenting etc. are the contents of Kansei' (JSKE, 2004). In contrast to Shimizu et al. (2004) Kansei is not only an internal process but a process in constant contact with the outer world receiving external information, processing it and reflecting it back to the outer world.

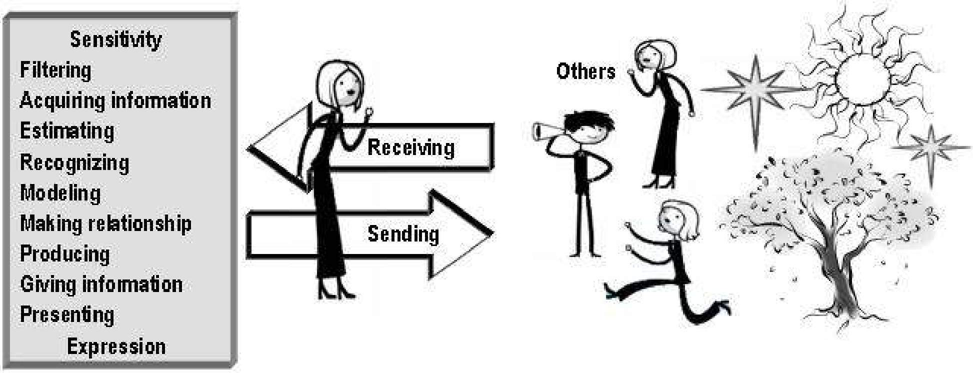


Figure 11: The Kansei according to Japanese Society of Kansei Engineering (JSKE, 2004).

According to Nagamachi (2001) Kansei is 'the impression somebody gets from a certain artefact, environment or situation using all her senses of sight, hearing, feeling, smell, taste [and sense of balance (annotation by the author)] as well as their recognition'. Due to his psychological background he sees sensation, perception and cognition as separate processes, but Kansei does only exist if they are cooperating.

Nagasawa (2002a) has a similar point of view. Like Nagamachi, he prefers the psychological view, and combines it with a part interacting with the outside world. He emphasises the connection between reason and Kansei by making a parallel process model. In his model the incoming stimuli is simultaneously processed by Kansei and reason which results in an occurring sentiment and an outside reaction. He also gives an example which is presented in the following:

1. Light of 650nm wavelength from a red flower reaches the eye
2. An image is built up on the epiploon and photo-receptor cells are stimulated
3. Physiological information is transferred to the brain
4. The perceived information is compared with knowledge data from past experiences and recognised as a red flower
5. At the same time a sentiment or emotion like 'beautiful' or 'passionate' are activated by the image.

6. The sentiment occurring in the mind is expressed by words, patterns, behaviours, facial expression etc.

(Nagasawa, 2002a)

In contrast to other models presented this model is the most comprehensive, since Nagasawa considers the philosophical approaches as ‘rather difficult to understand’. Furthermore, he states that engineering staff tend to find the concept of Kansei confusing and an opposite to reason and intellect. Hence, he offers them a model fulfilling their expectations by using engineering terms for explaining a psychological phenomena.

5.7. Kansei vs. Chisei

Emotion and feeling have traditionally found its counterpart in reason. When Baumgarten wrote his ‘Aesthetica’ (Baumgarten, 1961), one of his aims was to create an opposite pole to the field of logic and ratio described in Aristoteles’ ‘Organon’ (Schweizer, 1973). Also Kant realised the short comings of ‘pure reason’ and the necessity of creating a counter part (Kant, 2004). In the field of physiology Damasio (1996) could prove that emotion and reason in fact are hard wired in the human brain.

In practice Picard (1997) built interaction models on reason and emotion. On another area, in marketing experts distinguish between ‘feeling appeal’, i.e. commercial applying to ‘emotional, subjective impressions of product features’ and ‘thinking appeal’, i.e. commercial applying to ‘logical, objectively verifiable product features (Liu and Stout, 1987).

Lee et al. (2002) refers to this area as ‘Kansei’ and its counterpart ‘Chisei’. Whereas the concept of Kansei is closely connected to affective, emotional values of human beings, Chisei ‘works to increase the knowledge or understanding which is matured 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 12 displays this.

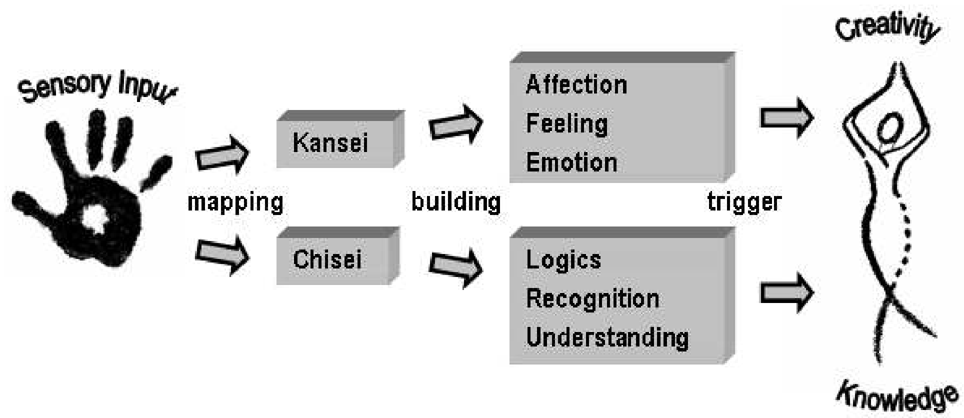


Figure 12: Model of the Kansei/Chisei.

In order to be able to cope with the term Kansei the expression has to be defined according to the author's point of view, based on existing models presented before. Summarising these definitions, the following model can be built as seen in Figure 13. A certain sensory input from at least one of the senses is mapped and build the Kansei. Outgoing from this concept, subjective values like affection, feeling, emotion and intuition are built up which in turn trigger human creativity.

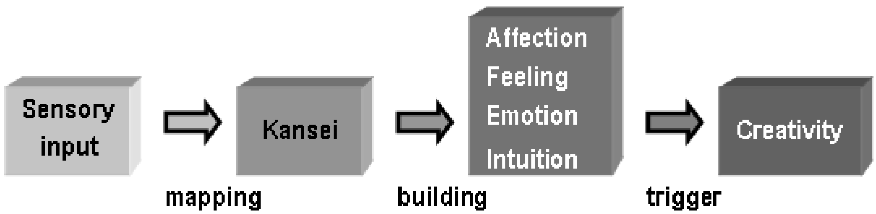


Figure 13: Model of the Kansei as it is used in this thesis.

5.8. A Hierarchy of the Kansei

As explained in the previous sections a specific Kansei arises when a human being is subjected to an artefact in a certain environmental context (Osborn, 1953). A walk through the forest lying in the first warm spring sun can e.g. evoke Kanseis such as beautiful, nice, astonishing, exiting, etc. However these Kanseis are just a small part of the overall experience. One might feel glad about that the winter is over and that the trees are in leaves once more. One might also feel enjoyment about the situation and look forward to the future. This all might end up in a big relief and an unspecified feeling of happiness.

This 'situational complexity' must be handled and the strategy chosen is to apply a hierarchic thinking. Certain simple Kanseis create higher Kanseis which in turn build up a general Kansei (Figure 14). The first degree Kansei is a collection of many transitory Kanseis, which appear spontaneously and build a higher degree Kansei. Many of these higher degree Kanseis can then be summarised in only one (or a few) general Kansei. In contrast to the higher degree Kansei the lower degree Kansei arises instantly where as higher degree Kansei take some time to be build up.

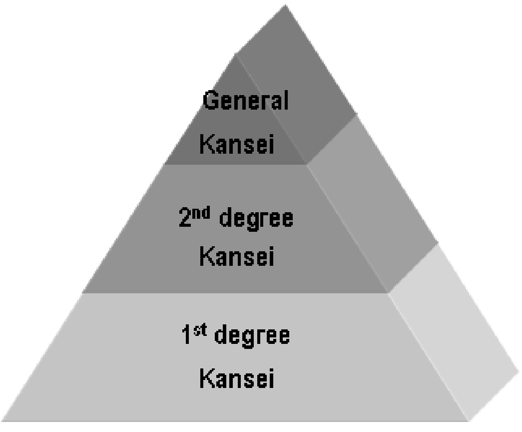


Figure 14: The hierarchy of the Kansei.

Mori (1998) became aware of this fact. He states that the lower degree Kanseis often are more individual than higher degree Kanseis. This means that e.g. many people have a feeling of happiness (general Kansei) when walking through the forest on a warm spring day, but not all do necessary experience it as beautiful (low degree Kansei). Mori (1998) therefore says that the hierarchical structure of the Kansei must be mapped clearly in order to understand the unconscious processes (Mori, 1998).

A very common general Kansei for Japanese people is the Kansei ‘high grade’. It stands for both quality aspects and aspects regarding the social status of the owner. In Europe research has not been conducted long enough in order to give a final solution about European general Kansei. However, an indication is that in many studies the expression ‘Quality’ in the sense of durable and value for money often occurs as a higher-level Kansei.

5.9. Measuring the Kansei

The Kansei is an individual mind structure. Understanding others' Kansei is not always easy and involves a large amount of empathy and experience. Hence, it might be advantageous to find rules and methods for quantifying the Kansei structure in order to make individuals' Kansei reasonably comparable.

However, the question arising is how the individual Kansei can be grasped and converted into information useful for product development. Kansei is an internal sensation, but at present it can only be measured using methods based on externalisation. Therefore, a series of standard measurement methods has been developed, interpreting:

- People's behaviours and actions
- Words (spoken)
- Facial and body expressions
- Physiological responses (e. g. Heart Rate, EMG, EEG)

(Nagamachi, 2001)

Nagasawa agrees with Nagamachi regarding this categorisation. He structures Nagamachi's model and distinguishes between two principally different measures.

1. Physiological measures, which are measures of physiological responses, behaviours, and body expressions (compare Nagamachi (2001)) generated by 'external stimulation'
2. Psychological measures, where he mainly refers to the Semantic Differential Scales Method (SD method) (compare Appendix B)

(Nagasawa, 2002a)

All of the previously mentioned methods have been applied successfully on specified areas of the Kansei. However, feelings and impressions are complex structures, which require sensitive measuring instruments. Unfortunately, even the most powerful of those measurement methods is not able to reveal the complete Kansei of someone, but only minor parts of it. This makes it necessary to carefully specify the interesting part of the Kansei and choose an appropriate tool for conducting the mapping.

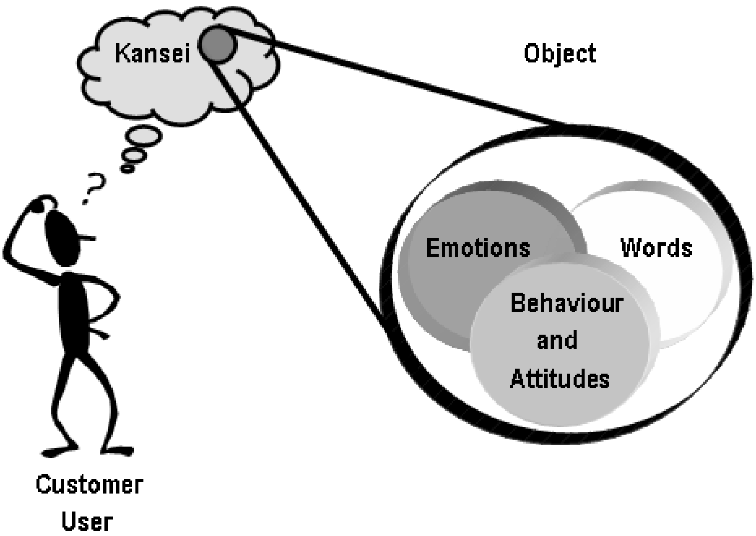


Figure 15: The excerpt from Kansei measured by different methods.

Because of the delicate structure of Kansei, which often includes small nuances of emotional impressions, mapping methods must be sensitive enough to show these shadings. Methods meeting these demands are preferably based on semantic descriptions, whereas methods measuring physiological responses (EEG, EMG, Heart Rate) are often regarded as too inexact, and methods interpreting facial expressions can often only be used in combination with semantic description methods. Nagasawa (2002a) also warns for over-interpreting the result from physiological methods of assessment. He states that ‘autonomic nerve reflections are not the Kansei itself, but only correspond to the Kansei’. This makes physiological measuring methods to an indirect measuring method (Nagasawa, 2002a).

Measurements of semantic exploration and description of the Kansei are foremost interview techniques as Means End Analysis (Reynolds and Olson, 2001) (see Appendix C), etc. Another approach is Semantic Differential Scales Method by Osgood (1957). It is based on subjective estimations of concepts which are ranked against each other (Osgood et al., 1957). Nagasawa (2002a) admits that this method cannot be objective due to the arbitrariness of the responses. However, for the purposes of positioning and identifying a rough picture of the Kansei, it is more suitable than evaluating data gathered by physiological measurement methods.

5.10. Kansei and Product Development

Design and development of new products and product concepts has always been a challenge. Internationalisation, technological development and economical pressure contribute to an increasing competition in practice on all international markets. An increased number of products available, sometimes in combination with decreased purchasing power of the customers force companies to re-consider their product development strategies (Shimizu et al., 2004).

Products, which have been newcomers not long ago (e.g. mobile phones, handheld computers etc.) are now becoming mature products and sales are not increasing as before. Quick model changes, technical updates or price reductions in order to improve the turnover can not be sufficient solutions.

Due to the new situation, customers' demands and expectations change. An increasing number of people want to express their individuality. Even mass-produced-products have to be adaptable to individual demands regarding form, design and function (Shimizu et al., 2004).

A long period of ergonomic development is followed by the pursuit of other sectors like cognitive ergonomic design in order to support customers' ability to understand technical gadgets in an easier way. E.g. new electronic products are preferred to be small, with many functions and easy intuitive access to them. Car stereo and navigation systems require operation with as little visual attention as possible and truck manufacturers seek for ways to increase the efficiency of their vehicles by designing more 'feeling' into the controls.

In general products are expected to be of high quality. However, they are also supposed to express high quality by their design and communicate this to the customers.

Eventually many customers make their final decision unconsciously based on rather subjective factors. They purchase the product, which 'feels' better, and are often unable to explain why. Taking this 'feeling' into account already in the design process can give a substantial selling advantage (Söderlund, 2003).

It is not easy to decide what property of the product evokes a certain Kansei and how the Kansei is influenced when this property is changed. Moreover, the Kansei depends in many cases not only on one product property, but on the composition and balance between them. The decision process, whether a bit of chocolate is good or not or if the new car has good quality is made unconsciously. Only the result of such a thinking process can be expressed in words.

Concluding, it would be advantageous if the Kansei could be used for analysing unexpressed and unconscious needs of customers and to develop such needs into an ‘affective’ specification list. Such a list would contain valuable information about how product properties or combinations of properties are perceived by the customer group examined, and the information will be used for drawing conclusions about trends in future products.

6.
Kansei Engineering
感性工学

This chapter gives an overview of the history of Kansei Engineering as a product design methodology. Also perspectives by different researchers are given. Finally the theoretical principles and different types of Kansei Engineering are presented.

6.1. History of Kansei Engineering

Mazda Motor Company manager K. Yamamoto used the term Kansei Engineering for the first time when he delivered a speech at Michigan University in 1986 (Yamamoto, 1992). Since then the term has been used by many researchers within the area. However, the research field is much older. Before Kansei Engineering was coined the term Sensory or Sensitivity Engineering was used (JSKE, 2004). Already in the 1970ies Nagamachi presented an affective product development method which he called 'Emotional Engineering'.

Today Kansei Engineering is a inter-disciplinary product design methodology that extends over the humanities, social sciences and natural sciences. It integrates affective elements in products already in the development phase.

Nagamachi was a researcher pioneering the development of Kansei Engineering in an academic context. His approach was to develop Kansei Engineering as an 'ergonomic consumer-oriented technology for new product development aiming at implementation of a consumer's demand in the product. He defined Kansei Engineering as a '… technique for translating the human Kansei into product design elements' (Nagamachi, 1989). The term Kansei used in this context is narrower than the original meaning. Nagamachi states: 'Kansei is a Japanese word which implies a customer's psychological feeling and image regarding a new product (Nagamachi, 1997a).

6.2. Perspectives on Kansei Engineering

Kansei Engineering is first and foremost a product development methodology, which translates customer's impressions, feelings and demands on existing products or concepts to design solutions and concrete design parameters (Nagamachi, 1989, Nagamachi, 1994a). Secondly, it shows how Kansei is translated into design (Schütte, 2002).

Figure 16 presents the basic idea: The Kansei is measured and inserted into a system which gives recommendations for design solutions. The system is here shown as a computer system, but in simpler terms it can also be presented as a mathematical regression model.

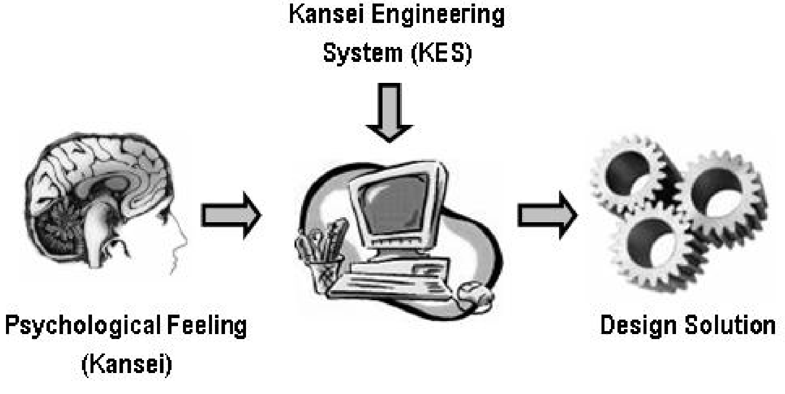


Figure 16: Principle of a Kansei Engineering System adapted from Nagamachi (1989).

According to Nagamachi (2001) there are three focal points of Kansei Engineering:

- How to accurately understand customer Kansei
- How to reflect and translate Kansei understanding into product design
- How to create a system and organisation for Kansei orientated design

The Japanese Society of Kansei Engineering sees in Kansei Engineering a web, which 'spins and weaves every thing (from an atom to spirit)'. They see in Kansei Engineering a link between society and its people with varying cultural backgrounds, and from this resulting demands on products. Figure 17 portrays JSKE's visualisation of Kansei Engineering.

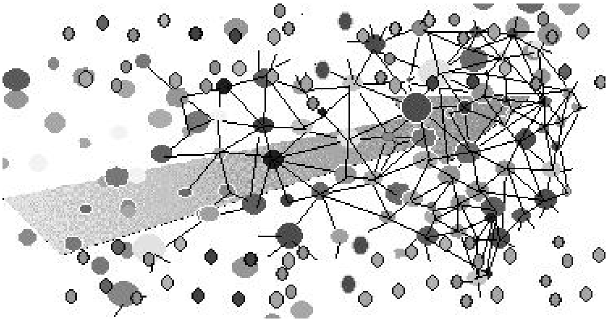


Figure 17: The structure of Kansei Engineering is a network according to JSKE (2004).

Shimizu et al. (2004) agrees with the JSKE, regarding the fact that Kansei Engineering is a network embracing all areas of society. Moreover, the authors, imply that Kansei Engineering is not only applicable for product development, but for all areas of the human existence. In order to illustrate this they roughly divide the field of Kansei Engineering into three parts: (1) Sensory Engineering which is a product design support evaluating 'short term emotions', (2) Kansei product technology, focusing on 'medium term reactions' and (3) Kansei culture, society and philosophy focusing on 'taste and sentiment over the long term'. For increased understanding Shimizu et al. (2004) developed a model resembling Maslow's ladder. The degree of involvement of Kansei thinking is indicated by a new step in this model (see Figure 18).

Kansei philosophy
Kansei sociology
Kansei culture
Kansei design
Kansei network
Kansei calculation system
Kansei busisness
Kansei goods
Kansei information
Kansei materials
Kansei physiology
Sensory engineering

Figure 18: The region of Kansei Engineering (Shimizu et al., 2004).

6.3. The Principle of Kansei Engineering

Different functional models have been drawn on Kansei Engineering. The most common type of model focuses on practical process mapping of grasping and translating the Kansei into products properties, as described before. Nothing has been written about how Kansei works 'inside' the human being. Outgoing from the model in Figure 12 the author tries to give a explanation about what happen inside the human brain, what the outcome is from an psychological point of view and how reliable the methodology is holistically. As described before, a sensory input from one or several of the senses of hearing, sight, smell, taste and touch leads to the building of Kansei. Humans also have a sense of balance and proprioception. At the same time a Chisei is built up by the same input, building knowledge through learning processes.

Kansei Engineering utilises certain stimuli (usually product samples and describing words) which are fed into the system. The output from the system is recorded usually in a questionnaire form. This data constitute in fact a representation of the people's Kansei on the product.

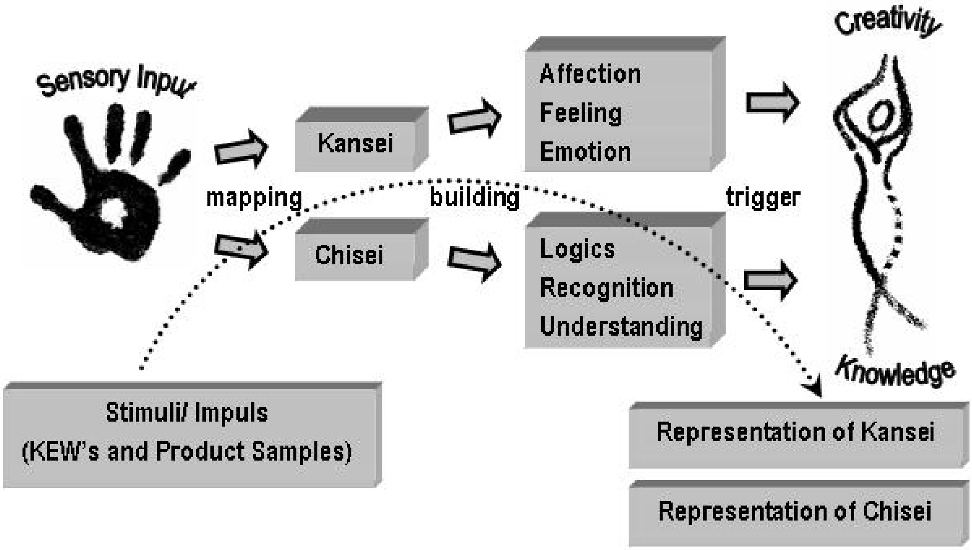


Figure 19: The working principle of Kansei Engineering.

Consequently, using Kansei Engineering techniques does not necessarily mean that the outcome of the study reflects the true Kansei somebody has about a certain product. It is just a picture taken at a certain point of time under certain circumstances. As with every picture the mapping of the persons Kansei is flatter, less contrasted and more static than the original. However, it could be seen that the greater the number of respondents is, the better is the representation of the Kansei. Anyway, a certain caution is necessary dealing with Kansei Engineering data.

6.4. Types of Kansei Engineering

As seen previously, today's Kansei Engineering is widely spread into many areas of society. Many researchers have worked in this area and made their contribution to the development of Kansei Engineering. Moreover, Kansei Engineering is expanding in many new areas including new innovative tools which are added to the original methodology. Kansei Engineering as a unitary methodology has grown more complex due to the plurality of its applications.

Nagamachi (1997a) collected all these applications on Kansei Engineering and grouped them according to the tools included and task areas. From these groups he identified so called types of Kansei Engineering. At present six different types of Kansei Engineering exist:

- ***Kansei Engineering Type I- Category Classification***
  In Kansei Engineering Type I, a product strategy and a market segment is identified and developed into a tree structure identifying the customer's affective needs. These affective needs or Kanseis are then connected manually to product properties.
- ***Kansei Engineering Type II- Kansei Engineering System***
  Kansei Engineering Type II is often a computer aided system using interference engines and Kansei databases (Nagamachi, 2001). The connections between Kansei and product properties are made using mathematical statistical tools.
- ***Kansei Engineering Type III- Hybrid Kansei Engineering System***
  Kansei Engineering Type III is also a computer database system similar to the second type. However, it can not only suggest suitable product properties from an intended Kansei, but also predict the Kansei that product properties elicit, e.g. a using prototype or mock-up.
- ***Kansei Engineering Type IV- Kansei Engineering Modelling***
  The forth type of Kansei Engineering focuses on building mathematical prediction models. These models are more strongly validated as in the Types II and III.
- ***Kansei Engineering Type V- Virtual Kansei Engineering***
  Kansei Engineering Type V integrates Virtual Reality (VR) techniques with standard data collection systems. This type replaces the presentation of real products with VR representations.

- ***Kansei Engineering Type VI- Collaborative Kansei Engineering Designing***
  In Kansei Engineering Type VI, the Kansei database is accessible via Internet. Such design supports group work and concurrent engineering.

(Nagamachi, 1997a, Nagamachi, 2001)

These types of Kansei Engineering are presented in more detail in Appendix E.

7.
A Proposed Model
提案するモデル

In this chapter a general model on Kansei Engineering methodology is proposed. The content of a chosen product domain is mapped from both a semantic and a physical perspective. Each Kansei can then be linked to corresponding physical properties. After a validation, prediction models can be built. Suitable tools are also given in this chapter.

7.1. A Proposed Structure of Kansei Engineering

Even if the procedure of Kansei Engineering at a first glance seems to be strongly dependent on the individual research context, there are in fact similarities in the procedures and the tools used for evaluation. Based on a literature review, the author proposed a framework on Kansei Engineering methodology. Figure 20 portrays this framework.

Based on an earlier chosen domain the idea behind the product can be described from two different perspectives: The semantic description; and the description of product properties.

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. 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.

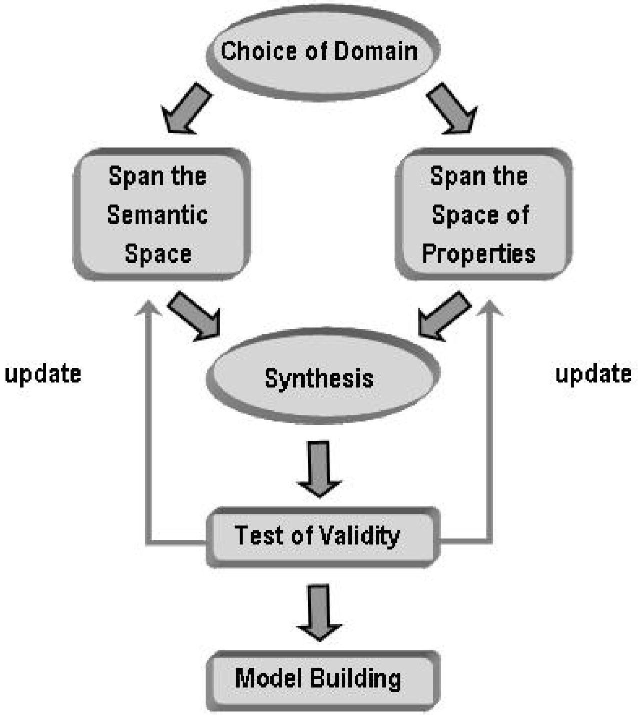


Figure 20: A proposed Model on Kansei Engineering.

7.2. Choosing the Domain

Choosing the domain includes the selection of a target group, market-niche, and specification of the new product. Based on this information, product samples are collected, representing the domain. The Kansei Domain can be understood as the ideal concept behind a certain product.

Despite the fact that a circle can never be drawn perfectly round, everybody knows what the perfect idea of a circle is. The Kansei domain is dealt with in the same way. It is an abstract super-ordinate mind structure while the representative products are either tangibles or intangible samples from this domain. As a result, a domain includes both existing products, concepts and even still unknown design solutions.

The task in this first step is to define the domain and find representatives (products, drawings, samples, etc) covering an as big as possible part of the domain.

7.3. Spanning the Semantic Space

The Kansei is hierarchic. This means that one higher-level Kansei join together several lower-level Kansei and facilitates in this way the representation of the customers' affective values (compare Section 5.8). For example the low-level Kanseis of 'slow', 'fast', 'indolent', 'agile', 'quick' and 'speedy' can be summed up to a single higher-level Kansei 'kinetic'.

In Kansei Engineering only higher level Kanseis are connected to product properties in the synthesis phase in order to achieve a better generalisation of the results. Spanning the Semantic Space identifies these higher level Kanseis from a great number of semantic expressions. Although the expression 'Semantic Space' origins from Osgood (1957), more methods than his Semantic Differential Scales are available nowadays.

7.3.1. The Procedure of Spanning the Semantic Space

For practical reasons spanning the Semantic Space has been subdivided into three steps as presented in Figure 21. Using the desired domain as a starting point, low level Kanseis also called 'Kansei Words' are collected, describing the considered product semantically (compare Section 7.3.2). In 'Kansei Structure Identification' higher-level Kanseis are then identified from this set using a number of possible tools (compare Section 7.3.3). In a Kansei Engineering literature these higher-level Kansei sometimes are also referred to as 'Kansei Engineering Words'. Finally, the data is compiled in a standardised way in order to facilitate the following synthesis phase. If important Kansei Words are missed in this step, the result may have significantly limited validity. Hence, it is better to select a few more words than necessary.

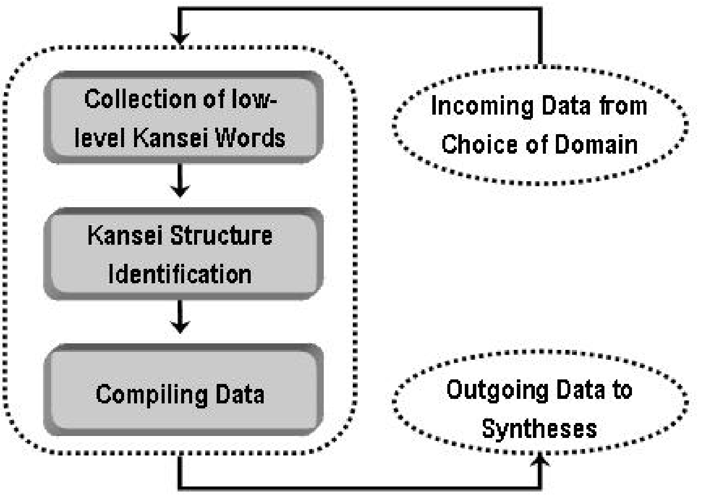


Figure 21: Procedure of Spanning the Semantic Space (see Paper D, Appendix A).

7.3.2. Collection of Kansei Words

A Kansei Word is a word describing the product domain. Often these words are adjectives but other grammatical forms are possible. For example when describing the domain 'fork lift truck', adjectives like effective, robust, quick, etc. but also verbs and nouns such as 'accelerate'/ 'acceleration' can occur (Schütte and Eklund, 2001). In order to get a complete selection of words all available sources have to be used, even if the words emerging seem to be similar or the same. Suitable sources can be:

- Magazines
- Pertinent Literature
- Manuals
- Experts
- Experienced Users
- Relating Kansei Studies
- Ideas, visions

An important point is to translate ideas and visions into Kansei Words because non-existing solutions should also be considered. In this way Kansei Engineering can be used as a creative product development tool, which generates innovative solutions. The task is to describe the domain, not the existing products. Depending on the domain considered, the number of existing Kansei Word generally varies between 50 and 600 words (Nagamachi, 1997a). Since it is of great importance to cover the whole Kansei, the word collection is continued until no new words occur. The data gathered will critically influence the validity of the results if important words are missing.

7.3.3. Tools for Semantic Structure Identification

For the identification of the Kansei structure, different methods are developed, tested and made available for use. These methods can roughly be divided into two different groups:

1. Manual Expert Methods
2. Statistical Methods

Manual Expert Methods

Expert groups often prefer manual methods. The Kanseis are grouped and summarised according to the participant groups preferences and needs. Tools supporting this are:

- Affinity Diagram (Bergman and Klefsjö, 1994) (see Appendix B)
- Designers choice
- Interview techniques

Statistical Methods
The major disadvantage of manual methods is that experts can fail. An alternative is to ask the users of the products about their Kansei and what they consider to be the important Kansei. Typically this is done by a questionnaire given to a customer group. Using statistical methods to evaluate of the gathered material quantifies the affinity between the different Kanseis. The following statistical methods are available today:

- Principal Component Analysis (Osgood et al., 1969) (see Appendix B)
- Factor Analysis (Osgood and Suci, 1969) (see Appendix B, C)
- Cluster Analysis (Hair et al., 1995) (see Appendix B)
- Quantification Theory Types II, III, IV (Tsuchiya, 2004)
- Neural Networks (Ishihara et al., 1996)

7.4. Spanning the Space of Properties

7.4.1. The Space of Properties as a Counterpart of the Semantic Space

As shown in Figure 20 the product domain is described both from a semantic perspective and a physical perspective. Both perspectives are presented in the form of vector spaces.

However there are significant differences in the theoretical background of the two spaces. Whereas the semantic descriptions possess a well researched theoretical background based on e.g. Osgood's Semantic Differential Technique (Osgood and Suci, 1969), there is no similar theory for the Space of Product Properties. Hence, there is no consistent way of developing the Space of Properties. At the same time, the selection of properties is essential (Nagasawa, 2002b). However, few studies really evaluate the affective impact and the importance of the product properties on the user. Often they are assumed to be relevant, given by the client company, or even chosen randomly. In the majority of cases however, the product properties are chosen due to the feasibility of producing product examples to present in the study (Kanda, 2002).

How can it be ensured that the properties chosen are really relevant to the user/ customer in the examined context? What happens if a trait chosen for selection is not important to the user? To illustrate, in a study the participants are asked to make a statement on the quality impression of a postal service. The samples differ in many of their properties and especially the delivery time and ability to track the batch may be of importance. If these properties are not chosen for evaluation the final result will not give a correct answer. Worse, it will not be possible to determine that there is a property missing. Consequently, it is necessary to rate the importance of the different product properties and make this a criterion for the selection.

There are certainly methods capable of making an adequate selection of product properties for Kansei Engineering but the problem is that they are not structured, nor generally tested for this task.

This section will make an attempt to assemble methods for different studies, but also use methods from other areas used for similar purposes. Probably the most important demand is to provide a structured approach for constructing the Space of Properties.

7.4.2. Proposing a Model for Spanning the Space of Properties

The systematic collection of Kansei Engineering Properties i.e. properties usable for a Kansei Engineering study, follows the model of the collection and selection of Kansei Engineering Words. It roughly can be subdivided into three steps as shown in Figure 22. In the collection step inspirational material regarding a product domain is collected from a variety of sources and potential properties are identified. In a second step they are sorted according to certain rules. The number of properties is narrowed by selecting the most important properties. Properties passing on to the following step possess only the highest affective impact for further evaluation.

Finally, example products are found possessing those properties chosen and representing in this way the space of properties. Depending on the method used for relationship identification the assembly of products can vary. In conformity with the building of the Semantic Space, the raw data is collected from different sources.

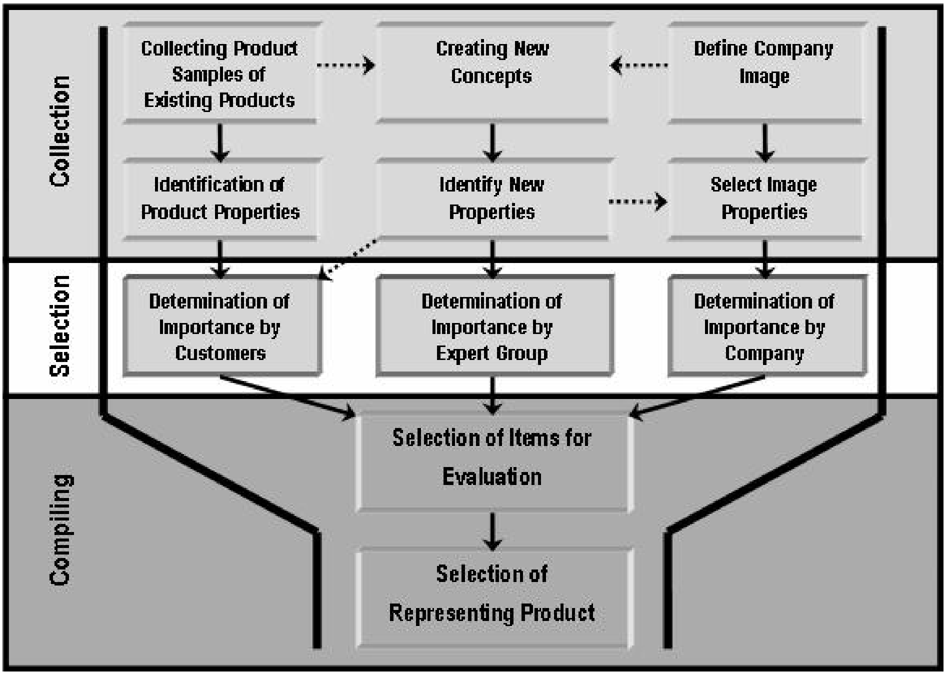


Figure 22: Spanning the Space of Properties (see Paper E in Appendix A).

Typically, existing products provide a wide variety of potential properties, which can be integrated into new products. Getting inspiration from already existing products is one of the most common ways of identifying relevant properties. As seen in the left-hand column of Figure 22, sources for collection are usually found in literature, technical datasheets, magazines etc. For identification often an assembly list of properties is sufficient. The determination of importance and selection of properties with the highest importance and affective value is preferably done by customer representatives. To facilitate the work of gathering raw data tools such as focus groups or one-to-one interviews can be used. For determining the importance, e.g. pareto diagrams (Bergman and Klefsjö, 1994) can be useful.

In almost all Kansei Engineering studies carried out within industrial product development projects, a central specification must also fit the company image. Companies therefore tend to integrate characteristic features in their products. The right column in Figure 22 identifies that coming from the companies existing products are the product properties which are unique to the company are identified. Together with company marketing experts, the relative importance of these properties is determined. Usually the number of image properties is so small that no special tool needs to be deployed.

The central column in Figure 22, however, is the integration of new product concepts. Kansei Engineering has been criticised for not being innovative. This part displays how creative thinking and new ideas can be integrated into Kansei Engineering as a method. As a main source the designers mind is used. A designer can make a sketch, a mock-up or a prototype of the whole product or parts of it. Thereby s/he creates potentially new properties, which are apprised and selected by an expert group.

However, Figure 22 also displays that these processes do not necessarily take place separately and in isolation. In contrary, they influence each other as indicated by the arrows. The designer might get inspiration from both existing products and company's image, which is then developed into a new solution. This new concept in turn might influence the companies decision making about which product properties to select as relevant image. Also, new trends identified by the designers may influence the choice of product properties from existing products.

Finally, all selected properties are brought together to one set of product properties from which representing products are determined or mocked up to be used in the following synthesis step. A practical example of the proposed model in Figure 22 is presented in the appended Paper E in Appendix A.

7.5. Synthesis

In the synthesis step the Semantic Space and the Space of Properties are linked together as displayed in Figure 23. For every Kansei Word a number of product properties are found, affecting the Kansei Word. Ishihara et al. (1998) conducted a study on beer can design. His results showed e.g. that the score of the Kansei Word 'bitter' is most affected by the colour of the can and the shape of the logo. In fact a black colour in combination with a non-oval logo evoked a strong bitter Kansei, whereas a white can with an oval logo involved the opposite Kansei.

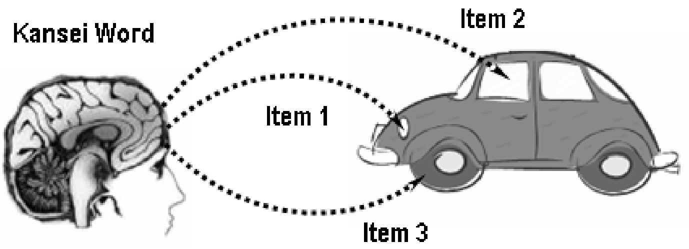


Figure 23: Synthesis Phase.

The research into establishing these links has been one of the core parts of Nagamachi's work with Kansei Engineering in the last few years. At present a number of different qualitative and quantitative tools are available. Since the incoming data is stacked in a standardised way every tool can be used, and it is even possible to use different tools and compare the results afterwards in order to reveal the most suitable tool.

7.5.1. Relationship Identification

This relationship identification conducted in the synthesis phase is the core of Kansei Engineering technology. Whereas the identification of the semantic structure is carried out in different forms even in other contexts as SMB (Küller, 1975) or Semantic Differential Method (Osgood et al., 1957), the translation of the determined Kansei is exclusively performed in Kansei Engineering. Due to this fact this part of Kansei Engineering has been in focus for research since the beginning of its existence.

A number of tools has been developed and are used for this part. Even here the same categorisation can be made into the three different areas:

1. Manual Methods
2. Statistical Methods
3. Other Methods

Manual Methods

Manual methods for connecting the Kansei and the different product properties are easy to perform and require comparatively small resources. These are the oldest tools are preferred by practitioners. One tool is:

- Category identification (KE Type I), (Nagamachi, 1997a, Nagamachi, 2001)

Statistical Methods

As in semantic structure identification, statistical methods are used for treating great amounts of data from questionnaires. The tools used here have to be modified in order to fit the requirements of Kansei Engineering. Some possible tools for statistical treatment are:

- Regression Analysis (Ishihara, 2001)
- General Linear Model (Arnold, 2002)
- Quantification Theory Type I (Komazawa and Hayashi, 1976)

Ranking/ Rating Methods

- Generic Algorithm (Nishino et al., 1999)
- Fuzzy Set Theory (Shimizu and Jindo, 1995)
- Rough Set Theory (Nishino et al., 2001, Mori, 2002)

7.6. Model Building and Test of Validity

Finally a mathematical or non-mathematical model is built depending on the synthesis method chosen. However, before using the model as a prediction model for future products it has to be validated. At present, not only are validation methods for the Semantic Differentials available, but there is a need for a more integrative validation concept.

8.

Research Contributions to Improvement of Kansei Engineering

感性工学の発展への寄与

This chapter collects the research contribution on the development of the methodology. The first part deals with topics of how sensory organs support and limit the building of the Kansei. This affects the way Kansei questionnaires are constructed. Finally, a model on determining the degree of attractiveness of a product is proposed.

8.1. Sensing the Kansei

As shown in the introduction of this work the Kansei as an internal sensation is closely related to the external senses. The external senses deliver the input which is needed to build up a Kansei and react in an appropriate way.

There are differences in the importance of the sensorial input. Sight is considered as the most important sense. The other senses of hearing, smell, taste and touch are usually used in a complementary manner. There are models ranking and arranging them in accordance to the frequency of usage and importance (Penfield and Rasmussen, 1950).

However, in Kansei Engineering context, these models are not very helpful. In fact, in many cases they are irrelevant, because the significance of sensory organs can vary between individuals and between products. For example for determining the quality of a cup of coffee the taste and smell are most suitable, the haptics of a textile surface is evaluated by the sense of touch and the sound of a car engine requires hearing as sensory organ. However, in most studies on Kansei products, all senses are needed; the degree or importance however depends on the product in question (Nagamachi, 2001).

8.1.1. Proximity of Interaction and Presentation

As seen, sensory organs play important roles in how the Kansei is achieved. But as mentioned earlier, the Kansei is individual. So besides the senses involved in this process; also the personal interest and experience contribute to build a personal Kansei. A first examination of the object is usually done visually. Depending on the individual Kansei and interest, people can then determine whether or not to intensify the examination by adding more sensory input. In other words, if a person spots something interesting, he might want to not only look on it but also touch and smell even taste the object.

Concluding, the degree of involvement of sensory organs has a strong effect on the Kansei. Picard (1997) calls this the 'affective channel width'. She concludes that computers affectively interacting with human beings have to provide a couple of signals, which can be sensed by human beings. In general it can be said that the more affective signals are given, the more clearly the message can be understood. For Kansei Engineering this means that, the more senses involved the better the mental picture (more intensive Kansei).

Other relevant aspects are physical factors such as the time period, the way, the intensity of interaction, previous knowledge about the product and its features, etc. Wikström (2002) shows in her study on stoves that the rating on semantic scales changes significantly when the participants use the stove instead of looking at it.

Further humans perform activities quicker the more often they have been repeated. People confronted with a new product will take some time to learn about its features. In a later state they perform faster and start to demand new properties. Cooper and Reimann (2003) state that the more familiar a user becomes to a computer software, the more they want to adapt it. The aspects presented above have crucial consequences for Kansei Engineering studies but in spite of that seldom addressed in English Kansei Engineering literature.

The Affective Flow

Time and economic resources are crucial in the design of studies. For Kansei Engineering studies this is especially true when it comes to the time resource, since product trends can be rather short-lived (compare Section 8.1.5). Consequently, studies should be designed as quick as possible and as economically as possible, but at the same time deliver correct results. The goal is to allow the participants an as complete Kansei as possible, but not to provide a wider affective channel than necessary. For example evaluating the sound of closing car door does not make it necessary to provide the whole car or even a picture of it.

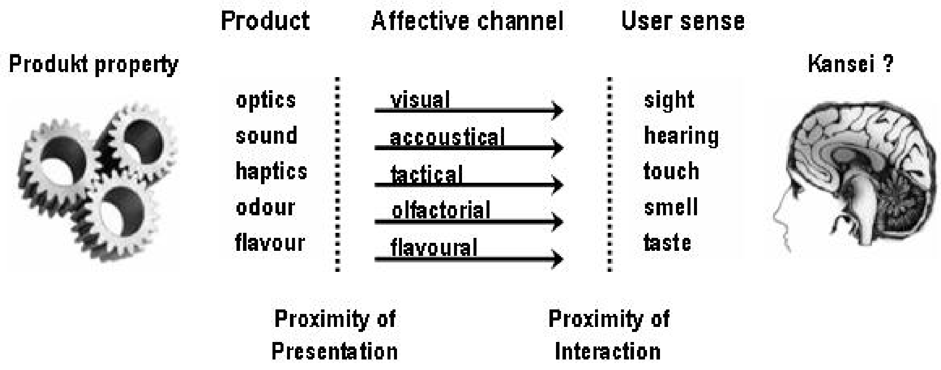


Figure 24: The affective flow insprired by Picard (1997) and Nagamachi (1994b).

Figure 24 illustrates the way the information travels when a Kansei is built. This may be referred to as the affective flow. A certain product property possesses attributes which are transferred by different ‘wires’ in the affective channel. This information is then received by the users senses and transformed into a Kansei. However, this is an ideal view. In praxis there are obstacles on the way, limiting or even cutting of the semantic flow. In Figure 24 these obstacles are referred to as Proximity of Presentation and the Proximity of Interaction, and act as ‘affective windows’ which limit the affective flow. In Kansei Engineering the ‘affective windows’ must be set in a way that information necessary for building up a sufficiently complete Kansei passes, but unnecessary information is blocked.

Proximity of Presentation

Product properties need certain senses to be transferred into a personal Kansei. In order to sense the Kansei fully, certain affective channels (Picard, 1997) must be used as shown in Figure 24. This means that the way a product is presented plays an important role. For example, the Kansei of a piece of chocolate is not satisfactory transferred by a picture, since the smell and taste are important stimuli which are suspended in this case and the user can not interact with the product in the way s/he normally would do. Hence, the ‘affective window’ must allow olfactorial, visual and flavoural information pass.

In general it can be said that the following two points have to be considered for each Kansei Engineering study.

- Definition of channels needed in order to give a full Kansei
- Definition of necessary degree of interaction

These definitions automatically devise the '(minimal) Proximity of Presentation'.

Proximity of Interaction

When performing a Kansei Engineering study, the goal must be that all participants experience the Kansei of the product in question. Otherwise, the impact of the affective values cannot be measured. The 'affective window' must be set in a way that the information sent by the product is really sensed by the user. Three points can be identified which have major influence on how well the Kansei is transferred.

- prior experience of the products,
- interest in the products
- degree of interaction

A study carried out on office chairs comes to similar results. In this paper the expression 'Proximity of Interaction' is suggested for describing this phenomenon (Eklund and Kiviloog, 2003). Experience by the author shows that a high Proximity of Interaction i.e. participants with good prior experience, high interest and a high degree of interaction usually deliver better results than other groups.

Paper B in Appendix A presents a study of rocker switches in work vehicles. Different samples are presented to the respondents separately (instead of fitted in a dashboard) in order to be evaluated on Kansei Engineering questionnaires. Such limited Proximity of Presentation narrows the affective channel and the limited opportunity to interact leads to an incomplete Kansei. However, the achieved Kansei was considered to be sufficient in order to draw conclusions about the affective impact of rocker switches.

8.1.2. Showroom Appeal

Users interact with products in different ways depending on the experience they have with it. First the users learn about the product features and how to use them. Finally, they become experienced users and they might wish to improve or adapt the product, additionally, depending on the user's stage, the Kansei changes. Cooper and Reimann (2003) indicates that novice users, normal users and expert users have fundamentally different demands on computer software due to their varying experience. Consequently their impression changes when they advance more. They therefore suggest that software should be designed for the medium user, and features should be added such as online help for novices and shortcuts for experts. Another example comes from Asatekin (1975) who points out that soft seats in furniture or in automobile use, are experienced as comfortable in short term use, but uncomfortable in long term use. His conclusion is that seats aimed for long term comfort must not be too soft in order to avoid discomfort. Eklund and Kiviloog (2003) call the short term experience ‘showroom appeal’.

Eklund and Kiviloog (2003) further discuss that manufactures could purposely create products which appear attractive in the showroom in order to increase sales, but loose attraction as soon they are used under real long term conditions. Seen from an economic perspective such behaviour does not create sustainable growth for a company. It is therefore not a good strategy. If a company wants to satisfy customers and make them return, they must produce products which keep up with the expectations the users have on the company and get from the product in the showroom (Juran et al., 1974).

Performing a Kansei Engineering study necessitates a decision in advance of whether the solution should support the long or short-term appeal This will influence the experimental design for the study. Following the ideas of Cooper and Reimann (2003) the product should generally be designed for long-term use. In order to improve the showroom appeal the relevant product properties can be designed in a way that reflects the intended short-term experience using Kansei Engineering.

In Paper C in Appendix A the comparison of affective values of manoeuvring panels of fork lift trucks are examined. One aspect of the study is the quantification of affective impressions of the different surfaces. A corresponding Kansei is the Kansei Word ‘nice to touch’.

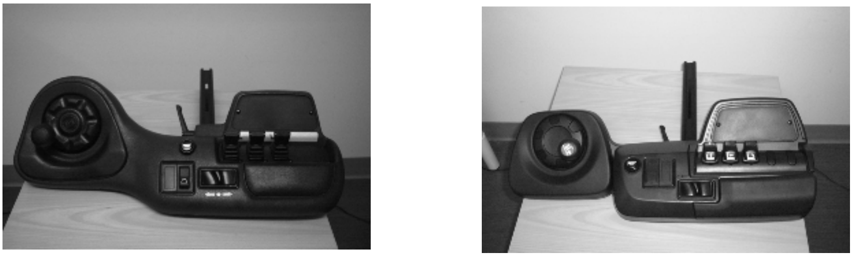


Figure 25: Manoeuvring panel for a BT REFLEX; left: old model, right: new model.

From the study it can be seen that the Kansei ‘nice to tough’ has been improved with the new model. This is a result of the re-engineered surface structure and improved integration of softer parts around the steering wheel and at the wrist support. However, the evaluations are done on brand-new models in a laboratory environment. These results will probably change over time since wear and tear have an impact on the subjective perception.

8.1.3. Indirect Affective Product Design

In general, it is preferable to let potential customers interact intensively with the product, before making a buying decision. Doing so enables the potential customers to learn about the product and to get a more complete impression, especially about product properties which normally are hidden and require some interaction to find out. Also certain property's quality does not appear in the first place but only after some time of interaction, (compare Sections 8.1.1 and 8.1.2).

In reality it is not possible to communicate the Kansei completely. A certain showroom feeling will remain. In cases where the affective channel width is limited due to the choice of communication medium, such as Internet or catalogues, it is particularly important to make efforts to strengthen the Kansei. In all cases the customers will make their buying decision on incomplete technical and affective data. First after some time of usage the user will be able to determine whether the product was a good buy or not.

Kansei Engineering can help to transmit the product qualities the user cannot sense immediately, using alternative channels. It is possible to bring out certain key-qualities using more than one channel. The author refers to this phenomenon as *indirect affective design* i.e. properties which are not directly or instantly detectable are presented using other affective channels.

An example can be found in the previously cited study on lift truck manoeuvring panels (Paper C, Appendix A). The intention of the designers was to design a 'durable' truck. This attribute does often not show until the truck has been used for a long time. However, there are ways of designing parts of the truck in a way that they appear 'durable' already in the showroom in order to reflect the 'hidden' qualities. The study showed that the new panel (compare Figure 25) had a significantly lower impression of 'robust' than the old one. This is probably a result of the optical separation of the steering wheel from the rest of the panel. However, this was intended and at the same time the Kanseis of 'ergonomic', 'nice-to-touch' and 'comfortable' could be strengthened.

8.1.4. Honest Products

As seen, product design can be used in order to express desired Kanseis and suppress undesired Kansei at the same time. Kansei Engineering makes it is possible to optimise the appearance of a product in a desired direction, almost independent of its real qualities. It is therefore possible to give the product the face of properties it does not possess in reality. It can also be speculated that manufactures could purposely create products which appear attractive in the showroom, but loose attraction as soon they are used under real condition. This in order to increase sales (Eklund and Kiviloog, 2003). This would, however create incongruent impressions of the product. If a company wants to satisfy customers and make them return, they must produce '*honest*' products, i.e. products which keep up with the expectations the customers and users have on the company and their expectations of the product initially.

An example of products, which sometimes are perceived incongruent to their appearance, is laminate flooring. Paper E in Appendix A presents the results of a study on this product type. It could be seen that people partly perceive laminate flooring as a dishonest product, since it imitates natural structures such as grains in wooden parquet or structure of ceramic flooring instead of using original materials. This has a significant negative impact on e.g. the Kansei of 'natural' (compare also Lindberg (2004)).

8.1.5. Trend Sensitivity

Trends and fashion have driven the development of new products since the beginning of industrialisation. As mentioned there are trend research institutes such as the Contemporary Trends Institute in London focusing on trends and predicting the direction in which products evolve. New products and trends change the perspective on the older products. Changes in lifestyle brought forward by new products will therefore also change the affective impact products have (Jordan, 2001). In Kansei Engineering research this has recognised a long time ago. Especially that the validity of the semantic descriptions is perishable. Also, Kano (1984) poses that the way anciently attractive product features are perceived changes quickly.

As a consequence, each time a Kansei Engineering study is made, new Kansei Words and product properties are collected in order to consider this effect. The strength of the trend sensitivity is also dependent on the product in question. Products with high trend sensitivity are generally products with short product life cycle time such as fashion products, whereas products with low trend sensitivity tend to have longer life cycles.

Yun et al. (2001) states that mobile phones are highly trend sensitive. Küller (1991) draw the conclusion that semantic descriptions for houses have been practically stable for more than 20 years (compare Appendix C). In Paper B, Appendix A the data on Rocker switches were collected in two rounds with 15 months in-between. No significant difference in the data could be seen, leading to the conclusion that rocker switches are relatively trend stable. The results of Paper A and Paper C in Appendix A on the affective impact of warehouse trucks, did not show significant differences either. Consequently, warehouse trucks are also relatively trend stable products.

8.2. Collecting Data for Kansei Engineering Evaluations

Most Kansei Engineering evaluations involve customer surveys. The main components of these surveys are questionnaires including different kinds of rating scales. In order to minimise the loss of information a good explanation, a clear structure and quick answering opportunities should be provided in order to increase the comprehensiveness. The quality is dependent on the presentation of the questions.

8.2.1. Scale Types

Very commonly used methods in subjective assessment are rating methods. They are widely known and provide relatively rich information if compared to other methods such as ranking methods. Moreover, data from a great number of participants may be collected with a minimum of resources.

Several different rating methods can be mentioned. Thurstone's Paired comparison technique, Thurstone's 'Equal-Appearing Intervals' or Likert's 'Summated Rating' method also known as 'Likert scale', are commonly used However these scaling methods are suitable if one wants to evaluate a number of different entities. It is more rare that one wishes to assess a group of entities just for one attribute alone. Doing so the Semantic Differential Scales (SD-scales) are more useful (Guilford, 1971).

Naming the anchors

In order to understand what the subject is supposed to do, the scales are named at the extremes. These are called the anchors. Choosing the labels can have a crucial impact on the results. The labels must be easy to understand for the subject and have to refer to the object of the study.

In Kansei Engineering every Kansei Word is attached to an individual scale. The way the extremes are handled is done differently by different researchers. This is due to cultural differences, deviating experiences or for practical reasons.

Osgood (1957) uses synonym and antonym for spanning the range of rating (compare Figure 26 (a)). This allows reducing the number of ratings to a minimum since both words are rated simultaneously. On the other hand, it sometimes is difficult to find words having exactly the opposite meaning. As an example the word comfort can be mentioned. It is shown that discomfort has a different content and can therefore not be used as an opposite on such type of scales (Zhang et al., 1996). Moreover, this type of data is difficult to handle by Quantification Theory Type I (compare Appendix B).

Nagamachi and many other Japanese researchers use the Kansei Word as an extreme on the left side of the scale, whereas he adds a ‘not at all’ on the right side (Nagamachi, 2001) (compare Figure 26 (b). Doing so, liberates from the force to find opposite meaning and makes the scale easy to understand and quick to complete for the participant. Disadvantages are then again a skewed distribution. People experience the scale as un-balanced and see the neutral value more to the left side of the scale.

Hence, the author chose to combine the advantages of both scales at the same time excluding most of the problems. The Kansei Word is placed on top of the middle of the scale, while the anchors are labelled as ‘not at all’ and ‘very much’ (compare Figure 26(c)). This constellation delivers good data distribution. Together with a 7-point or VAS scale it is one of the most comprehensive solutions for the subjects. Küller (1975) uses such scales in the Semantic Description of Environment (SMB) method (compare: Appendix C). Nevertheless, some disadvantages still remain. The extremes are in many cases considered to be indefinite which in turn means that the distances are not considered to be completely equal. Even if this effect is slighter than in the other cases, even this scale must be called an ordinal scale. Another problem is that subjects which have no opinion or understanding regarding a certain Kansei Word, feel forced to check ‘somewhere in the middle’ biasing the result. Therefore if the mean value of a distribution is around the middle value of the scale, it could be because the word either is meaningless for the object evaluated or subjects did not understand the word properly.

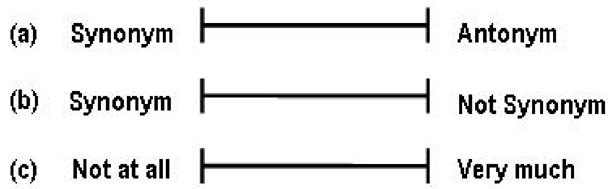


Figure 26: Typical scales used for semantic evaluations. Scale (a) is Osgood's original SD scale (Osgood et al., 1957), (b) is a scale used by many Japanese Kansei Engineering researchers (Ishihara, 2001) and (c) is a modified SD scale by (Küller, 1975).

How many Scale Steps?

Osgood (1957) uses 7 point Semantic Differential Scales gathering for evaluation. Nagamachi and many Japanese researchers use this type of scale (Nagamachi, 2001, Nishino, 2001). However they use a 5 point scale. Also Sinclair (1990) provides a 5 point SD scale. The advantages of SD-scales are that they are recognisable by the participants since many of them have prior experience of working with them (Guilford, 1971).

One problem especially with 5 point-scales is that the type of distribution of the data is difficult to determine. Moreover, the 5 point scale sometimes is experienced as to narrow (see Paper A in Appendix A), in particular when a neutral point is located in the middle. Participants are experiencing the extremes 1 and 5 as overly extreme statements and the remaining three points are not sufficient for making a proper estimation (Schütte, 2002).

Therefore it might be better to choose a 7-point scale in those cases. (Küller, 1975) uses 7-point scales in SMB for similar tasks as in Kansei Engineering. A 7-point scale allows more sensitive ratings, while it is as comprehensive and quick to use as a 5-point scale. However, the problems with determination of the data distribution due to the low number of discrete steps remain.

In medical science, another type of scale is used, the so called Visual-Analogue Scale (VAS), sometimes also called 'Quality of Life Scale' according to its application. It is basically a 100mm horizontal strip, with extreme statements on both ends (Figure 27 (a)). The participants mark their estimation with a cross on it. Despite the fact that this scale possesses discrete steps, the sheer number of them (100) makes it appear as continuous for the participants. It is therefore very sensitive and has no technical details such as numbers etc. that can confuse the subject. The disadvantage is that it is not commonly known and therefore not easily understood by all participants. Moreover, it is not completely linear (even if this effect is much smaller than in the other scales presented). This type of scale have been used several times before (compare Paper A, B and C in Appendix A).

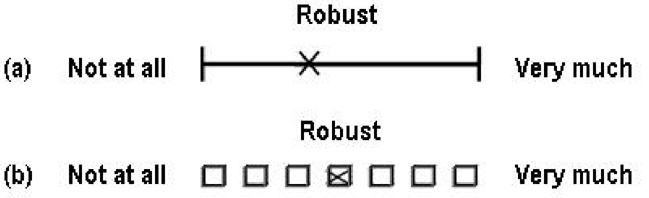


Figure 27: Rating scales used in the experiment in this work. Above a 100mm VAS scale, below a 7 degree modified SD-scale.

Statistical Treatment

Another aspect in this context is that most statistical treatment methods and in particular the methods used in Kansei Engineering require data from continuous scales, i.e. an interval or ratio scale must be diploid (compare Guilford (1971)). However, the SD-scales used here do in fact deploy an ordinal scale. Consequently, the SD-data could not be used e.g. for factor analysis as Osgood (1969) does. Also the data must have a bivariate normal distribution, which e.g. is not the case in the 5 point SD scale used by many Japanese researchers (Figure 26(b)). Nevertheless, experience shows that even these 'dirty' ordinal scales lead to similar conclusions as data from interval scales, and Visual Analogue Scales. Paper B in Appendix A also supports that.

8.2.2. Computerised vs. Manual Data Collection

Mass data collection dates back to the period 1930 to 1950 when the increased demand for data collection in sufficient volume occurred in order to provide statistical significance (Drury, 1990). Traditionally, questionnaire data collection is performed on a sheet of paper, which is given to the participants. This type of collection method is still up to date and because of its simplicity and not requiring much knowledge, is still the most common method. Nevertheless, with the arrival of computers, new ways of collecting data occurred. Data can now be collected using special software on personal computers. Internet questionnaires are a recent advancement of this technology.

In this work both conventional and computerised data collections were used. The computerised data collection was performed both using mobile units and Internet surveys (compare Papers A in Appendix A). Doing so has many advantages. Compared to manual data collection, the data can be collected and stored electronically. An additional data transfer from paper to computer is omitted and thereby the risk of errors in data transfer is drastically reduced. Moreover, it becomes easier to transfer the data into other evaluation programs. This reduces the collection time, allows the collection of more data and thereby improves the statistical strength. Common commercial software enables the researcher to perform rapid statistical operations and prepare the data already during the data collection for further evaluation. Optional functions such as automatic pre-evaluation of the data, makes it possible to check the data quality in an early phase and result in improved control of tendencies and suitability.

Other practical advantages are that studies using computerised data collection can be performed in other places without the physical presence of a researcher. Using the same software layout for all participants, every participant experiences an almost identical test environment, which reduces nuisance and increases statistical strength. The disadvantage is that an electronical device is needed and participants with no or low computer experience are distracted. Internet surveys might be opened incorrectly by different web browsers or the access might be prohibited by a firewall as used in many big companies.

However, in order to overcome these obstacles, Drury (1990) foresees improved computers, which have better input devices and displays. Together with people becoming more used to common computer software, he assumes the problems stated above will soon disappear. But this is not the main advantage in using computers. The biggest opportunity lays in the future development of software and hardware. Future data collection will be carried out by intelligent software, which can adapt to the individual respondent and ask question more naturally (Drury, 1990). Intelligent tools can evaluate data starting with the first input and interpret the respondents' behaviour; doing so the participant can be supported optimally. This means that the gap between questionnaire and one to one interview can possibly be closed.

8.2.3. Constructing Kansei Engineering Questionnaires

The future visions drawn in the previous chapter are however, not yet existing. Questionnaires are still relatively inflexible and made in advance. Therefore it is important to design them in a way that is less disturbing for data quality and allows the respondent to fill in as much of his/her own opinion as possible.

The structure of the questionnaire

The structure of the questionnaire depends on different aspects such as purpose, respondent group, available resources, aims and also the researchers personal style. However two main types can be differentiated as shown in Figure 28.

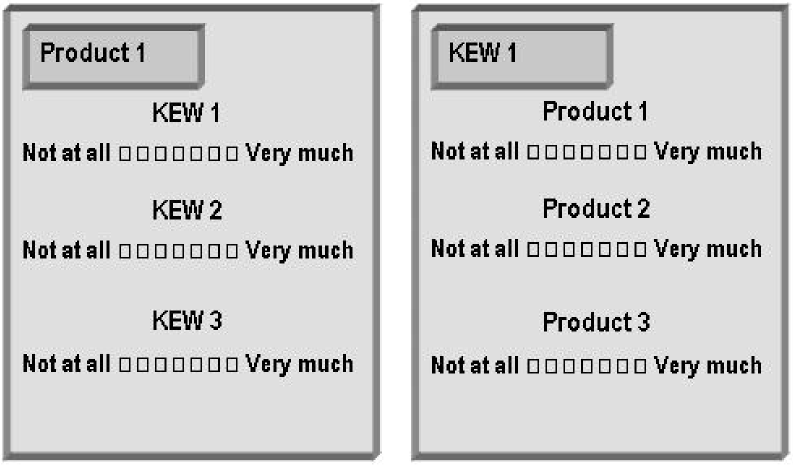


Figure 28: Two types of Questionnaires. Left: Semantic Differential style; right: Likert style.

On the left hand side the traditional Semantic Differential Scales are presented. One entity is placed above and rated according to a number of Kansei Engineering Words. This type of scale is the most common scale for both Semantic Differential studies and Kansei Engineering studies. It allows rating the entities (products) separately according to the semantic dimensions spanned by the Kansei Engineering Words (KEW). The example on the right hand side presents a modified version. It evaluates the same facts, but is built resembling a Likert scale. The KEW is on top and the products are rated below. This design allows to make a rating at the same time as the products are ranked.

Both types and several hybrids have been used for this work. Despite from the fact that no special examination on the suitability of the two structure types has been done, no problem with the resulting data which could be related to the structure design, was detected. However, careful consideration and adaptation to the purpose was always carried out before.

Randomising Questionnaires

The Questionnaire design will almost automatically influence the way the respondent thinks. It is certainly positive to guide the respondents' thoughts in a certain way but too obvious guidance leads the customer in the wrong direction. For example rating the Kansei Engineering word 'easy' before the word 'precision' could result in a better rating for the second word than as if it was given separately or in context with other words.

Guilford (1971) suggests randomising the order of appearance of the questions in order to avoid such problems. Randomising the Kansei Engineering Words helps to spread out such effects and treat the fluctuations using statistics. For most of the studies in this work, the order of appearance of both concepts and Kansei Engineering Words was randomised. Moreover, computerised data collection made it possible to randomise the data and present the rating scales separately to the participant. Although the effect of randomisation on the result was not explicitly measured, it is obvious that randomized questionnaires produce less biased data than non-randomised ones.

Language in Questionnaires

Some studies included in this work were carried out either in different countries or with foreign students. The problem occurring was that the terms and expressions had to translated to be the respective language.

Translating the Kansei Engineering Words is a special problem, since translations in many cases are not completely accurate. For example, the word design is used in both English speaking countries, Germany and Sweden. However, a native English speaker links the expression both to engineering design and artistic design. In Sweden and Germany the word is almost exclusively used for artistic design. So if the word is used in both contexts the result will be biased due to the different understandings. This example is quite obvious and easily fixed by adding a short term of explanation, but native German or Swedish words are not that easily translated. Unfortunately the author could not find a final satisfying solution for this problem. Even many Japanese researchers observed this problem without solving it (compare Lee et al. (2002)).

8.3. Degree of Importance

The problem all affective engineering methods have in common is that not all aspects of a products affective value can be accounted for. For Kansei Engineering this means that not all semantic descriptions can be evaluated as Kansei Words and not all product properties can be examined regarding their affective impact on the user. The reason for this lays in the sheer quantity of possible aspects and the hard limited processing ability of the human mind. Only if the data is prepared into useful information for the human mind, the meaning of it can be understood and transferred into real knowledge (compare Section 2.6). In research, facilitated models are built in order to make the problem more comprehensive.

In the case of Kansei Engineering, building a model means that the semantic descriptions becoming Kansei Words as well as the product properties to be evaluated must be prioritised and selected. For this certain factors can play a role:

- The strongest affective impact
  The semantic or physical description making the strongest impression on the user are preferably those to be selected. Which description makes the strongest affective impact is totally dependent on the context, the research question and the product type.

- Behaviour
  The behaviour of how people interact with the product indicates what properties receive their intention. Verbal expressions they use while interacting with the product can be included in the Semantic Space. This type of data can be gathered using observational methods (compare Section 8.2).

- Experimental design
  Another factor is the intention of the experimenter, who sets the rules of how the participants are supposed to interact.

- Interest and background
  The users interest and background in the product plays a major role. In general it can be said that the more experienced the participants are with this type of product the more they will focus on the 'Achilles heel' of the products. Moreover they will be able to express themselves in more appropriate terms.

Spanning the Semantic Space according to Osgood et al. (1957), includes the prioritisation for the Semantic descriptions. This is done by either factor analysis or manual system such as card systems (Ishihara, 2001) or affinity diagrams (Bergman and Klefsjö, 1994). The previously mentioned techniques collect possible semantic expressions, assemble them into groups with words possessing similar meaning and finally select words covering the most important part of the Kansei (see Figure 15).

As pointed out previously the Space of Properties is not well researched. Determining the degree of importance for a property is not specifically documented in English literature. However, the literature research within this work gave at least some hints about how the prioritisation could be performed. Together with the experience the author gathered from practical work in Kansei Engineering studies, three different ways could be found:

- Interview studies
  Typically these studies are carried out in Focus groups, but also One-to-One interviews occur. One example is a study carried out by the women's underwear manufacturer Wacol, where 3000 women were interviewed in order to find their preferences (Nagamachi, 1997b).

- Observational studies
  Observational studies can aid the finding of the most relevant product properties by observing how the user interacts with the product in question. Properties used frequently, are likely to be the most important. However, those studies are often carried out in association with interview studies. Examples here are studies on vehicle interior (Ishihara et al., 2001) and an overall car design (Mazda Miata) (Nagamachi, 2001) where drivers behaviour was observed. Another study was done on hair-treatment products using data from audio-visual observation of buyers at the shop shelf (Nagamachi, 2001).

- Expert knowledge
  This is the most common type of determination. Experts involved in the product development process and possessing knowledge about marketing strategies are useful for this task. As method e.g. affinity diagrams can be used. This has been done in most of the studies carried out for this work; in several cases in combination with interview studies. Examples are studies made in close cooperation with company development departments.

8.4. Designing Attractive Quality into Products

8.4.1. Connecting the Kano Model to Kansei Engineering

The Kano model (Kano et al., 1984) is used in order to create attractive products. As seen in Section 1.4.3 different types of quality can be recognized. Successful product development means that the development team must meet the basic expectations (the must-be quality) as well as the one-dimensional quality, which correspondents to the expressed expectations a customer has on the products. However, this is everyday work for product designers. What is considerably more complex but necessary is the attractive quality creation in new products. Once an attractive new property is integrated into the product, the customer is surprised and delighted and is tempted to purchase the product.

One way of making the degree of attractiveness visible on the base of Kansei Engineering data was proposed by Schütte (2002) who claims that the overall impression of a product can be estimated in relation to competing products (see Equation 1). The Kansei Score for each Kansei Word is added and related to rating of ideal values. Multiplying by 100 gives the percentage certain product rates against the imaginary ideal product. The application of this procedure to a number of different products allows a comparison of the overall impression.

Equation 1:

$$\frac{\sum_{i=0}^{n} KS_{\Pr oduct\ i}}{\sum_{i=0}^{n} KS_{Ideal\, i}} \cdot 100 = SK[\%]$$

With:

SK ....Degree of attractiveness compared to the ideal value
$KS_{Product\ i}$.........................Kansei Score for a certain product regarding a Kansei Word
$KS_{Ideal\ i}$............................Kansei Score for the ideal product
i.......................................Consecutive number for Kansei Words
n.....................................Total number of Kansei Words
(Schütte, 2002)

However, this formula is linear and assumes that not only the absolute affective value for a semantic impression is measured, but also an ideal value, i.e. a value indication how the product should be designed.

Axelsson et al. (2002) used a similar approach in order to tie Kansei Engineering results to the Kano model. In contrast to Schütte (2002) they decided to approximate the affective impact with a quadratic function suggested by the Kano model.

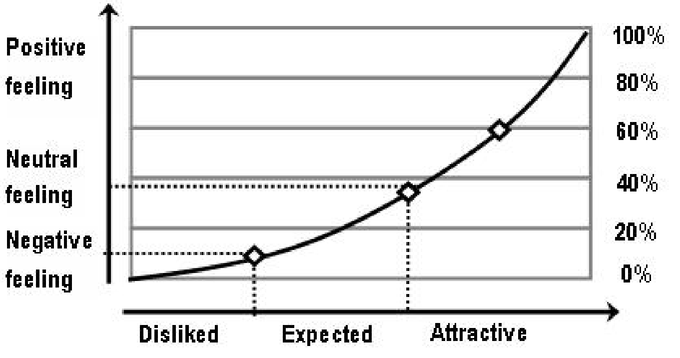


Figure 29: ***Quadratic model of user perception from Axelsson et al. (2002).***

As seen in Figure 29, three different products, in this case incontinence protection for the elderly are rated on a 7-point SD-scales. The result is plotted in a radar diagram and the area included by the particular products is calculated as a percentage from the theoretical maximal area (all Kansei Words are rated '7'). Since the area function is a quadratic function the results fit the Kano model. Plotting the results from an ergonomic rating of the time the caregiver stands flexed, gives the diagram presented in Figure 29. Finally, the ranges of 'must-be'-quality, one dimensional quality and attractive quality are set and related to the feeling, in Axelsson's model referred as negative, neutral and positive feeling. Calculating the area included gives a quadratic function.

8.4.2. Suggesting a new Mathematical Model

Axelsson (2002) and Schütte (2002) fit their mathematical models to the respective product leading to different results. In Schütte's case, the model is linear whereas Axelsson suggests a quadratic model. In reality feelings are certainly neither linear nor quadratic; the equations used can therefore only be approximations.

Equation 2 suggests a mathematical model which can be seen as an improvement from both previous models. The Kansei scores are made dimensionless by dividing by the number of points on the rating scale used and summed up. Later the result is divided by the number of Kansei Words used and the result is given in percentage. Depending on which dignity is used different characteristic can be achieved. Since only d=1 and d=2 have been tested before, other product types might require different characteristics. Consequently the power ‘d’ can be chosen freely in order to match the product type in question.

Equation 2: $\frac{1}{n}\sum_{i=0}^{n}\left(I_{KW}\frac{KS_{\mathrm{Pr}odukt\ i}}{a}\right)^{d} * 100 = SK[\%]$

With:
SK ....Relative degree of attractiveness
$KS_{\text{Product } i}$ ....Kansei Score for a certain product regarding a Kansei Word
i......................................Consecutive number for Kansei Words
n.....................................Total Number of Kansei Words
d.....................................Dignity
a.....................................Number of points in the rating scale
I_{KW} ....Degree of Importance for the respective Kansei Word

The model can be used in order to compare different products which have been rated on e.g. SD-Scales. Products receiving higher SK values are experienced as more attractive than others. Moreover it is possible to define boundaries for negative, neutral and attractive feeling according to Kano (1984).

This measurement is quick and comprehensive, however it still might fail if a certain Kansei Word has extremely low ratings but high affective impact on the user. In such cases the total rating can be high, but the customer do no really like the product due to an important affective aspect missing. Hence the model includes the value I_{KW}, which expresses for the relative importance of the Kansei Word used.

In order to clarify the usage of the proposed mathematical model an example is presented in Table 2. The data from three rocker switches were selected from the same data used for Paper B, Appendix A. Moreover, the Kansei Words distinct, durable and quality and the Importance factors I_{KW} were chosen based on the final results from the same paper. Frequency analysis with pareto diagrams was made in this case. Finally, Equation 2 was deployed for both d=1 and d=2.

Table 2: Data collected for rocker switches.

Kansei Word	Importance factor I_{KW}	Avarage Kansei Score		
				
Distinct	0,3	2,6	5,5	3,9
Durable	0,7	3,7	4,1	4,9
Quality	0,9	3,7	3,0	4,8
$SK_{\text{Linear (d=1)}}$		31%	34%	42%
$SK_{\text{Quadratic (d=2)}}$		12%	12%	25%

It can be seen that the three switches differ for the three Kansei Words. However, the first two switches are more similar than the third, which is also reflected in the results. The order of the switches is the same for both assumed linear and quadratic correlation. The quadratic assumption distinguishes the switches more than a linear assumption, i.e. only switches with very high ratings are considered to be attractive. So, the quadratic approach probably reflects the reality better then the linear approach.

9.
Discussion
議論

9.1. Kansei Engineering–not only a Method for Industrial Design

Many Kansei Engineering studies are made presenting pictures or computer graphics to the participants. This seems to be a natural and convenient way of carrying out Kansei Engineering studies. Kansei evaluations that don't provide real products for participant evaluation save time and money.

On the other hand doing so strongly restricts the way people can interact with the product. The number of senses used for experiencing the Kansei is limited to the visual sense. Consequently the Kansei is incomplete or even misleading (compare Section 8.1.1). In fact, by presenting a picture or a computer model, only the exterior shape and industrial design is evaluated. This is not always sufficient, since understanding design in many cases also involves other senses such as the tactile sense. One could argue that using visual presentations is only a sufficient method for indirect affective design (compare Section 8.1.3), i.e. certain 'concealed' qualities are presented indirectly by other factors e.g. shape and design. For example the Kanseis of 'Quality' and 'Robustness' can be expressed by suitable industrial design. This is certainly correct, but the product must show the intended quality in all its details, which might require a broader affective channel (see Section 8.1.4).

Evaluating product properties that can be sensed solely from pictures of the products leads to 'shallow' results. Kansei Engineering may also evaluate 'concealed' product properties which are deeply merged with the product itself and give recommendations of how to improve them. An example of this is the driver feeling in vehicles. It is undeniable that certain cars 'feel' better than others on e.g. curvy roads. This depends on how the engine, the power train, the steering and the wheel suspension are to designed harmonise. In this process a large number of variables are involved. Kansei Engineering may identify those with the highest affective impact and give concrete technical values of how they should be tuned in order to match a certain Kansei, e.g. 'sporty', 'control', 'safe' etc.

9.2. Short- Cuts to Kansei Engineering?

One reason for presenting pictures to the participants and thereby restricting the affective channel width might depend on limited time and economic resources. Kansei Engineering studies require time, financial resources and expert knowledge. The authors experience in different companies was that they found the method of Kansei Engineering highly interesting, but requested a 'lighter' version. One opportunity to less time demanding Kansei Engineering studies lies in careful preparation. This includes determination of which properties that have the highest affective impact. The proposed model of Kansei Engineering methodology in Section 7.1) makes a contribution to this. From this it can be determined which senses are required and limit the affective channel by setting the 'affective windows' in the proximity of interaction and the proximity of presentation respectively (compare Section 8.1.1).

This certainly makes the process more effective and saves time and financial recourses. However, the whole process of collecting words and properties, and prioritising them before the evaluation on SD-questionnaires and synthesis can be carried out, must be performed each time. So, expert knowledge is still required. The question arising is whether it is possible to simplify some work intensive steps such as the erection of the two spaces of semantics and product properties from e.g. previous studies. Küller (1975) shows in his SMB method how he collected descriptive words. Using factor-analysis of data gathered from thousands of participants, he finally found 8 factors relevant for architectural structures. Also for Kansei Engineering similar attempts has been made erecting databases including Kansei Words. (Nagamachi, 2001). It is also imaginable that similar developments can be done for the Space of Properties.

Regarding the synthesis phase and the different mathematical statistical tools, simplifications can surely be done. In fact there are already computer programs on the market, performing e.g. QT1 analysis according to the 'black-box'-principle.

9.3. Qualitative vs. Quantitative Approaches

Scientific theories must be falsifiable i.e. they must be verifiable and disprovable. This means in consequence that findings must be documented in a suitable way. In the area of technology and engineering, quantitative measurements is the preferred way of documenting findings. Mathematical and statistical tools can be applied. In other areas such as in humanistic science, qualitative measures are common. Since Kansei Engineering is located in between different research areas using different types of measurements, confusion has occurred. Traditionally, feelings and emotions, in brief the Kansei - have been treated by behavioural science, psychology, and sociology etc. using qualitative measurements. Although engineers realised early that the Kansei is an important factor in product design they have been unable (and sometimes even unwilling) to treat these topics successfully in many cases due to the uncommon measurement type.

The forerunners of Kansei Engineering and other methodologies in affective product development realised this problem and designed Kansei Engineering as a methodology bridging the gap between techniques and human science. As a result Kansei Engineering can not only quantify the formerly ‘soft’ topics of Kansei, but also build a mathematical statistical correct prediction model of customer behaviour. If wanted every form of qualitative measurement can be suspended. At a fist glance this seems to be the ultimate solution. Presenting Kansei in figures in fact increased technician’s interest in affective methods and promoted the dissemination of Kansei Engineering as a method in product development. For the first time many engineers had the impression that they could ‘understand’ feelings.

However, using Kansei prediction models without knowing the limitation may lead to seriously misleading predictions. As in solving an equation one should have a certain expectation about the result. When engineers are equipped with a tool such as Kansei Engineering, it takes time to develop the experience required. It is therefore indicated to educate engineers better in the background and assumptions of affective product design. Failures of new product’s affective value prediction may be avoided that way.

9.4. Reductionism vs. Holism

It is characteristic for reductionistic approaches that the reality is reduced to a (mathematical) model. In most natural sciences this is the preferred approach to explain phenomena isolated from its context in order to simplify and purify. Among others engineering science is a strong representative for this view. Holistic approaches on the other hand can often be found in humanistic science. This philosophy arose as a reaction on reductionism in natural science. It assumes that a system is more than the sum of its parts. Alternative medicine methods such as practiced in traditional Chinese medicine are representatives for this philosophy. The symptom is not treated isolated, but as a consequence from many different causes in the environment. However, recently holistic approaches have also been discussed in natural science. They are referred to as anti-reductionistic tendencies (Helm et al., 2004).

Kansei Engineering in its original meaning supports the reductionistic perspective in natural sciences. Consequently, Kansei Engineering performs a prioritisation of both semantic descriptions and physical descriptions and builds a model which is only based on the most important factors for the products in question ignoring factors with minor impact on the total Kansei. This is probably due to the prevailing paradigm in the application areas of Kansei Engineering, i.e. product development departments. One reason that Kansei Engineering appears attractive to engineers might be the fact that it uses a similar approach in problem solving that most staff in product development use. One advantage of a reductionistic approach is that Kansei Engineering can be spread more easily to practitioners in product development departments. Reducing the number of influencing factors to a minimum, i.e. finding the most essential semantical and physical descriptions of the product domain, facilitates the understanding, enhances the knowledge of the product and makes the affective needs of the customers clearer to the designers (Helm et al., 2004).

Applying Kansei Engineering without proper knowledge of the background and the prediction models limitations can lead to mistakes which could be avoided using a anti-reductionistic perspective. Omitting factors which presumably does not have a measurable effect on the customer Kansei can have its risks. Even small effects can sum up to a big impact if they all point in the wrong direction. Additionally if they are not in the prediction model, somebody with a reductionistic perspective in mind might not find the reason for the deviation. Certain details of the Kansei cannot be caught using Kansei Engineering. This is a direct consequence of its reductionstic view. However in humanistic science there might be holistic approaches, which can deal with the missing parts of the Kansei; even not quantified. Although all studies in this thesis are designed from a reductionistic perspective the respondents were also supposed to give an opinion on the total impression of the product in question (compare Papers A, B, C and E in Appendix A).

9.5. The Words are not enough

The structure of the Kansei is explained in detail in chapter 5. Roughly it can be said that the Kansei is a subordinated mind structure, which connects exterior stimuli to emotions. Most emotions are generated in the brain in an area which is called the limbic system. From an evolutionary perspective the limbic system is much older than the rest of the human brain. It includes basic function such as heart and breath regulation, blood pressure, etc. and controls the way we emotionally react on external stimuli (Damaiso, 1996). In this way the limbic system protects us e.g. by generating an emotion of fear in dangerous situations. However, all these processes take place unconsciously since the consciousness is placed in the 'newer' parts of the brain, e.g. the frontal lobes in the cerebrum. Physiologically the limbic system is 'hard-wired' to the cerebrum but the connections are few. Moreover a larger number of connections lead from the limbic system to the cerebrum then vice versa. This means that human beings can control their emotions to a certain degree consciously, but not completely (Damaiso, 1996). For the Kansei this means that it exists in the form of emotions in the limbic system. When the Kansei is measured by external methods, such as words, only the impressions and emotions can be described which reaches the consciousness (compare Section 6.3). Consequently, the description of the Kansei is incomplete.

According to researchers in the field of Kansei Engineering, there are other tools in order to measure the Kansei. Nagamachi mentions measurements such as EMG, EEG, eye movement, heart rate and galvanic skin sensitivity (Nagamachi, 2001) (see also Section 5.9). As mentioned above these reactions are directly controlled by the limbic system and reach the measuring apparatus unfiltered by any conscious process. Unfortunately, the sensitivity of these measures is rather low, which makes it difficult to use in this context. However, as a complementing additional measure to semantic descriptions these methods have been proven to be useful (compare Picard (1997)).

So, the dilemma remains. At present it is not possible to measure the Kansei completely. The most effective way is therefore to give a stimulus to the participants and measure the change in the measurements we have today as explained in Section 5.9.

9.6. Asian Advantages?

During the research for this thesis the author has viewed many sources of information on the topic of integrating affective values in products. As mentioned before most publications on Kansei Engineering originate from Japan and Korea and are published in the respective languages. This might not be surprising since the method itself was founded there. However, the research on such methods seems to be largely limited to these regions. Western researchers noticed the area quite recently around the beginning of the new millennium, and they are just a few. It can also be seen that companies from the Far East are most effective to integrate affective techniques into their internal processes as a product philosophy. These are not small companies, but big conglomerates such as Mazda, Toyota, Sharp, Sony, etc. Examples of Western companies are fewer and those who work with affective methods, often co-operate with one of the bigger Japanese conglomerates. Maybe the need for designing feelings into the products is exaggerated? Maybe there no need for such methods in Western industry? Maybe Western customer products can still be sold even with the competition from Asian companies.

The authors experience tells another story. Even if just few Western companies explicitly think in similar terms, the need is there. In particular the market situation of many similar products makes it necessary to produce products which 'feel' better. Many decision makers know about this, but they struggle with problems. In particular translating the emotions into product solutions is vague and often dependent on trial and error. Many companies therefore rely completely on experienced designers' intuition. The backup from universities is limited and consultants can seldom offer tools powerful enough. In Europe just a handful of universities work on these topics and are still in the very early stages. This becomes even more severe considering that not until 2004 a project financed by the European Union started in order map the area of affective product development work (ENGAGE, 2005). So the need of research and implementation is eminent.

9.7. Implementing Kansei Engineering

In Japan, Kansei Engineering is often considered as an independent product development philosophy, which typically is carried out in concurrent engineering processes. However, since the methodology is little known in European industry, it turned out to be helpful to pinpoint possible entry points for Kansei Engineering methodology in the company's individual product development processes. In practice this means to identify product development methods such as QFD etc., which are suitable for transferring Kansei Engineering results into conventional product development.

9.7.1. Integrating Kansei Engineering in Product Development Processes

The major field of application for Kansei Engineering today lays in industry. As shown earlier, Kansei Engineering is mostly deployed as a tool for product development, improvement and innovation creation. Kammerlind and Schütte (2001) and Antoni and Schütte (2002) therefore focus on existing product development processes in companies and the integration of Kansei Engineering in them.

As an practical example Antoni and Schütte (2002) mention BT Industries AB representing an industrial company in the vehicle sector. Like many other companies BT Industries AB uses a Stage-Gate model. As a standard product development Stage-Gate model (Cooper, 1998) can be quoted with his model portrayed in
Figure 30. Within each stage an exactly defined part of the product development process is carried out and subsequently 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 when Kansei Engineering data has been found to be most useful for the product development process.

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 studies 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 recognised in the Stage-Gate model in Figure 30.

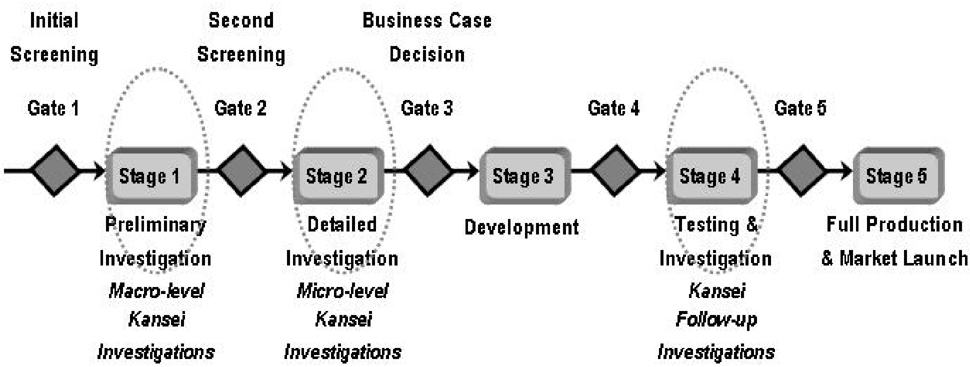


Figure 30: A Stage-Gate process for product development, adapted from Cooper (1998).

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 studies 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 fulfil the requirements regarding emotional impact or not. At this point small changes such as colour setting, tuning parameters or changing minor modules can still be made.

9.7.2. Integrating Kansei Engineering Data in QFD

Many companies use standardised methods for the translation of customer wants and needs into product and process properties (compare e.g. Gustafsson (1998)). One of the most common methods is QFD. Since BT Industries uses QFD, especially in the second stage of their development processes (compare Cooper (1998)) a recurring question was if and how Kansei Engineering can contribute or be combined with QFD. A combination of deductive work and reanalysis of empirical studies could spot five potential approaches. Kansei Engineering data can be used in order to identify customer needs and determine their importance, facilitating the setting of target values for technical data and perform benchmarking between different products and brands and quantify the relationships in the relationship matrix in a more exact way (Figure 31).

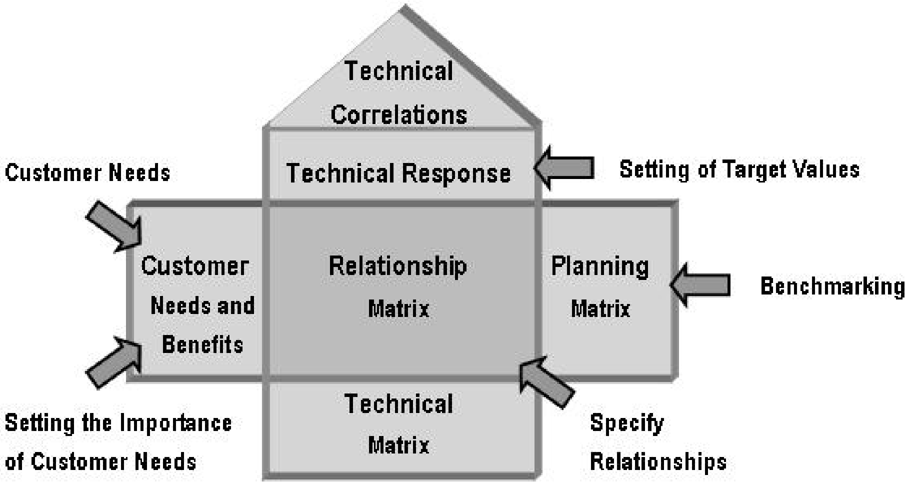


Figure 31: Entry points for Kansei Engineering data in QFD.

In the relationship matrix the customer's needs are linked to the technical responses. The strength of the relationships is determined by more or less qualified guesses of experts distinguishing between strong, medium and weak relationships. Further refinement of the scale complicates the decision process and as a consequence increases the evaluation time. However, in some cases more detailed information is desirable. Kansei Engineering can quantify those relationships by building mathematical models of the customer's Kansei. Moreover, statistics allow examination of whether different customer group have different opinions which in turn can lead to the development of alternative product concepts.

In QFD the customer needs are collected using focus group interviews, activity analysis etc. The data gathered is evaluated and interpreted by i.e. Voice of customer tables, etc. Those tools try to grasp even implicit needs and wants and link them to product parameters. However, interpreting the customers' statements is very difficult and requires much experience. Kansei Engineering is designed for evaluating the unconscious wants and needs, and delivers statistical mathematical values for the connection between a need and its technical response. Regarding furniture the customer may describe her home as 'elegant'. One way is to treat this statement with VOCT, and feed it into the 'House of Quality'. An alternative way is to make a Kansei Engineering evaluation and get an exact translation into product properties with only minor influence from the researcher. In the following step within the QFD procedure, customer needs are ranked after their importance. QFD offers a number of different tools, based on (subjective) expert knowledge. Kansei Engineering offers the opportunity to collect the customer's attitude about the particular importance of the different product properties. Paper B in Appendix A describes how the type of importance can be valued and ranked by customers (see also Section 8.3).

A third way Kansei Engineering can be used in the QFD process is the setting of the target values for the product properties. For every customer need, a number of product properties can be identified. Collecting additional information about what the ideal product should feel like, gives a clear indication about in which direction the Kansei Score of the certain Kansei Word has to be adjusted to suit the customers' needs in a better way. Since it is known how and in which way the product properties are connected to the certain word, it becomes clear how the Kansei can be adjusted. As a result Kansei Engineering can help to set target values for the technical specifications.

Success in international markets does not only require a customer-focused design, but also knowledge about the competition situation in the specific market segment. QFD provides a product comparison where different products within the same segment are compared regarding the degree of fulfilment of a specific customer need. By comparing the results of Kansei Engineering studies made for different competing products, a benchmarking profile can be developed and integrated into the 'House of Quality'. Such a combination of the 'House of Quality' and Kansei Engineering allows a special profiling of the products expressed Kansei.

9.8. Tangible and Intangible Products

Products may be physical artefacts or services. A more general definition is that products are the result of all kinds of man-made allowances towards an intended purpose. In order to discriminate between services and artefacts the terms tangible and intangible products was coined (Röstlinger and Goldkuhl, 1999) (compare also Section 2.4.).

Kansei Engineering traditionally treats only tangible products. Some few intangible products such as web pages etc. have been examined, but there is now a strong focus on integrating these products types into the methodology. However, as shown before, the market of intangible products is growing and new types of products combining both tangible and intangible parts occur. An example of these types of products are mobile communication devices. An artefact, the phone itself is needed, but this is just a smaller part. The service behind it, is more cost intensive and more relevant to the customer. In principle, Kansei Engineering can cope with these products too. However minor technical modifications have to be made to the methodology. For example, the collection of the semantic and physical description must be enhanced towards the intangible properties. New tools might be found. Also the name 'physical description' does not longer apply. There is no general difference in how the incoming data is treated. This means that the synthesis phase and the model building in Figure 20 will be applicable.

The main problem is the lack of experience with this type of products. Defining the domain might be more complex. Whereas tangible products have clear physical limitation, the decision of what property is part of combined tangible/intangible products is much more difficult.

9.9. Innovativeness in Kansei Engineering?

Critics of the method have claimed that Kansei Engineering has a lack of innovativeness. However, Kansei Engineering has been involved in the development of many successful products such as the Mazda Miata or the Camcorder from Sharp (Nagamachi, 1999), but the argument is that Kansei Engineering itself can not contribute to the new features.

Kansei Engineering methodology is often used in order to evaluate already existing products. It can determine which product features are important for a certain impression or Kansei and give recommendation about how to combine them with each other in order to achieve the intended Kansei or even combinations of different Kanseis. The reason for this is that the customers/ users of a product must have sufficient experience in order to determine the its Kansei. This is not the case if the product type is completely new. It is difficult for people to have opinions of products the have not interacted with. Hence, Kansei Engineering is more useful for evaluating mature products. People are used to them and have clear opinions about them. They can also evaluate new features in old products. Even if Kansei Engineering can not directly take part in the generation of new ideas and concepts, it presents suggestions and delivers a ground of discussion which triggers creative processes in product development staff. This is the way it has been used in the cases of Mazda and Sharp.

In most cases product development is not about revolutionising the product type. It is more about attractive quality creation (Kano et al., 1984), i.e. a gradual improvement of the products affective values by adding a few attractive qualities and at the same time ensuring one-dimensional and must-be-quality (compare also Section 1.4.3). Kansei is designed to accomplish this. However, there are development opportunities in Kansei Engineering which also have been addressed previously. One is the integration of creativity tools. These are techniques collecting and ‘harvesting’ new ideas. Some of them have already been suggested for usage in Kansei Engineering such as brainstorming, Pareto-diagrams, Card-systems and Affinity diagrams. So there is no reason why no more methods can be included into Kansei Engineering.

A final point is the product image and the brand image. Some brands have the reputation of being progressive and include more new solutions than other more conservative brands. The need and the degree of developing innovative products also vary with the target group (Naoki, 2002).

9.10. Applying Kansei Engineering in Europe

Kansei Engineering has been used in the Far East by many researchers and companies since the 1970ies. Its application technique is well developed. However starting to use Kansei Engineering in Europe resulted in unexpected difficulties. Partly, these difficulties depended on missing knowledge about the method, but other problems seemed to depend on cultural differences between Japan and Sweden/Europe. One of the difficulties was that participants asked what the purpose of the study was. Some suspected a psychological test, and refused to attend. Suitable explanations took much time, required the presence of the researcher and destroyed some of the intuitiveness needed since the participants tried to understand instead of giving their first impression. Another hitch, which was probably related to the above was that participants were not used to the SD-scales used. It could be seen that people ranked erroneously or did not understand the task. This was more severe the more 'non-academics' there were among the participants. In this context also the number of rating points resulted in confusion. Japanese researcher often use 5-point scales. These types of scales worked well in Germany and France, but in Sweden the results did not show as good a distribution.

However one of the most severe difficulties which took many experiments to solve was the fact that participants in Europe could not make as many ratings as in Japanese studies. This showed itself by incomplete data sets, obviously wrongly checked data sheets and bad data quality due to fatigue (compare Schütte (2002)). According to Japanese researcher the rating of up to 20 products with 100 Kansei Words each was no problem in Japan, but in Europe is was. The consequences were lower statistical power due to the low number of voluntary participants and insufficient data quality. The solution was to reduce the number of ratings. As a rule of the thumb 15 minutes is the maximum including introduction to the products in question. So the maximum number of ratings lays around 200 which equals ca. 20 Kansei Words for 10 products. The reasons for the difficulties described include the fact that both researchers and participants are untrained in the application of the method in Europe. However, some reasons can also be found in cultural differences.

10.

Conclusions

結論

Increasing customer demands on product design have resulted in that not only functionality and usability of the products have to be fulfilled. Today, many companies meet challenges that force them to put strong emphasis on also integrating affective aspects in their product design, something that now has become distinguishing qualities of products. Different methodologies have been developed and integrated in product design processes in order to measure the affective impact of different products on customers and users. Kansei Engineering is one of these methods, aimed at determining relationships between on the one hand the feelings and impressions of the humans and on the other hand product properties. The special characteristic of this methodology is that it identifies concrete product design solutions, based on the feelings and impressions of the users and customers. For this purpose (mathematical) prediction models are built. Even if quantitative measurements in most cases are used as the basis for these relationships, there are also studies and elements that require qualitative approaches. The studies in this thesis have demonstrated the ability of the Kansei Engineering methodology to evaluate, improve and validate product design changes towards a desired impact. They have also identified improvement areas in the methodology and proposed new developments, including the use of scales, experimental design and validation methods. Further, a conceptual model of Kansei Engineering was proposed in order to provide a structure for performing Kansei Engineering studies and studies within the field of affective design. This conceptual model has become a useful tool for explaining and applying the concept. More structured ways of identifying design parameters and relevant product properties have been given high priority in the improvement work of the methodology. A model for spanning the Space of Product Properties is presented and applied. It was found to support study performance, make it easier and more structured. Advantages of using Kansei Engineering are that abstract feelings are visualised and made comprehensible. Thus, it may provide a structured support for integrating affective values into product design, especially in early and late stages of the product development process. However, performing full Kansei Engineering studies takes time, resources and special competence of the facilitator. Moreover, it is difficult to learn the methodology from publications available in English. In conclusion, Kansei Engineering is a concept and a methodology in strong development, a framework in which tools and methods are continuously developed, added and integrated.

11.
Future Research

Kansei Engineering and the area of affective values in products is developing quickly and the experience of application of different methodologies is limited. Most of them need more development both regarding general parts and adaptation to application areas.

According to the proposed model on Kansei Engineering there is much further development potential. One of the most important points is the spanning of the Space of Properties, where there is a need for further research. Methods for the synthesis phase exist, but there is a need for better adaptation to the context. This is closely connected to the development of improved validation tools.

Kansei Engineering as used in this thesis was limited to evaluations of physical products. However, services are a growing sector and an important type of product. Also, combination of artefacts and services occur increasingly. The experience with this product types is partial since not many studies has been performed in these areas. One challenge for the future is to extend Kansei Engineering into this direction.

Kansei Engineering is has the potential to evaluate the affective impact of product parts the user is not even aware of. Unfortunately, many product designers do not exploit this ability and many studies often focus on apparent features such as exterior design.

A weakness of Kansei Engineering is its consumption of time and resources and the need of highly competent facilitators. There are good opportunities for automation of data collection and evaluations. Also databanks can be built storing information of e.g. exemplary sets of Kansei Engineering Words and sets of product properties for certain product domains. Also, methods that are easier to apply, based on qualitative data need to be developed. This could finally lead to further development of qualitative methods based on interviews with quick and easy evaluation as in e.g. means-end-analysis. There is also a great need of knowledge summary reports and state of the art descriptions in order to further the developments in this field.

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