User Experience of Interaction with Technical Systems

Theories, Methods, Empirical Results, and
Their Application to the Development of Interactive Systems

vorgelegt von
Diplom-Psychologe
Sascha Mahlke
aus Berlin

Von der Fakultät V – Verkehrs- und Maschinensysteme
der Technischen Universität Berlin
zur Erlangung des akademischen Grades
Doktor der Ingenieurwissenschaften (Dr.-Ing.)

genehmigte Dissertation

Promotionsausschuss

Vorsitzender: Prof. Dr.-Ing. Matthias Rötting
Gutachter: Prof. Dr.-Ing. Luciënne Blessing
Gutachter: Prof. Dr. phil. Manfred Thüring

Tag der wissenschaftlichen Aussprache: 07.02.2008

Berlin 2008

D 83

Abstract

Today, people use interactive systems to accomplish many of their professional and personal goals. The use of interactive products has become an integral part of our everyday lives. In response, interactive system development does not exclusively focus on design of useful and usable products anymore, but takes the entire user experience into account to be successful. But what determines a good user experience? To answer this question, an approach to user experience of interaction with technical systems is presented that makes theoretical, methodological, and empirical contributions to overcome shortcomings of existing approaches and gives recommendations to incorporate user experience design goals already in early stages of the development process of interactive systems.

A user experience framework introduces instrumental and non-instrumental quality perceptions as well as emotional user reactions as central components of user experience. Perceived usefulness and usability are discussed as aspects of the instrumental quality of interactive systems. A hierarchical approach to non-instrumental quality perceptions takes into account three categories: aesthetic, symbolic, and motivational aspects. A multi-component approach to emotional user reactions is proposed that defines five aspects of emotions: subjective feelings, physiological reactions, motor expressions, cognitive appraisals, and behavioral tendencies. Interactive system properties, user characteristics, and context parameters are discussed as main influencing factors of user experience, and overall judgments, choices between alternatives, and usage behavior are taken into account as consequences of user experience. Interrelations between the factors of the framework are discussed in detail and form the basis for empirical research questions.

The assessment of non-instrumental quality perceptions and emotional user reactions is focused in the methodological section. Toolboxes of methods are proposed for these two user experience components, which are applied in the empirical part. In summary, the results of three studies on portable audio players support most of the assumptions made in the user experience framework. All three categories of influencing factors have a significant impact on user experience. While system properties have a direct effect on instrumental and non-instrumental quality perceptions, user characteristics and context parameters affect the interrelations of the user experience components and their impact on consequences of user experience. With respect to interrelations of the user experience components, the results support the assumptions that (1) instrumental and non-instrumental qualities are perceived independently, (2) emotional user reactions are determined by instrumental and non-instrumental quality perceptions, and (3) consequences of user experience are influenced by all three components of user experience.

In conclusion, the theoretical, methodological, and empirical results are summarized in suggestions to add user experience design goals during the development process of interactive systems. Recommendations are formulated for analysis, design generation, and evaluation activities.

Acknowledgements

Many people have contributed their ideas, time, and energy to helping me in the pursuit of this research. I am grateful to my two supervisors: Manfred Thüring and Luciënne Blessing. Manfred Thüring gave me the opportunity to work on this topic, convinced me to incorporate an experimental approach, and taught me a great deal about writing research papers. Luciënne Blessing assured that the project satisfies the applied needs of the engineering design discipline and was my resource for information about product development in general.

Michael Minge, Iris Lemke and Andreas Wand did their diploma thesis as part of this research project. It was great working with them on new ideas and discussing with them many of the issues of the topic in detail. Furthermore, I appreciate the help of Jasmin Hannighofer and Djamila Maleika conducting the empirical studies.

Many of my colleagues supported me in pursuing this research. I am especially thankful for the support of Anne Klostermann, Nicola Fricke and Krisztin Pataki who were always there to discuss crucial issues and gave a lot of important comments to improve the dissertation. Additionally, I thank all members of the Center for Human-Machine-Systems and the Research Training Group *prometei* who supported me by discussing ideas, commenting on drafts, and providing good company. The research project was supported by a scholarship of the German Research Foundation (DFG) as part of the Research Training Group ‘Prospective Engineering of Human-Technology Interaction’.

I spent four month of the research project at the Human Oriented Technology Lab at Carleton University in Ottawa, Canada. I thank Gitte Lindgaard and the other members of the lab for hosting me at this time and supporting the work on the project. Funding for the research stay was provided by the German Academic Exchange Council (DAAD).

Creative Labs GmbH and Motorola GmbH supported two studies that are part of this project – thanks for that. The work would also not have been possible without the technical and administrative support of Nikolaus Rötting, Mario Lasch, Birgit Trogisch, Elke Fadel and Karin Scherinsky-Pingel.

Many people in the human-technology interaction community contributed to this research by exchanging their ideas, challenging my approaches, and commenting on drafts. I wish it were possible to thank them all.

Finally, I wish to thank my family and friends for their support and company during this exciting and challenging period of my life. I am especially thankful to Thorb Baumgarten and Jens Riegelsberger, who have accompanied my way in the area of human-technology interaction for many years – as friends. Many thanks to Johanna Muth for the comments on the framework and everything else.

Table of Contents

List of Figures

List of Tables

Designing for the full range of human experience may well be the theme for the next generation of discourse about software design.

Terry Winograd in *Bringing design to software* (1996, p. 19).

1 Introduction

The use of interactive systems has become an integral part of our everyday lives. While in their early stages (1960s), they were only used by developers and operators with a technical background, they later (1980s) moved to the offices to be used by non-technical, but trained people (Grudin, 1990). Today (2000s), interactive systems are necessary tools for communication, entertainment, and a whole range of other tasks outside professional environments. People use various kinds of websites, computer programs, or interactive appliances to accomplish their personal goals.

Due to this shift in interactive system use, the focus has changed for accomplishing a user-centered design process. Traditionally, development of interactive systems concentrated on instrumental aspects. This especially made sense at a time when interactive systems were so expensive that every second saved during operation could cut costs. As interactive systems became more affordable for the professional context, the focus shifted to what users really need and what the systems have to be like so that users could integrate them more easily in their everyday work (Davis, 1989). As a result, a huge amount of knowledge is now available that supports a development process for useful and usable interactive systems.

Nowadays, as interactive systems play a role in most areas of our everyday lives, more aspects seem to be important than just efficient task completion. Research expanded the focus to design not only for efficiency and effectiveness, but for the full range of human experience (Winograd, 1996). The needs of people who use interactive systems to satisfy personal goals are different from those that have been traditionally focused on in user-centered design.

1.1 Research problem

User experience has become a buzzword in the area of user-centered design over the last ten years to describe this shift to a more holistic approach. Nowadays, usability professionals call themselves user experience specialist, and entire departments change their names from usability to user experience research. These developments give the impression that the change that has just been described is already established in the professional area of human-technology interaction. However, it often seems that even though the necessity is realized, the real focus of work still remains on the traditional agenda, and not much more than the names have changed.

Research on user experience in human-technology interaction still concentrates on demonstrating the importance of considering additional aspects that might be relevant from the users' perspectives. Most of the early approaches viewed the traditional, instrumental focus and the new area of research as opposing elements. The new concepts have a variety of different names ranging from pleasure (Jordan, 1998) to flow (Draper, 1999) and from hedonic (Hassenzahl, 2001), aesthetic (Tractinsky, 1997), affective (Zhang & Li, 2005) to emotional aspects (Logan, 1994).

This indicates that a variety of different new aspects might be relevant and should be integrated into an approach to user experience. However, differing concepts are often seen as similar, or discussions focus on the question of relevance without having an empirical basis. To judge which new concepts are relevant, more empirical research is needed that integrates new facets of user experience and instrumental aspects. The approach taken here deals with the questions of how an approach can be formulated that integrates all relevant aspects of user experience of interaction with technical systems and how it can be empirically validated. Furthermore, the problem of which methods are available to investigate user experience and how these methods can be used during the development process are addressed.

1.2 Scope

The presented work has been part of the Research Cluster 'Usability Workbench - Methods for User Modeling and System Evaluation' of the Research Training Group 'Prospective Engineering of Human-Technology Interaction' and was sponsored by the German Research Foundation (DFG) from 2004 to 2007. The Research Training Group develops and integrates methods, procedures and tools in order to investigate human-technology interaction already in the early development phases of technical systems. The focus on early stages of the development process is of central importance. Therefore, the approach developed here offers a prospective perspective on the design for a positive user experience. The aim is not only to explain and understand user behavior, but also to offer a theoretical basis and applicable methods for user researchers as well as guidelines and background information for designers and developers that can be applied early in a user-centered design process.

The empirical studies that are described in the following chapters focus on a specific application area. Consumer electronic products and especially portable audio players and mobile phones were chosen as stimuli for the studies. Although the studies focus on one area of interactive systems, the theoretical assumptions, methodological recommendations and even most of the empirical results should be transferable to other domains.

1.3 Research goals

After sketching out the issues related to user experience of interaction with technical systems, this section introduces the set of specific research goals that are addressed.

Research goal 1 (theoretical)

Creating a framework to describe user experience of interaction

The current discussion of user experience in human-technology interaction is fragmented in terms of approaches, methods, and definitions. It is often unclear which aspects of user experience are investigated and to what extent findings can be generalized. An integrative framework of user experience in human-technology interaction can help to overcome this situation by considering all relevant aspects of user experience as well as technological and contextual factors. Such a framework defines influencing factors of user experience, integrates central components of user experience, discusses the interrelations of these components and describes the most relevant consequences of user experience.

Research goal 2 (methodological)

Developing a toolbox of methods to assess the central components of user experience

Sound knowledge of methods to measure the perception of instrumental qualities of interactive systems is available, but existing methods to assess non-instrumental quality perceptions and emotional user reactions need to be improved. Although there are a variety of questionnaires to survey non-instrumental qualities, like aesthetic and symbolic aspects, the definitions of dimensions overlap and it remains unclear how various concepts relate to each other. A structure of relevant dimensions based on theoretical considerations can form a basis to integrate available methods to offer a comprehensive approach to the measurement of non-instrumental qualities. Likewise, various methods have been applied to measure emotional aspects of user experience, but here too it remains unclear how these methods can be combined. Therefore, another sub-goal is to offer a theory-based way to structure available methods in order to measure emotional user reactions.

Research goal 3 (empirical)

Investigating influencing factors, the interrelations of the central components, and their influence on consequences of user experience

Assumptions made in a user experience framework have to be verified empirically. As the aim of the framework is to structure influencing factors of user experience, integrate central components of user experience, describe the most relevant consequences of user experience and discuss the interrelations of these components, empirical studies focus on assumptions regarding these aspects of user experience. The results of the empirical studies are used to revise the user experience framework.

Research goal 4 (application-oriented)

Compiling recommendations regarding the use of the theoretical, methodological, and empirical contributions in the development process of interactive systems

To be useful during early stages of the development process the theoretical, methodological, and empirical results have to be summarized to support various activities during the development process of interactive systems. Existing process models from engineering design, user-centered design, and usability engineering help to detect common activities and stages during the development process at which the user experience framework and the methodological toolboxes can be used and the empirical results should be considered.

1.4 Overview

An integrative approach to user experience in human-technology interaction is developed in the following chapters. Chapters 2 to 4 establish the conceptual and methodological background. They are followed by Chapters 5 to 7, which present three studies undertaken to address the empirical research goals. Each experiment is an independent investigation of several issues addressed, but approaches and hypotheses of the later experiments are informed by the outcomes of the earlier ones. Each of these chapters includes research questions, methodological details, results, and a discussion of the findings. Chapters 8 to 10 represent the concluding part.

Chapter 2 initiates the discussion of the role of users' experience of interaction for the design and evaluation of interactive systems. It argues for the relevance of other aspects of the user experience in addition to traditionally focused, instrumental values. A critical literature review of research on user experience of interaction is followed by an argument for an integrative user experience framework.

Chapter 3 introduces a framework of user experience of interaction with technical systems. This framework incorporates existing research and concepts, but aims at an innovative attempt to integrate various components of user experience. It provides the conceptual and terminological basis for the following parts. Methodological and empirical research questions that arise from the framework are formulated.

Chapter 4 starts with a short overview of existing methods to assess user perceptions of instrumental qualities. The main focus of the chapter is on the measurement of non-instrumental quality perceptions and emotional user reactions. Methods to assess these aspects are structured using theory-based assumptions made in the framework. The application of two resulting toolboxes is demonstrated in two studies: one on the measurement of non-instrumental quality perceptions, the other on the measurement of emotional user reactions.

Chapter 5 presents Study 1. Four existing portable audio players are used in the study as stimuli to better understand how differences in system properties affect various aspects of user experience. The used interactive products differed in various system properties and were selected for heterogeneity, i.e. to maximize variance of the user experience with the systems.

Chapter 6 presents Study 2, which also studies the influence of system properties on user experience, but has an experimental set-up. Two groups of system properties are varied to influence the perception of instrumental and non-instrumental qualities independently. So, it is investigated how system properties affect specific quality perceptions and impact emotional user reactions as well as overall judgments, and choices between alternatives. Additionally, physiological methods are used to assess specific aspects of emotional user reactions.

Chapter 7 presents Study 3, which expands the previous experiment by integrating a variation of user characteristics and context parameters as additional influencing factors. Culture is chosen as a user characteristic and data are collected in Canada and Germany. Two situational settings are chosen to study the influence of context parameters.

Chapter 8 combines the findings of all three empirical studies, and the results are reflected on the basis of the user experience framework. Necessary changes and clarifications of assumptions made in the framework as well as further theoretical research questions that remain open are discussed.

Chapter 9 aims at integrating the theoretical, methodological, and empirical results in the development process of interactive systems. Therefore, process models from engineering design, user-centered design, and usability engineering are reviewed to identify the main process stages and activities for the consideration of user experience goals. Recommendations are given for analysis, design generation and evaluation activities separately.

Chapter 10 summarizes the substantive theoretical, methodological, and empirical as well as the application-oriented contributions by reconsidering the research goals. Furthermore, areas for future research are discussed.

The Appendix contains the material used for the reported studies. This includes questionnaires, instruction sheets, and stimulus material, such as descriptions of the used portable audio players, mobile phones, and simulations as well as tasks given to the participants. Furthermore, details of the data analysis can be found here.

2 Background

This chapter provides the theoretical background. It first positions the investigations of user experience in the wider field of user-centered design (Section 2.1), and then goes on to discuss the relevance of the user's perspective of the quality of interactive systems (Section 2.2). Next, the development from early concepts of user satisfaction to the emergence of the idea of user experience is discussed (Section 2.3). The main part of this chapter is formed by a critical discussion of existing approaches to user experience in human-technology interaction (Section 2.4). A summary of the main shortcomings and questions open for further research as well as the approach taken to tackle these questions are described in Section 2.5.

2.1 Criteria for user-centered design

User-centered design (UCD) can be seen as a philosophy as well as a process. It places the user at the center of the design process rather than the product, and focuses on human factors as they come into play during peoples' interactions with technical artifacts. UCD seeks to answer questions about users and their tasks and goals, and then uses the findings to drive development and design (Katz-Haas, 1998). The evaluation of interactive systems plays an important role in all areas that apply a user-centered design approach.

Depending on product categories, approaches to UCD differ slightly whether the background is more in human factors (process control, in-vehicle information/assistance, machine control), human-computer interaction (software, websites), or product design (consumer electronic products). As interactive systems are increasingly computerized, approaches from these different areas have become more alike over recent years, and important criteria for UCD are used for all product categories.

2.1.1 Usability and user-centered design

One particularly important concept to define the interactive quality of interactive systems has been developed over the last thirty years: usability (Cakir, Hart & Stewart, 1979; Shackel, 1984). Shackel (1991) presents the following definition:

> *"Usability of a system or equipment is the capability in human functional terms to be used easily and effectively by the specified range of users, given specified training and user support, to fulfill the specified range of tasks, within the specified range of environmental scenario,"* (Shackel, 1991, p. 24).

Summarizing, an interactive system is usable if it has the capability to be used easily and effectively by humans. However, Shackel's definition already considers that the usability of an interactive system is not only influenced by certain properties of the system, but also depends on characteristics of the user and the context. Bevan and Macleod (1994) discuss usability as *"… a property of the overall system: it is the quality of use in a context"* (p. 136). Accordingly, quality of use became a synonym for usability. The term helps to explain the relation of the concept of usability to the overall quality of a system.

ISO 9126 (ISO, 2001) on general product quality also associates usability with the properties of a system that lead to high quality of use. Criteria of quality of use are effectiveness, productivity, safety, and satisfaction. ISO 9241-11 (ISO, 1998), which has become a main source for the definition of the concept of usability, applies a slightly different definition, namely *"… the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"* (p. 4). Accordingly, effectiveness can be described as the degree of accuracy and completeness with which the user's goals are satisfied. Efficiency can be characterized as the effectiveness of system usage in relation to its costs in terms of effort or time and satisfaction relates to user's comfort and acceptance of the system. Different measurement approaches to usability apply these definitions and range from a focus on product attributes to an assessment of the interactive quality of use.

2.1.2 Measurement approaches to usability

Rauterberg (1993) distinguishes four different approaches to the measurement of usability of interactive products:

1. The *product-oriented view*: usability is measured in terms of the ergonomic attributes of the product itself (descriptive measures).
2. The *formal view*: usability is inferred form formalized and simulated interactions in terms of mental models (formal concepts).
3. The *interaction-oriented view*: usability is measured in terms of how the user interacts with the product (performance).
4. The *user-oriented view*: usability is measured in terms of the mental effort and attitude of the user (questionnaires and interviews).

While the product-oriented view focuses on the evaluation of product attributes based on expert knowledge or checklists/guidelines and the formal view uses abstract models to assess the interaction between user and product, the interactive qualities of user interfaces are only quantified in the context of the interaction-oriented and the user-oriented view. The latter two approaches may be more time consuming and more expensive, but they actually measure the quality of use of a product.

Shackel (1991) stated that quality of use has these two perspectives, one related to objective measures of the interaction and the other to subjective perceptions of the used product. While the interaction-oriented view focuses on criteria such as effectiveness and efficiency of the interaction, the user-oriented perspective takes aspects of user satisfaction into account (ISO 9241-11). In the same way, Bevan (1995) distinguishes between measuring user performance and satisfaction. The approach taken here aims at improving the user-oriented view on interactive system quality.

2.2 Evaluation from the user's perspective

As discussed in the previous chapter, the traditional focus of interactive system design and evaluation was on products that were used in professional contexts. Machines and first computer systems were mainly used in work environments. Interactive systems were very expensive and it was important that they were used as efficiently as possible. Therefore, the focus in system evaluation was on user performance. In recent years, the use of interactive products has become an integral aspect of our everyday life. The relevance of the user's perspective on the quality of an interactive product has become more important.

Although Nielsen and Levy (1994) argue that users' preferences predict their performance with an interactive system quite well, further research on the interrelations of objective and subjective measures of quality of use has shown that they can differ significantly. Based on an extensive meta analysis of 73 studies, Hornbæk and Law (2007) find that objective and subjective measures of usability vary and that measures of users' perceptions are generally not correlated with objective measures.

2.2.1 User satisfaction as part of usability

ISO 9241-11 (1998) states that satisfaction can be specified and measured by attitude rating scales or measures such as the ratio of positive to negative comments during use. Additional information may be obtained from long term measures such as the rate of absenteeism from work, health problem reports, or the frequency of job transfer requests. However, the last criteria can only be applied in a work environment, but not in the many other situations, in which interactive products are used.

Questionnaires to measures of satisfaction may assess attitudes towards use of a product, or assess the user's perception of aspects such as efficiency, helpfulness, or learnability. A variety of standardized questionnaires were developed especially during the mid 1990s to assess user satisfaction. The Software Usability Measurement Inventory (SUMI; Kirakowski, 1996), the Questionnaire for User Interaction Satisfaction (QUIS; Chin, Diehl & Norman, 1988), and the System Usability Scale (SUS; Brooke, 1996) are examples. These questionnaires focus on users' evaluations of specific dimensions that relate to user satisfaction like controllability, ease of use and learning.

Another well established approach to assess users' attitudes comes from the technology acceptance literature. Davis (1989) proposes a model of users' intention to use an interactive system that takes into account the perceived usefulness and perceived ease of use as two main aspects of technology acceptance. This approach also offers questionnaires that have been used in various studies and have been applied in various domains (Taylor & Todd, 1995; Venkatesh & Davis, 2000; Morris & Turner, 2001).

However, Hornbæk (2006) found in a review of 180 usability studies that standardized methods to measure user satisfaction are rarely used. One reason seems to be that there is disagreement about the best criteria to assess user satisfaction and which aspects should be considered to capture the user's view on product quality sufficiently.

2.2.2 Limitations of the user satisfaction concept

Users' perceptions of aspects such as efficiency, helpfulness, or learnability as recommended in ISO 9241-11 are linked to users' perception of their performance with an interactive system. Therefore, the definition of user satisfaction focuses on users' experience of instrumental qualities of the system. This focus on users' tasks, goals, and their efficient achievement repeatedly led to criticism. Hassenzahl, Platz, Burmester and Lehner (2000) criticize the definition of user satisfaction explicitly:

> *"We are aware that user satisfaction is a part of the usability concept provided by ISO 9241-11. However, it seems as if satisfaction is conceived as a consequence of user experienced effectiveness and efficiency rather than a design goal in itself. This implies that assuring efficiency and effectiveness alone guarantees user satisfaction." (Hassenzahl et al., 2000, p. 202)*

Lindgaard and Dudek (2003) argue similarly, but take the limitation of existing methods to measure user satisfaction additionally into account:

> *"Indeed, many measurements of user satisfaction are limited to, what users think of a given application. Not surprisingly, instruments intend to measure user satisfaction also tend to be quite crude and vague and focus mostly on the efficiency and effectiveness of the interaction." (Lindgaard & Dudek, 2003, p. 430)*

Thus, in the area of human-technology interaction the concept of user satisfaction is seen as problematic to sufficiently capture the user's perspective on interactive product quality. First, the interpretation and operationalization of the concept is mostly bound to users' perceptions of the instrumental values of an interactive product. Second, user satisfaction is more an outcome of a user's interaction with a system, while the process of experiencing the product during the interaction is not taken into consideration.

2.3 From user satisfaction to user experience

Already, Norman and Draper (1986) use a different term to consider a user's subjective view on the interaction: user experience. In the introduction to their well-known book on user-centered system design, they refer as follows to the section on user experience:

> *"This section … directly asks the ultimately central question "what is the experience like for the user?" In the end, that is the basic question underlying all user-centered design." (Norman & Draper, 1986, p. 4)*

In the introduction of that section they underline their point of view:

> *"This section of the book contains chapters that get directly at the question of the quality of the user's experience. This is of course the ultimate criterion of User Centered System Design, but most workers approach it obliquely in various ways such as exploring the implementation techniques, or applying existing cognitive approaches. These chapters attempt more direct analyses." (Norman & Draper, 1986, p. 64)*

This early use of the term user experience already contains the key understanding of the concept as it is used today. User experience takes an entirely user-oriented perspective on human-technology interaction. The user's perspective on the quality of the interaction is the ultimate criterion. In comparison to user satisfaction, user experience is not only an outcome of the interaction that can be measured easily in the end, but a complex process that is influenced by various relevant characteristics of the user, the usage situation and the used interactive system. Laurel (1986) suggests thinking of interactive systems as a theater stage, capable of letting the users experience the world. From her point of view, interactive system design is particularly about the 'first person experience' (Laurel, 1991).

Few other early contributions discuss the user-centered view on interactive product quality as more than the outcome of effective and efficient interaction, although they do not use the term user experience. Malone (1981) studied what makes computer games enjoyable to identify design principles, which have the power to promote fun and enjoyment. Carrol and Thomas (1988) warned not to confuse the concepts easy to use and fun to use when talking about interactive system quality.

In the area of product design and consumer research, Kano (1984) differentiates between must-be and attraction product features. Similarly, Batra and Athola (1990) show that consumer attitudes have distinct hedonic and utilitarian components and that they play a differentially salient role across different consumer products. Oliver (1993) discusses the relevance of affective aspects as part of user satisfaction.

In the context of technology acceptance research, Davis, Bagozzi and Warschaw (1992) show the relevance of perceived usefulness and enjoyment on users' intention to use interactive system and their actual usage. Mundorf, Westin and Dholakia (1993) demonstrate that hedonic features of a screen-based information service (presence of color and music) affect the level of perceived enjoyment and intention to use the service, and Igbaria, Schiffman and Wieckowski (1994) found that user characteristics, like computer anxiety, influence both the perception of the usefulness of an interactive system and the level of enjoyment.

Even in usability research, further approaches are proposed to enhance the user-oriented view on product quality, although the concept of user satisfaction had been already established. Logan (1994) develops a two-component usability concept that considers behavioral and emotional usability. While behavioral usability refers to a more or less traditional use of the term usability, Logan (1994) defines emotional usability as *"… the degree to which a product is desirable or serves a need beyond the traditional functional objective"* (p. 61). Kurosu and Kashimura (1995) show that subjective judgments of usability are strongly affected by the aesthetic appearance of the interactive product.

Although all these contributions focused on the enhancement of the user-focused quality perspective and fit well into the outline Norman and Draper (1986) made for an approach to the user's subjective view of the interaction, none of them explicitly used the term user experience. Alben (1996) brought the term back to the area of human-technology interaction. In her article on quality of experience, she discusses interaction design criteria that have to be taken into account to provide people with a successful and satisfying experience. From her point of view all the aspects of how people use an interactive product have to be taken into account: the way it feels in their hands, how well they understand how it works, how they feel about it while they are using it, how well it serves their purposes, and how well it fits into the entire context in which they are using it.

Since then, more detailed work has been published regarding the design for user experience with interactive systems and for a better theoretical understanding of what forms the user experience. Additionally, a number of empirical studies, which have been published over the past decade, have helped to understand which aspects of user experience seem to be important and how they interrelate. An overview of the most important theoretical and empirical contributions is given in the following section.

2.4 Existing approaches to user experience

Approaches to user experience in human-technology interaction are very diverse. No simple structuring is available to classify the contributions. Researchers from different disciplines and with diverse backgrounds contributed to the field. It is therefore not surprising that often persons and their contribution cannot be associated with only one discipline. Furthermore, the used terminology differs, what makes it hard to relate the various contributions.

Phenomenological contributions form one perspective on user experience of human-technology interaction and a selection is discussed in Section 2.4.1. Afterwards, contributions are summarized that explicitly focus on supporting the design of user experience and take a holistic view on user's interaction with products (Section 2.4.2). Perspectives that center on emotional components of user experience are summarized in Section 2.4.3, and in the last part of this review, contributions are discussed that concentrate on specific non-instrumental quality dimensions, like aesthetic and symbolic aspects (Section 2.4.4).

2.4.1 Phenomenological approaches

Phenomenological approaches to user experience resist the reduction of experience into a number of factors or processes. They argue for a holistic and qualitative study of user experience.

In an early framework to help designers think about user experience, Forlizzi and Ford (2000) point out that designers trying to craft an experience can only design situations rather than neatly predicted outcomes. Next to the user's personal interpretations of a situation, there are other factors that are beyond control when designing: different cultural backgrounds or prior experience as well as emotionally aroused states which cause different subjective interpretations of a certain moment Forlizzi and Ford (2000) summarize influencing factors on user experience as well as different qualities of user experience. As influencing factors, they highlight characteristics of the user and the product as well as the context of use. They introduce four concepts relevant to understand the quality of an experience: sub-consciousness, cognition, narrative, and storytelling. Sub-conscious experiences are those that do not compete for user's attention and thinking process, but are rather used 'thoughtlessly'. Cognition is used to represent experiences that require users to think about what they are doing: interactions with unfamiliar or confusing products as well as tasks that require attention, cognitive effort or problem solving skills. The narrative concept represents experiences that have been formalized in the user's head. The set of features and affordances of a product offers such a narrative of use. In turn, a user interacts with some subset of features and affordances, based on location in a context, prior experience and current emotional state to make a unique and subjective story. The concept of storytelling is used to represent this subjective aspect of the experience. Battarbee (2003) introduces the concept of co-experience to consider experiences constructed in social interaction. Co-experience can be described as an experience that users themselves create together in social interaction. Together Forlizzi and Battarbee (2004) present an approach to incorporate the concept of co-experience into the framework proposed by Forlizzi and Ford (2000).

McCarthy and Wright (2004) present another phenomenological approach to user experience and describe it as an orientation toward the felt life of technology-toward engagement, enchantment, irritation, and fulfillment. They point out that life does not begin or end with the immediate quality of an experience with an interactive system and propose a framework for analyzing experience with technology, which consists of four intertwined threads of experience: the compositional, sensual, emotional, and spatio-temporal thread. Even though the framework is presented as a set of components, McCarthy and Wright (2004) point out that each of these parts are inter-connected and constitute an integrated framework. The compositional thread deals with how the elements of an experience fit together to form a coherent whole. This refers to the narrative structure, action possibility, plausibility, consequences, and explanations of actions. The sensual thread is concerned with how the design, texture, and the overall atmosphere make users feel. This relates to the concrete, palpable, and visceral character of experience that is grasped pre-reflectively in the immediate sense of a situation, e.g. the look and feel of a mobile phone and the sense of warmth in a social space. The emotional thread is concerned with the emotions that are part of an experience. This refers to value judgments that ascribe importance to other people and things with respect to our needs and desires. The emotional quality of an experience tends to summarize the experience, e.g. as fun, exciting, or frustrating. Finally, the spatio-temporal thread deals with place and time. This draws attention to the quality and sense of space and time that pervades experience. Time may speed up or slow down, pace may increase or decrease, and spaces may open up or close down, affecting user’s willingness to linger or to re-visit such places.

In addition to the four threads of experience, McCarthy and Wright (2004) discuss six processes of sense-making to describe that people actively construct or make sense of experiences. Sengers et al. (2004) argue in a similar way that users are actively involved in constructing their experiences through a process of interpretation. As a consequence, experience is co-constructed between users, designers and systems. They assert that it is necessary to shift human-technology interaction design strategies from control of user experience to support for flexible interpretation. Similarly, Boehner, DePaula, Dourish and Sengers (2007) offer an interactional perspective to emotions in human-technology interaction.

Phenomenological approaches to user experience offer some interesting ideas about the user’s perceived quality of interactive products, e.g. the relevance of the situation a system is used in and the active role of the user in interpreting the interaction. Swallow, Blythe and Wright (2005) argue that the most important advantage is that phenomenological approaches resist the reduction of experience into a number of factors or processes, what may be useful for experimental analysis, but can miss important insights for design. However, such a holistic approach makes it hard to capture the user experience and therefore, an empirical basis is mostly missing. Suri (2002) argues that it may be hard to fully understand user experience in an analytical way and that it is more reasonable for designers to just ‘tune in’. Nonetheless, a variety of contributions that approach the topic of user experience from a design-oriented perspective try to deconstruct user experience in differentiated components that can be addressed separately.

2.4.2 Design-oriented approaches

Some approaches to user experience explicitly focus on the support of designers. They do not claim to explain users’ experience based on empirical data, but are mainly conceptual contributions. Nonetheless, they try to be comprehensive and take into account many relevant aspects of user experience.

Crilly, Moultrie and Clarkson (2004) present an integrative framework of user response to products that considers cognitive, affective, and behavioral components. Qualities of a product that play a role on the cognitive level are summarized in three categories: semantic interpretation, aesthetic impression, and symbolic association. Semantic interpretation describes the proportion of the product value that is attributed to its utility. Contrast, novelty, and order as well as subjective concinnity that may be regarded as the extent to which the design appears to make sense to the user in respect to personal, cultural, and visual experience are aspects of aesthetic impression. Furthermore, two categories of symbolic association are described. On the one hand, self-expressive symbolism is specified as associated with products that allow the expression of unique aspects of one’s personality. On the other hand, categorical symbolism is associated with products that allow the expression of group membership, including social position and status.

To describe the affective level of consumer response, Crilly et al. (2004) apply a model of product emotions initially presented by Desmet (2003a), which has five categories for the emotional responses that products may elicit: instrumental, aesthetics, social, surprise, and interest. Instrumental emotions (such as disappointment and satisfaction) derive from perceptions of whether a product will assist the user in achieving their objectives. Aesthetic emotions (such as disgust or attraction) relate to the potential for products to delight or offend our senses. Social emotions (such as indignation and admiration) result from the extent to which a product is seen to comply with socially determined standards, and surprise emotions (such as amazement) are driven by the perception of novelty in a design. Finally, interest emotions (such as boredom or fascination) are elicited by the perception of challenge combined with promise. Additionally, Crilly et al. (2004) see users’ cognitive and affective responses to influence the way in which they behave towards the product. They use the concepts of approach and avoid to distinguish between the behavioral responses of an interested or disinterested consumer.

Creusen and Schoormans (2005) present a model that focuses on six different roles of product appearance: communication of functional, ergonomic, aesthetic, and symbolic information as well as attention drawing and categorization. The functional value of a product pertains to the utilitarian functions a product can perform and the ergonomic value entails the adjustment of a product to human qualities. The aesthetic value of a product relates to the pleasure derived from seeing the product without considering its utility. Symbolic value refers to the fact that consumers use products to express their ideal self-image (Belk, 1988). As these first four aspects can be found on Crilly et al.'s (2004) cognitive level of user response, the remaining two roles of product appearance may not be that relevant for the quality of the users' experience of the interaction with the product. The attention drawing aspect refers to a product standing out from competing products so that chances are higher that consumers will pay attention to the product in a purchase situation. This role of product appearance may be more relevant for the seller of the product than for the user. Even the role of product identification that will be easier when a product resembles other products in the same category may be less relevant for the actual user experience.

Other authors take differing concepts into account when thinking about the design for user experience. MacDonald (1997, 2001) discusses the idea of 'aesthetic intelligence' which acknowledges that people posses an innate, sometimes subconscious ability to perceive a wide range of qualities in products that shape their response. He links sensual qualities to cultural values and proposes a process of designing for the senses. Similarly, Overbeeke, Djadjadiningrat, Hummels and Wensveen (2002) focus on two aspects of human-technology interaction that they feel are often neglected: human perceptual-motor skills and emotional skills. Regarding the first aspect they propose a shift of focus from beauty in appearance to beauty in interaction. Beautiful appearance may be part of beautiful interaction, but it also encompasses a more nuanced cooperation with an interactive object. With respect to the emotional aspect of the user experience, they argue that a user may choose to work with a product, although it is difficult to use, because it is challenging, seductive, playful, surprising, memorable, or rewarding. Gaver and Martin (2000) present a similar approach and focus on the exploration of sensual aesthetics and implicit expression, coupled with the value they place on emotional aspects of the interaction. They argue for the importance of a whole range of specific non-instrumental needs, such as surprise, diversion, or intimacy.

One difference of design-oriented approaches in comparison to phenomenological contributions is that they divide experience into a number of components that constitute the user experience. They argue that a better understanding of these components can support the design for a more positive user experience and even a focus on selected components can make it possible to reach this goal. Although they all agree on these basic assumptions, differences can be found regarding the components that are discussed in detail. While Creusen and Schoormans (2005) focus on the combination of instrumental and non-instrumental aspects, non-instrumental aspects as well as affective components of experience are used to extend the traditional focus on instrumental aspects in the other design-oriented approaches. However, the contributions have limitations: by tacking into account many different aspects of user experience and focusing on the support of design, concepts are not defined in much detail and no empirical data is presented to support theoretical assumptions.

In the following two sections, contributions are discussed that focus on either non-instrumental or emotional aspects of experience in more detail. Thus, some of the following contributions give a less holistic view on user experience of interaction, but offer a more detailed analysis of specific aspects of user experience. Furthermore, they are based on more empirical research than the conceptual ideas discussed so far.

2.4.3 Emotion-focused approaches

In this section, approaches are discussed that focus on emotional aspects of user experience. Initially, contributions are described that concentrate on specific emotions like pleasure, fun, or flow. Approaches that take emotions in general into account and try to explain the role of emotion in users' product perceptions in more detail are discussed afterwards.

Jordan (1998, 2000) discusses the concept of pleasure as a design goal. He argues for a hierarchical organization of user needs where functionality is the basis, usability is another aim and pleasure is an even higher and increasingly important level. Based on a general approach to pleasure by Tiger (1992), four aspects of pleasure are distinguished. Physio-pleasure is associated with a user's sensual experience of product use. Psycho-pleasure is related to the experienced usability of an interactive system and emotions that arise because of the existence or absence of effective or efficient interaction. In contrast, socio-pleasure refers to emotions that arise based on relationships to others, e.g. products that make people feel socially accepted. At last, ideo-pleasure pertains to values that can include tastes, moral values, or personal aspirations.

Carroll and Thomas (1988) argued for the consideration of fun of use in interactive system design. Monk, Hassenzahl, Blythe and Reed (2002) established the term funology for the research field on design for fun of use. Other authors use terms like joy of use (Hatscher, 2000) or ludic products (Gaver et al., 2004) to describe a similar design goal. Carroll (2004) describes the interaction with objects as fun when they attract, capture, and hold users' attention by provoking new or unusual perceptions, or arouse emotions in contexts that typically arouse no emotions. A whole range of other contributions to the design for fun of use can be found in Blythe, Overbeeke, Monk and Wright (2003).

Draper (1999) discusses flow as one possible precondition of fun. Introduced by Csikszentmihalyi (1990), flow is described as a mental state of operation in which the person is fully immersed in what he or she is doing, characterized by a feeling of energized focus, full involvement, and success in the process of the activity. A variety of empirical contributions to the concept of flow in human-technology interaction concentrated on website usage (Novak, Hoffman & Yung, 1999; Chen, Wigand & Nilan, 2000; Finneran & Zhang, 2003)

The presented approaches focus on the design for specific emotion-related phenomena (pleasure, fun, and flow). They can be helpful to design for situations that elicit these emotions, but they do not help to understand the role of emotions as past of user experience in general.

Other approaches focus on a general understanding of emotions in human-technology interaction to consider diverse qualities of emotions. Additionally, these general approaches to emotion are based on fundamental theories from emotion science. However, as there are still a lot of unresolved questions and competing models in emotion science, different frameworks are utilized. For example, Martinho, Machado and Paiva (2000) discuss Ortony, Clore and Collins' (1988) cognitive theory of emotions, Kallio (2003) proposes focusing on Damasio's somatic markers hypothesis (Damasio, 1994), and Zhang and Li (2004, 2005) apply Russell's theory of affective quality (Russell, 1980, 2003) to better understand the role of emotions in human-technology interaction. In the following, three further general emotion-focused approaches are discussed in more detail.

Norman (2002, 2004) proposes a model for the role of emotions in human-technology interaction that defines three levels of information processing (Ortony, Norman & Revelle, 2004): first the automatic, prewired level, called the visceral level; the second that contains the brain processes that control everyday behavior, known as the behavioral level; and third the contemplative part of the brain, or the reflective level. According to Norman (2004), the visceral level marks the start of affective processing by making rapid judgments on what is good or bad. Processes on the visceral level are biologically determined. The behavioral level is the site of most human behavior. Its actions can be enhanced or inhibited by the reflective layer and, in turn, it can enhance or inhibit the visceral layer. While the reflective level does not have direct access either to sensory input or the control of behavior, it watches over, reflects upon, and tries to bias the behavioral level. Norman (2004) proposes that different aspects of emotions play a role on all three levels of information processing, but it remains unclear how emotions arise from the interaction with an interactive product.

Desmet and Hekkert (2002) establish a basic process model regarding the elicitation process of emotions in human-technology interaction that comprises three parameters: appraisal, concern, and product. The three parameters and their interplay determine if a product evokes an emotion, and if so, which one. The central implication of the concept of appraisal is that not the event as such is responsible for the emotion, but the meaning the individual attaches to this event. Concerns that can be needs, instincts, motives, goals, and values can be regarded as points of reference in the appraisal process. Thus, the significance of a product for our well-being is determined by a concern match or mismatch. Products that match users' concerns are appraised as beneficial, and those that mismatch their concerns are harmful.

Additionally, Desmet (2003a) proposed a categorization of emotions elicited by interactive products as part of user experience that was already discussed in the previous section in the context of the design-oriented approach suggested by Crilly et al. (2004). Desmet (2003a) proposes five categories for emotional responses to products: instrumental, aesthetics, social, surprise, and interest. Rafaeli and Vinali-Yavetz (2004) develop a similar model of the relationship between the qualities of physical artifacts and emotions they elicit. This model suggests that artifacts are analyzed according to three conceptually distinct aspects: instrumentality, aesthetics, and symbolism. Rafaeli and Vinali-Yavetz (2004) discuss three different mechanisms of emotion elicitation, each based on one of the three quality dimensions: a hygiene, a sensory and an associative mechanism. They argue comparable to Desmet (2003a) that different kinds of emotions arise based on the perceptions of each of the three quality dimensions.

General approaches to emotion support a better understanding of the role and the development of diverse qualities of emotions in human-technology interaction. Desmet (2003a) as well as Rafaeli and Vinali-Yavetz (2004) particularly explain the elicitation of various kinds of emotions and relate it to the perception of product qualities. Further approaches to user experience explicitly focus on quality dimensions that are seen as important for positive experiences. Hassenzahl (2004a) even argues that emotions can be quite ephemeral since they depend to a large extent on factors that can hardly be predicted. Therefore, he proposes focusing on quality aspects that can result in more positive emotions.

2.4.4 Quality-focused approaches

Design for functionality and usability has been a central topic in human-technology interaction for a long time. Some aspects of design for usability have been discussed at the beginning of this chapter. Here, contributions are presented that concentrate on specific non-instrumental quality aspects. In some of the approaches mentioned so far (Crilly et al., 2004; Rafaeli & Vinali-Yavetz, 2004; Creusen & Schoormans, 2005), two categories of qualities are distinguished next to the instrumental values of products: aesthetic and symbolic aspects. Various other contributions focus on selected aspects of aesthetic and symbolic quality in human-technology interaction.

Liu (2003) proposes that a discipline of engineering aesthetics should address two major questions: first, how to use engineering and scientific methods to study aesthetic concepts in system and product design, and second, how to incorporate engineering and scientific methods in the aesthetic design and evaluation process beyond designers' intuitions. Tractinsky (2004) argues that in particular *visual* aesthetics are relevant to interactive systems research and practice. Users' evaluations of the environment are primarily visual, and the environment is getting increasingly replete with information technology. Furthermore, aesthetics satisfy basic human needs and human needs are increasingly supplied by interactive systems.

A few early studies underlined these assumptions. Burmester, Platz, Rudolph and Wild (1999) have studied the influence of visual aesthetic design on users' quality perceptions by using a traditional version of a user interface and one that was worked over completely by a designer to find that the later version received higher rating with respect to quality impression, apparent usability and superiority. Kleiss and Enke (1999) conducted a study to identify the visual appearance attributes of automotive audio systems that impact users' judgments. The results reveal specific visual appearance attributes that contributed separately to the perception of stylish appearance and to the perception of quality. Schenkman and Jönsson (2000) have studied users' first impressions of websites and found that beauty was the best predictor for the overall judgment.

Other studies focus on specific design dimensions to improve aesthetic quality. Park, Choi and Kim (2004) conducted empirical studies with professional web designers and users to identify critical factors for the visual aesthetics of websites. They identified thirteen aesthetic dimensions and instructed designers to design example websites with respect to selected dimensions. They found that users rated the quality on a specific aesthetic dimension higher if the designer had focused on it. Laugwitz (2001) concentrates on the impact of the use of color on aesthetic perceptions in the context of software systems and found interrelations between system properties and users' judgments. Leder and Carbon (2005) report a study in which the influence of stimulus properties on the appreciation of car interiors is investigated. Three design components (complexity, curvature, and innovativeness), which were all thought to affect design appreciation, were combined in a fully factorial design. All dimensions were confirmed to affect users' ratings. In particular curvature and innovativeness affected the attractiveness ratings. Curved and non-innovative designs were generally preferred.

A couple of theoretical frameworks are proposed to explain aesthetic appreciation of visual stimuli. Lindgaard and Whitfield (2004) discuss visual aesthetics of interactive systems within an evolutionary context. They apply Whitfield's (1983, 2000) collative-motivation models of aesthetics to explain results from existing experimental research on product preference. This approach combines cognitive and affective processes to explain aesthetic appreciation based mostly on the prototypical nature of a stimulus. Leder, Belke, Oeberst and Augustin (2004) propose an information-processing stage model of aesthetic processing. According to the model, aesthetic experiences involve five stages: perception, explicit classification, implicit classification, cognitive mastering, and evaluation. The model also differentiates between aesthetics emotion and aesthetic judgments as two types of outputs. Reber, Schwarz and Winkielman (2004) take an approach to understanding aesthetic pleasure based on the concept of processing fluency. They argue that aesthetic pleasure is a function of a perceiver's processing dynamics: the more fluently perceivers can process an object, the more positive their aesthetic response. They review variables known to influence aesthetic judgments such as figural goodness, figure-ground contrast, stimulus repetition, symmetry, and prototypicality and trace their ability to change processing fluency. However, in contrast to theories that define aesthetic pleasure as objective stimulus features per se, they propose that aesthetic appreciation is grounded in the processing experience of the perceiver. The processing experience is only in part a function of stimulus properties. Hekkert, Snelders and van Wieringen (2003) found different empirical evidence. They argue that typicality and novelty of a product are joint predictors of aesthetic preference. According to them, products with an optimum combination of both aspects are preferred. Therefore they urge to design the most advanced and yet acceptable solution when it comes to visual aesthetics.

Next to visual aspects of aesthetic experiences, other qualities can play an important role in human-technology interaction. Especially, haptic and acoustic perceptions of the interaction can influence the aesthetic appreciation of an interactive product (Schifferstein, 2005), but only a few contributions concentrate on their importance. Jordan (2000) argues for the consideration of haptic experiences in the description of his concept of physio-pleasure. Sung, Kwang, Myung and Sang (2004) found that surface structure and perceived weight play an important role for the preference of mobile phones. Although auditory interaction techniques play an increasing role in human-technology interaction, not many contributions focus on acoustic quality of interactive systems in general. Research on the users' perceived acoustic quality has only been performed in specific domains, e.g. those that relate to multimedia and speech technologies (Watson & Sasse, 1998; Jekosch, 2004; Gulliver & Ghinea, 2006).

More attention has been dedicated to symbolic aspects of users' quality perceptions. The concept of hedonic quality proposed by Hassenzahl (2001) is often used in human-technology interaction. Hassenzahl (2001) defines hedonic quality as a quality aspect that addresses human needs for social power, novelty, and change. In a later publication he distinguishes three sub-dimensions of hedonic quality: identification, evocation, and stimulation (Hassenzahl, 2003). Identification relates to people's tendency to express their self through physical objects. To fulfill this need, a product has to communicate identity. Evocation relates to the fact that products can evoke memories. In this case, the product simply represents past events, relationships, or thoughts that are important to the individual. Stimulation provided by novel, interesting or even exciting functionality, content, presentation, or interaction style may help to fulfill people's need to strive for personal development.

The concept of stimulation relates to motivational aspect of human-technology interaction. Other authors have also focused on the motivational quality of interactive systems (Millard, Hole & Crowle, 1999; Kohler, Niebuhr & Hassenzahl, 2007), but only preliminary results are available regarding these aspects. Nonetheless, motivational qualities have become a more important topic for research especially in areas where interactive systems are used in a professional context for longer periods.

In summary, a variety of non-instrumental qualities is seen as important and has been studied empirically. Non-instrumental qualities range form aesthetic to symbolic and motivational aspects. Their relevance has been shown separately, but no integrative approach exists.

2.5 Conclusions

User experience research offers a new perspective on the user-oriented view of interactive product quality. The field emerged from traditional approaches regarding the consideration of users' subjective evaluation of an interaction that focused on the concept of user satisfaction. A variety of previously neglected aspects have been studied recently and several approaches have been presented. They differ with respect to their empirical foundation and comprehensiveness (Figure 2.1).

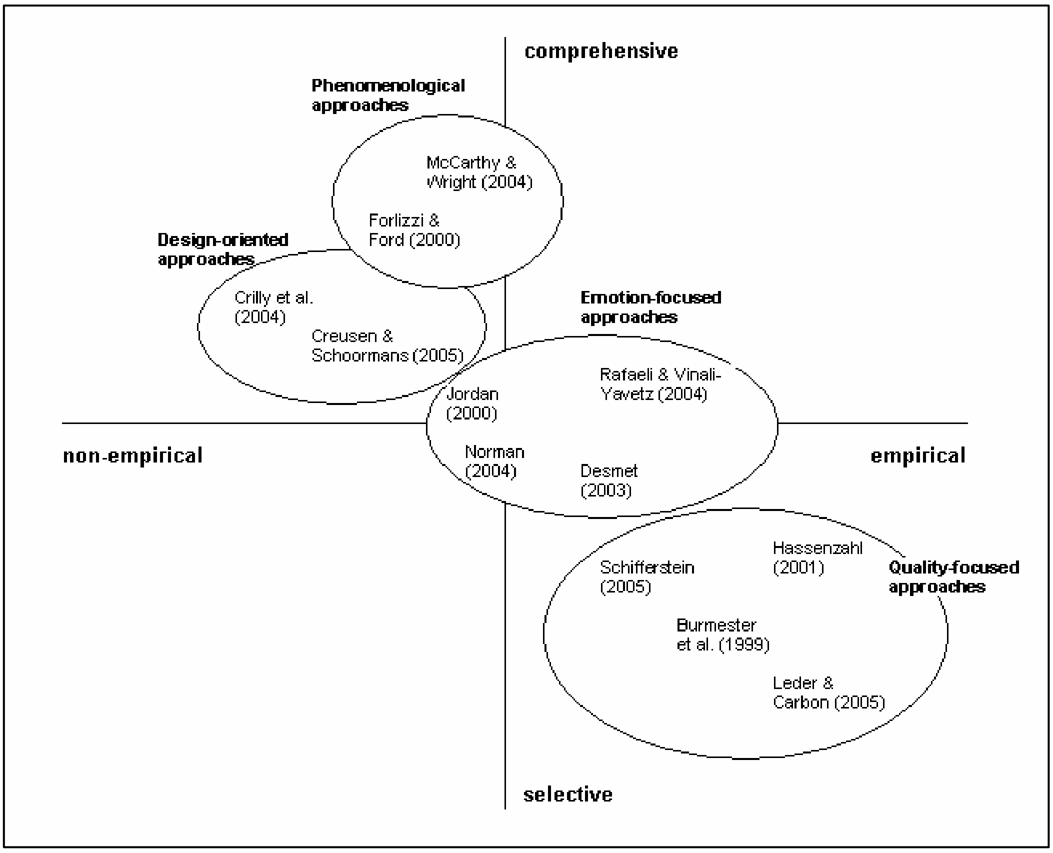


Figure 2.1: Existing approaches to user experience classified with respect to their degree of empirical foundation and comprehensiveness.

Phenomenological approaches (McCarthy & Wright, 2004; Forlizzi & Battarbee, 2004) take a holistic view of user experience. However, they often lack an empirical basis in the field human-technology interaction. Although some of the contributions only want to inform design, empirical evidence seems necessary for them to be useful. As the approaches are based on qualitative methods they are harder to verify. *Design-oriented approaches* (Crilly et al., 2004; Creusen & Schoormans, 2005) also take a holistic perspective and try to consider all relevant aspects of the user experience. Concepts are well-defined, but no methods are introduced that help to gain information about the relevant aspects of user experience during the design process. Some of the concepts are based on empirical research (e.g. Creusen & Schoormans, 2005), but most of them are merely theoretical considerations.

Most of the *emotion- and quality-focused approaches* concentrate on specific aspects of user experience. Often theoretical assumptions are tested in empirical research and methods are suggested to measure the selected aspect of user experience. However, in focusing on specific aspects the holistic picture is lost. Authors advocating a phenomenological approach (e.g. Blythe, Reid, Wright & Geelhoed, 2006) argue that the reduction of experience into a number of factors or processes can miss important insights for design. Rafaeli and Vilnai-Yavetz (2004) as well as Norman (2004) try to maintain a holistic perspective, but fail to offer usable methods that can be applied in the design process. As Figure 2.1 demonstrates, none of the approaches is comprehensively describing user experience and is based on empirical research. This is one of the shortcomings that is addressed by the approach to user experience described in the following chapters – it is positioned in the upper right quadrant of Figure 2.1.

Another problem of various contributions is the mixture of non-instrumental qualities and emotions. For example, Zhang and Li (2005), who applied a concept from emotion psychology, describe their approach similar to others focusing on visual aesthetics, first impression, and hedonic quality. This assumption suggests that all concepts that go beyond the traditional focus on instrumental needs fall into only one category. Kim, Lee and Choi (2003) present another example. They focus on the design of emotionally evocative homepages by trying to find relations between concrete design factors and specific emotional dimensions. In a study, they identified thirteen generic dimensions of secondary emotions that people usually feel when viewing diverse websites. The dimensions they found range from tense and adorable to simple and futuristic. Some of the dimensions seem clearly based on emotion-related concepts, but others simply refer to quality aspects that go beyond the instrumental value of an interactive system. It might be true that non-instrumental qualities are more associated to emotions than instrumental aspects (Hassenzahl, 2007). However, users can also be emotionally affected by an interactive system that offers a surprisingly simple interaction or a system that is not usable at all. Therefore, it is argued for a separate consideration of non-instrumental quality perceptions and emotional user reactions both being strongly linked to instrumental quality aspects.

Another shortcoming of previous contributions is that influencing factors of user experience often remain abstract and are seldom studied experimentally. Most approaches assume system properties as general antecedent without a detailed analysis of design dimensions. Only few contributions consider contextual factors or characteristics of the user as factors influencing user experience (e.g. Hassenzahl & Ullrich, 2007). A more comprehensive analysis of these factors can offer a basis for further experimental studies of user experience and be a supporting resource when discussing user experience questions during the design process.

Most existing approaches do not span the range from theory and methods to empirical results and recommendations for application. However, all these aspects are necessary to guarantee an approach that is theoretically and methodologically sound, backed by empirical evidence and can successfully support the design of interactive systems. Therefore, a complete approach to user experience research is presented here that integrates four building blocks: theoretical considerations / framework (Chapter 3 and 8), methodological contributions / methods (Chapter 4), empirical studies (Chapters 5 to 7), and recommendations for the development of interactive systems (Chapter 9).

2.6 Chapter Summary

User-centered design offers an approach to the development of interactive systems that explicitly focuses on the users. Usability is used as the main criterion to ensure a high quality in use, which is mainly measured using performance characteristics. Additionally, the concept of user satisfaction has been defined to take into account the user's perspective on the interaction. However, the concept of user satisfaction has repeatedly led to criticism. Norman and Draper (1986) describe the question of the quality of user experience as the ultimate criterion of user-centered design and Alben (1996) states that more aspects are important to understand user experience than the issues that make up user satisfaction.

Over the past decade, a variety of contributions have been published regarding the design for user experience with interactive systems and for a better theoretical understanding of what forms the user experience. Phenomenological, design-oriented, emotion-focused, and quality-focused approaches are distinguished. Phenomenological approaches to user experience resist the reduction of experience into a number of factors or processes and argue for a holistic and qualitative study of user experience. Design-oriented contributions focus on the support of designers, are mainly conceptual and try to be comprehensive and take into account many relevant aspects of user experience. Emotion- and quality focused approaches concentrate on specific aspects of user experience are mainly tested in empirical research and suggest methods to measure the selected aspect of user experience.

However, four major shortcomings are apparent for existing contributions and addressed in the approach described in the following. First, most contributions either lack empirical evidence or focus on specific aspects and therefore miss to address the concept of user experience comprehensively. This approach combines empirical evidence and comprehensiveness. Second, non-instrumental quality perceptions and emotional user reactions are considered as separate aspects of user experience that are strongly linked to instrumental quality aspects. Third, a more comprehensive analysis of influencing factors of user experience offers a basis for further experimental studies. Fourth, this approach to user experience in human-technology interaction addresses four building blocks: theoretical considerations, methodological contributions, empirical results, and guidelines for their application.

3 Framework

Three of the main limitations of current approaches to user experience research that have been discussed in the pervious chapter concern theoretical considerations and are addressed in a framework on user experience that is described in this chapter. First, the framework integrates many aspects that contribute to user experience comprehensively. Second, non-instrumental quality perceptions and emotional user reactions are considered as separate aspects of user experience that are strongly linked to instrumental quality aspects. Third, a comprehensive analysis of influencing factors offers a basis for further experimental studies and is a supporting resource when discussing user experience questions during the design process.

This chapter starts with an overview of the proposed framework on user experience (Section 3.1), before its main components are discussed in more detail and sub-models are presented (Sections 3.2 to 3.6). These sub-models are integrated into the overall framework and interrelations of the components are discussed in Section 3.7. Methodological and empirical research questions that arise from the research framework are specified in Section 3.8.

3.1 Framework overview

The user experience arises from the interaction with a technical system (Norman & Draper, 1986; Norman, 1999). The character of the human-technology interaction depends on influencing factors like the properties of the system. While the interaction is experienced by the user, various components of user experience play a role. Finally, the quality of user experience determines consequences of the experience. These basic assumptions are incorporated in the user experience framework presented in Figure 3.1.

Influencing factors include all aspects that have an impact on the interaction between a user and an interactive system. The interaction can be influenced by various relevant characteristics of the user, the usage situation and of course the used interactive system. Influencing factors will be discussed in more detail in the following section to consider the demand of a comprehensive consideration of influencing variables on user experience.

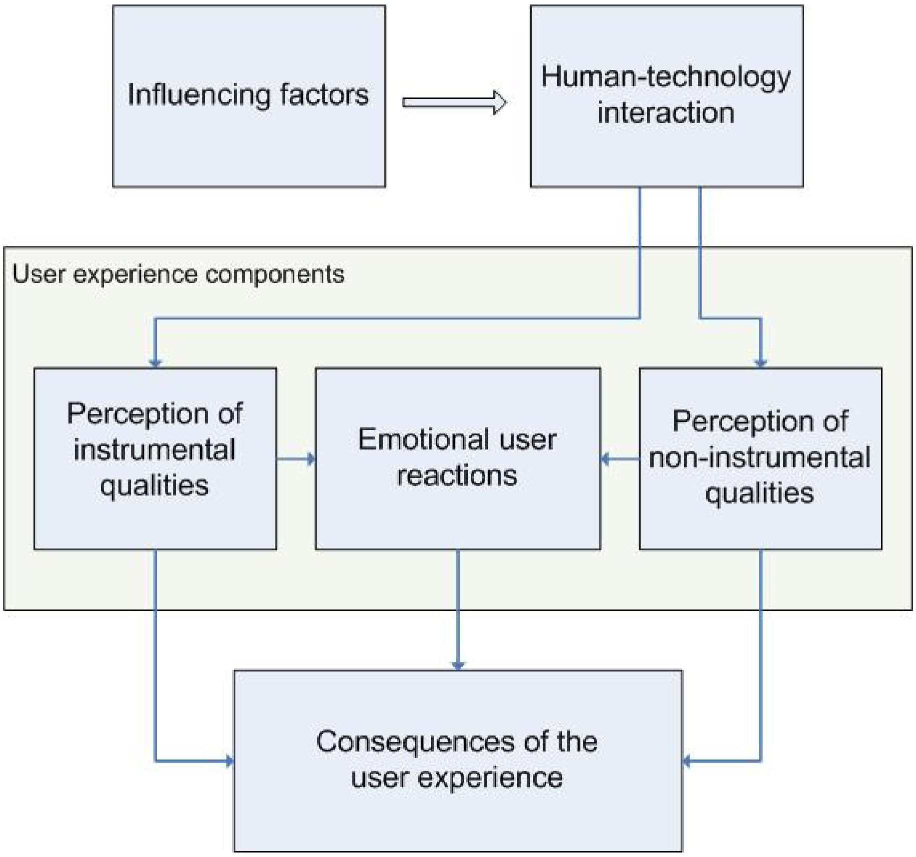


Figure 3.1: User experience research framework.

Three main components are defined in Figure 3.1: non-instrumental quality perceptions and emotional user reactions are considered as distinct aspects of user experience and complement the perception of instrumental quality. Furthermore, the perception of instrumental and non-instrumental qualities as well as emotional user reactions determine consequences of user experience. Consequences incorporate for example acceptance of the system and usage behavior.

Before discussing the interrelations between the proposed components of the user experience framework in Section 3.7 in more depth, each component is defined in the following sections.

3.2 Influencing factors on human-technology interaction

The component of human-technology interaction represents the actual interaction between user and technical system. Interaction-focused approaches to quality in use measure some of the characteristics of the interaction directly, like task completion rates or time on task (as discussed in Section 2.1); others can only be assessed asking the users about their experience of the interaction.

The interaction depends on various factors. Forlizzi and Ford (2000) highlight characteristics of the system, the user as well as the context of use, shaped by social, cultural and, organizational behavior patterns as influencing factors. Similarly, Hassenzahl and Tractinsky (2006) define user experience as a consequence of the characteristics of the designed system (e.g. complexity, purpose, usability, functionality), a user's internal state (e.g. predispositions, expectations, needs, motivation, mood), and the context within which the interaction occurs (e.g. organizational/social setting, meaningfulness of the activity, voluntariness of use). Accordingly, influencing factors are summarized in three categories: system properties, user characteristics, and context parameters (Figure 3.2).

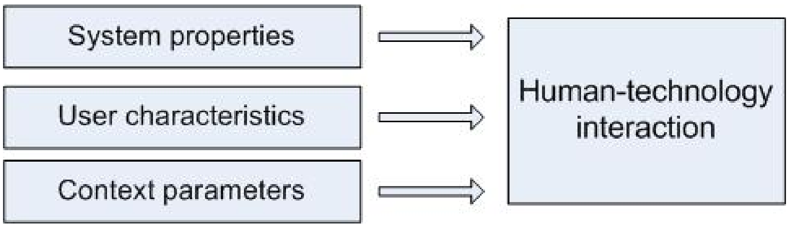


Figure 3.2: Influencing factors.

3.2.1 System properties

Interactive system properties refer to specific design solutions. They belong to the designer domain of product-related knowledge and are product-specific. By contrast, all aspects of user experience (instrumental and non-instrumental quality perceptions as well as emotional user reactions) are subjective evaluation criteria that users apply when they experience the interaction with an interactive product and make overall judgments (Keinonen, 1998).

Various approaches exist to describe interactive product components and properties. A rough classification considers input, output, and interaction aspects as different components of the system (e.g. Preece, 1994). In ISO 9241-11, a similar model of system properties can be found that additionally divides the interaction aspect into information presentation and dialog control (ISO, 1998), whereas the IFIP model for user interfaces (Dzida, 1983) recognizes an input/output interface, a dialogue interface, a functional interface, and an organizational interface.

Other approaches divide the user interface into more abstract levels. For example, Foley and Van Dam (1982) suggest concept level, semantic level, syntactic level, and lexical level. The concept level lists the features of the interface, their properties, and the actions needed to facilitate the interaction, i.e. the inputs and outputs of the system and the actions expected from the user. The semantic level concerns questions, such as the objects or commands that can be integrated or the final command set provided for the user. The syntactic level deals with problems of relating the objects and actions to each other. It includes the construction of menu hierarchies, the design of appropriate groupings of items for screen layouts, and the definition of the sequences of use. The lexical level involves the appearance of design elements and the manner of realizing the actions, e.g. icons and the wording of labels.

While the terms above are taken from linguistics, corresponding categories apply more technical labels. For example, Bevan, Kirakowski and Maissel (1991) give a list of system attributes, which influence human-technology interaction that includes functionality, dialogue principles as well as style and properties of the interface. The style and properties of the interface apparently refer to the surface level presentation, including syntactic and lexical aspects according to Foley and Van Dam (1982). According to Cushman and Rosenberg (1991), interactive products have three architectural components. The data model describes the information and features available to the users. The navigational model includes the procedures for gaining access to and manipulating the information and features of the data model. The interface style refers to the surface presentation of the interface and interaction methods.

Summarizing, it seems justified to manage the complexity of possible system properties by classifying them into three categories. The *functionality* of the product is one category. The whole internal logic of the interface is called *dialogue*. Another level is the *presentation* of user interface objects, though it is referred to by various names.

Since all of these approaches describe interactive products with the goal to improve the usability of systems, other system properties that are not related to effective and efficient interaction with the product are not considered. For instance, aspects of product form, appearance, or design that do not directly participate in the interaction are not included, such as the size and weight of the product, its color, or other surface properties, like a metallic or plastic look, hardness, roughness, and the geometry of the product. However, when studying the whole user experience with an interactive product these *appearance* attributes of the system form a fourth, relevant category of system properties.

Summarizing, four levels of system properties are distinguished: functionality, presentation, dialogue and appearance. These are the basis for the empirical studies presented in Chapters 5 to 7.

3.2.2 User characteristics

User characteristics consider all attributes of the person who is using an interactive system. Hassenzahl and Tractinsky (2006) mention predispositions, expectations, needs, and motivations as examples of user characteristics.

Age, gender, memory capacity, verbal ability, and personality are predispositions. The area of universal design has developed as a specific research focus in designing for special user needs caused by differing predispositions (Stephanidis & Salvendy, 1998). Age in particular has become an important aspect, as many societies are aging (Zajicek & Brewster, 2003). Also, individual differences in cognitive processing have been studied for a long time in human-technology interaction (Oulasvirta & Saariluoma, 2004). Furthermore, subjective technical confidence and computer expertise in the relationship between performance and acceptance have often been analyzed (Compeau, Gravill, Haggerty & Kelley, 2006).

Also differences regarding expectations and needs of users result in variations in preferences. The concept of centrality of visual product aesthetics is a construct that is relevant when studying the relevance of instrumental and non-instrumental qualities. Defined by Bloch, Brunel and Arnold (2003), it can be seen as an important moderator of the relevance of the aesthetic value of products. Centrality of visual product aesthetics subsumes three aspects: value, acumen, and response. Individuals with a high centrality of visual product aesthetics attach personal value to aesthetic aspects of products; they think of themselves as connoisseurs, able to perceive the subtlest differences in aesthetics, and they strongly respond to beautiful things. Individuals with high centrality of visual product aesthetics are more prone to use a visual style of processing, they more strongly desire to acquire objects that only few others possess, and the acquisition of aesthetic objects becomes a central pursuit of their lives closely linked to happiness and success. Bloch et al. (2003) found that centrality of visual product aesthetics moderates the overall evaluation, purchase intention, and the willingness to pay for products. Whereas for individuals with low centrality of visual product aesthetics neither evaluation nor purchase intention varied significantly as a function of aesthetics, it made a large difference for individuals with high centrality of visual product aesthetics.

Differences in quality perceptions can also be caused by cultural differences. Forlizzi and Ford (2000) emphasize the role of different cultural backgrounds for user experiences and Crilly et al. (2004) mention that user preferences may be largely defined by cultural agreements on *'what looks good … what materials are to be valued … what is worth aspiring towards and how aspirations can be reinforced with products'* (p. 572). Hofstede's (1980) approach to culture is often used to understand consequences of cultural differences in human-technology interaction. For example, Plocher, Garg and Chestnut (1999) identify relevant aspects of cultural differences that relate to user characteristics, which in turn have implications for user interface design. They discuss values and traditions, family and societal structures, nature of the language as well as norms for interpersonal communication as relevant cultural aspects. Differences on these dimensions influence user characteristics like attitudes toward technology and authority, the meaning of work and home as well as preferred mode of communication or cognitive style. Accordingly, culture can be seen as a factor that has an impact on various user characteristics.

In short, a variety of user characteristics can influence user experience of interaction. Differences in cultural background and centrality of visual product aesthetics have been discussed as examples and are incorporated in the last study in Chapter 7.

3.2.3 Context parameters

Context parameters include all aspects of the situation in which a product is used in, including the task or activity that is supported by the system in that situation. Hassenzahl and Tractinsky (2006) mention organizational and social setting, meaningfulness of the activity, and voluntariness of use as examples of context parameters. Also Crilly et al. (2004) discuss situational and environmental factors as influencing variables. From their point of view, the user's degree of motivation to interact with an interactive product in particular has the potential to influence their response. For example, intrinsically motivated users may value some qualities of a product over others that are valued by mandatory users.

Several contributions have studied the influence of these contextual parameters on aspects of user experience empirically. For example, Creusen and Schoormans (1998) studied the influence of observation time on the evaluation of the product. They showed participants products for a second or a longer period (about 90 seconds) and found that observation time does not influence the importance of non-instrumental qualities, but instrumental qualities are less important with short observation. Furthermore, with short observation time, most instrumental quality perceptions are based on salient aspects, such as size or overall product impression, while with long observation specific details play a more important role.

Hassenzahl (2003) discusses the importance of usage modes. He defines usage modes as psychological states and argues that every product can be experienced in different usage modes. The perception of a product character as primarily instrumental or non-instrumental is not influenced by usage modes. However, overall judgments and emotional reactions could depend on the momentary fit of the product to the usage mode (Hassenzahl, 2003). Hassenzahl, Kekez and Burmester (2002) report that the influence of instrumental and non-instrumental quality perceptions on overall judgments differs depending on whether users are in a goal-mode or action-mode. In the goal-mode, participants are required to accomplish given tasks, or they have the same amount of time to explore the system on their own in the action-mode. The results show that in the action-mode overall judgments are determined solely by perception of non-instrumental quality perceptions, whereas in the goal-mode both qualities play a substantial role.

Summarizing, a variety of context parameters influences user experience of interaction with technical systems. The variation of usage mode is applied as an example in Study 3 (Chapter 7).

After discussing system properties, user characteristics, and context parameters as influencing factors of user experience, the three central components of user experience that are influenced by these factors, i.e. instrumental and non-instrumental quality perceptions as well as emotional user reactions, are discussed in detail in the next sections.

3.3 Instrumental quality perceptions

The focus of current approaches to user-oriented quality of interactive systems on instrumental quality perceptions has been discussed in Section 2.2. The relation of utility and usability as two aspects of instrumental value are now highlighted and a model is proposed to measure instrumental quality perceptions in user experience research.

3.3.1 Defining instrumental quality perceptions

The instrumental value of an interactive system is related to the tasks and goals that the user wants to accomplish with a system. General approaches to quality in use like ISO 9241-11 and ISO 9126 do not intend to explain users' perceptions of instrumental qualities. In contrast, Shackel (1991) defines utility and usability as the two instrumental values of an interactive system that influence system acceptance. According to his definition, utility refers to the match between user needs and product functionality, while usability refers to the ability to utilize the functionality in practice. Similarly, Nielsen (1993) considers utility and usability being two important aspects which influence product acceptance and suggests that *"… utility is the question of whether the functionality of the system in principle can do what is needed, and usability is the question of how well users can use that functionality"* (p. 25). This view is also supported by Grudin (1992), who associates usability and utility with different disciplines. Utility is defined first by the product managers, usability being subsequently optimized by the designers. Grudin heavily stresses a more integrated design process, but does not suggest that the concepts themselves should be merged.

3.3.2 A model of instrumental quality perceptions

Davis (1989) was able to show that from the user's perspective both the perception of the utility and the usability are important for the intention to use a system. The two dimensions as included in his model are defined as usefulness (relating to the perceived utility of a system) and ease of use (relating to the perceived usability of a system). Davis (1989) describes perceived usefulness as *"… the degree to which an individual believes that using a particular system would enhance his or her job performance"* and perceived ease of use as *"… the degree to which an individual believes that using a particular system would be free of physical and mental effort"* (p. 320). A range of empirical studies verified the importance of these two dimensions (Davis, Bagozzi & Warshaw, 1989; Adams, Nelson & Todd, 1992; Hendrickson, Massey & Cronan, 1993; Segars & Grover, 1993; Subramanian, 1994). All argue that from the user's perspective both utility and usability determine the instrumental value of an interactive system. This assumption is illustrated in Figure 3.3.

Figure 3.3: Instrumental quality perceptions.

While the concept of perceived utility is sufficiently defined by Davis (1989), different approaches have been made to define the concept of perceived usability in more detail. Shackel (1991) argues that for a system to be perceived as usable it has to achieve defined levels on the following four scales:

- *effectiveness*, meaning the results of interaction in terms of speed and errors;
- *learnability*, meaning the relation of performance to training and frequency of use;
- *flexibility*, allowing adaptation to tasks and environments beyond those first specified;
- *attitude*, associated with acceptable levels of human costs in terms of tiredness, discomfort, frustration and personal effort.

Nielsen (1993) considers five similar criteria: *efficiency*, *errors*, *learnability, memorability* and *satisfaction*. While the models on perceived usability by Shackel (1991) and Nielsen (1993) are based on theoretical assumptions, Kirakowski (1996) based the following dimensions of perceived usability on empirical results:

- *efficiency* as a measure of the user's perception of temporal efficiency and mental workload caused by the interaction;
- *controllability* addresses the responses the product gives to the user's actions;
- *helpfulness* as the perceived quality of the messages the system provides;
- *learnability* as the perceived effort of learning, memorability, and quality of documentation.

As a variety of studies replicated these dimensions (e. g. Kirakowski & Corbett, 1993), this categorization is used in Figure 3.3 to distinguish sub-dimensions of perceived usability. Furthermore, Kirakowski (1996) considers the role of affect. Aspects that relate to this dimension are discussed in the following sections on non-instrumental quality perceptions and emotional user reactions.

3.4 Non-instrumental quality perceptions

The importance of non-instrumental qualities for product evaluations has already been discussed in Chapter 2 (e.g. Crilly et al., 2004; Hassenzahl, 2004b; Tractinsky, 2004). Before proposing an integrative model that incorporates diverse dimensions of non-instrumental quality perceptions in user experience research, this section discusses the concept of non-instrumental qualities in general.

3.4.1 Defining non-instrumental quality perceptions

Non-instrumental qualities of an interactive system satisfy user needs that go beyond the mere instrumental value of the product or as Logan (1994) describes it *"… serve needs beyond the functional objective"* (p. 61). Various contributions have been made that underline the importance of products to satisfy user needs beyond the instrumental value. Already, Shackel (1991) discusses the role of what he called likeability of an interactive product to influence system acceptance. Even before this, Belk (1988) portrays how consumers extend their selves into things such as places, experiences, ideas, and objects perceived to be 'mine'. In this sense, an interactive product can have a symbolic value to its user. Norman (2004) goes even further and discusses the role of memories associated with products to be important on a reflective level of interactive product use.

Aesthetics of an interactive product are regarded as another essential aspect and are defined for example by Rafaeli and Vilnai-Yavetz (2004) as *"… the sensory experience a product elicits, and the extent to which this experience fits individual goals and spirits"* (p. 95). Hassenzahl (2007) proposes a similar definition of aesthetic judgment as *"… the sensory nature of input to judgment"* (chap. 11). As Hassenzahl (2007) emphasizes the role of visual aesthetics, other authors stress the importance of other senses in the experience of interactive products – in particular acoustic and haptic quality aspects (Schifferstein, 2005).

Only few authors argue for the importance of a motivational role of interactive systems. Hassenzahl (2006) applies Ryan and Deci's (2000) self-determination theory to argue for the importance of experiencing a sense of competence, i.e. to take on and master hard challenges. Millard et al. (1999) focus on the design of motivational user interfaces and apply these ideas to software interfaces for call center workers.

3.4.2 A model of non-instrumental quality perceptions

On the basis of these definitions Mahlke, Lemke and Thüring (2007) propose a hierarchical model of non-instrumental qualities (Figure 3.4). Additional to aesthetic and symbolic qualities, motivational aspects are included.

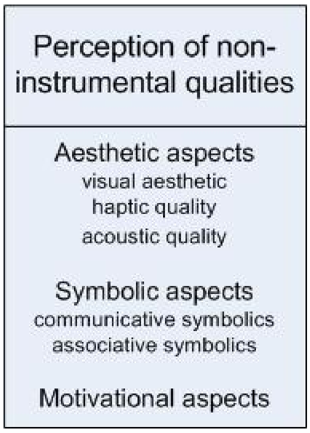


Figure 3.4: Non-instrumental quality perceptions.

Aesthetic aspects of non-instrumental quality are divided into various dimensions related to the human senses. Visual, haptic, and acoustic perceptions are most relevant in human-technology interaction and therefore stated in the model. Visual aesthetics of products is defined as the extent to which sensory (e.g. colors, see Laugwitz, 2001) and formal (e.g. shapes, see Leder & Carbon, 2005) attributes of a product provide positive visual experiences for the user (Lang, 1988). Process theories can explain the visual aesthetic experience in more detail (Lindgaard & Whitfield, 2004; Leder et al., 2004; Reber et al., 2004; Hekkert et al., 2003).

Next to visual aspects, aesthetic perceptions related to other senses are also important. Schifferstein (2005) studied the role of vision, hearing, touch, taste, and smell for evaluations of a variety of products. He found that averaged over products vision is the most important sensory modality, but for about half of the individual products, the importance ratings for vision are lower than for one of the other modalities. For interactive products especially haptic and acoustic quality is important. Haptic quality of products is defined as the extent to which sensory (materials) and formal (forms) attributes of a product provide positive haptic experiences for the user (Ashby and Johnson, 2002). Acoustic quality is defined as the extent to which sensory attributes (loudness, frequency) of a product provide positive acoustic experiences for the user (Lyon, 2003; Jekosch, 2004). Although taste and especially smell have been studied in human-technology interaction (Lauriault & Lindgaard, 2006; Davis, Davies, Haddad & Lai, 2006), they are not included here, because they do not play a relevant role in today's interactive product design.

Regarding symbolic qualities, two dimensions can be distinguished: communicative and associative aspects. Communicative aspects are related to the messages that a product communicates. They relate to the expression of unique aspects of either one's personality or group membership as described in Crilly et al. (2004). So-called self-expressive symbolism relates to individual qualities, values and attributes and serves to differentiate the user from the people that surround her or him. The categorical symbolism associated with products allows the expression of group membership, including social position and status. These categorical meanings serve to integrate the user with those people around. Both self-expressive and categorical aspects are summarized in the dimension of communicative symbolism and are defined as the extent to which communicative attributes (personal values, group membership) of a product provide positive experiences for the user.

Associative aspects are concerned with personal memories as described for example by Norman (2004). These personal memories can be related to a specific product or only to properties of a product (form, materials) that have already been experienced. For example, the use of wood may evoke images of craftsmanship, while the use of metal may be associated with precision. Associative symbolism is defined as the extent to which a product's associative attributes (personal memories) provide a positive experience for the user.

The third category of non-instrumental qualities focuses on motivational aspects. Motivational qualities can be defined as the perceived ability of a product to motivate the user. It includes non-instrumental qualities like for example described in Hassenzahl's (2003) concept of stimulation.

In summary, a hierarchical approach to non-instrumental quality perceptions in human-technology interaction research is proposed that considers three categories of non-instrumental quality: aesthetic, symbolic, and motivational aspects. Sub-dimensions of these categories are defined that can be used to measure non-instrumental quality perceptions (Section 4.2).

3.5 Emotional user reactions

Some approaches to emotions in human-technology interaction have already been discussed in Chapter 2 (e.g. Desmet, 2003a; Norman, 2004; Rafaeli & Vilnai-Yavetz, 2004). Before proposing a different approach, a brief overview of psychological research is given to illustrate the main problems when dealing with emotions in human-technology interaction.

3.5.1 Defining emotional user reactions

Even though the literature on emotions offers competing models to define emotions, they agree on the following: emotions have to be distinguished from moods, emotional traits, or sentiments (Frijda, 1994). Emotions are intentional because they imply and involve the relation between a person experiencing them and a particular object, i.e. one is afraid or proud of *something*. In contrast, moods, emotional traits, and sentiments lack this relation and also have rather a long-term character ranging from hours to a lifetime.

Models to structure emotions can be divided in categorical and dimensional approaches. Categorical approaches define a set of basic emotions. For example, Ekman (1992) proposes seven basic emotions: surprise, joy, sadness, disgust, fear, anger, and contempt. These are the basis for combinations that are called secondary emotions. Although several proposals have been made for relating secondary emotions to basic emotions (including fusing, blending, mixing, and compounding), no details are offered about how most pleasant emotions can be derived from the basically unpleasant.

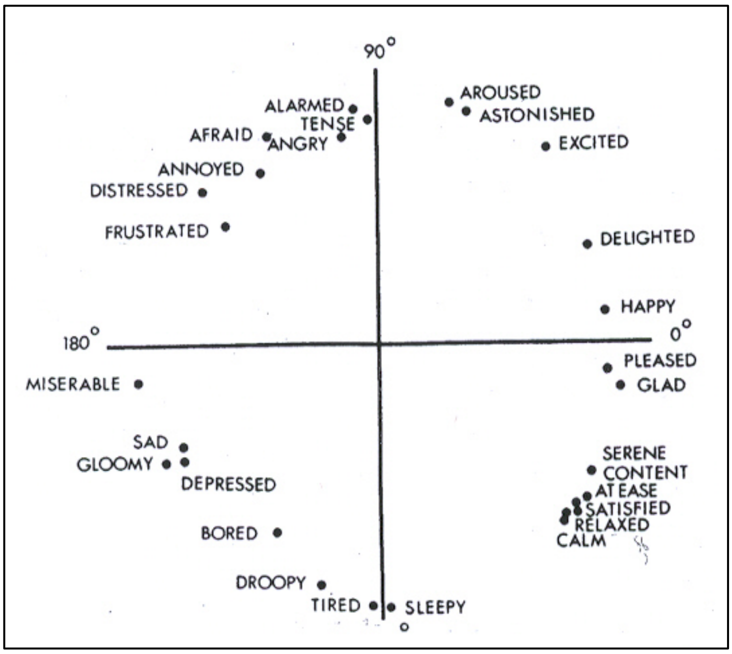


Figure 3.5: Dimensional approach to emotions (Russell, 1980; horizontal axis valence, vertical axis arousal).

Dimensional approaches to emotions define a number of dimensions to describe emotional qualities and generate a dimensional space that includes all possible emotions. For example, Russell (1980) defines valence and arousal as two basic dimensions that describe the quality of an emotion (Figure 3.5). Russell (1980) showed that specific emotions are arranged as a circumplex in the two dimensions. An advantage of dimensional approaches is that they allow smooth transitions between different qualities of emotions.

Over the past 25 years, there have also been many cognitive approaches to emotions (Scherer, 1984; Oatley & Johnson-Laird, 1987; Smith & Ellsworth, 1985; Ortony et al., 1988; Frijda, 1988; Lazarus, 1991; Roseman, 2001), which examine the role of cognition in the development process of emotions. In other words, they deal with the question why the same situation can induce different emotions depending on how a person interprets the situation. All cognitive theories propose a set of dimensions that are relevant for the interpretation of a situation in relation to the development of emotions. Although the proposed dimensions differ to some extent, efforts have been recently made to find an integrative model of cognitive appraisals (Ellsworth & Scherer, 2004).

However, Zajonc (1980) questions the view of emotions as consequences of a cognitive appraisal. He shows that emotional reactions can be instantaneous without cognitive processing.

And indeed, neurophysiology has discovered a neural shortcut that takes information from the senses directly to the part of the brain responsible for emotional reactions before higher order cognitive systems have had a chance to intervene (LeDoux, 1995). Nonetheless, these instantaneous emotional reactions differ from complex emotions such as hate, love, disappointment, or satisfaction. They are more diffuse, mainly representing a good/bad feeling of various intensities about an object, person, or event. To distinguish this type of emotional reaction from the more complex discussed above, they are often called affective reactions in contrast to emotions. Immediate, unmediated affective reactions are shown to be often used as information influencing and guiding future behavior (Schwarz & Clore, 1983). Damasio (1994) develops the notion of somatic markers attached to objects, persons or events, which influence the way we make choices by signaling good or bad. Although this is an interesting additional perspective on emotional reactions, it will not be covered in the following.

Emotion research suggests that emotions represent a complex phenomenon consisting of reactions at various component levels (e.g. Scherer, 1984). No single parameter or component can index emotional states unambiguously. Therefore the assessment of user's emotional reactions can be improved by combining methods that are associated with different components of an emotion. Larsen and Fredrickson (1999) state that emotion measures come in many forms and – in their opinion – should be used in many forms. Perhaps most important, no single emotion measure can serve as gold standard for other emotion measures. Every type of emotion measurement has its strengths and weaknesses and each one only provides an incomplete picture of emotional processes. So, to the extent that emotions evoke changes across numerous channels and component systems, data streams from those various channels should be collected in synchrony. Cross-referencing multiple measures of emotions increases the chances of pinpointing emotions and discerning their precursors and effects.

3.5.2 A model of emotional user reactions

Most methodological approaches to emotions in human-technology interaction fail to account for the multi-component character of human emotions. Nonetheless, a number of psychological theories address this fact and define emotions as complex phenomena consisting of changes in different relevant subsystems. Various models describe relevant components of emotions and can be used in human-technology interaction to consider the multi-component character of emotions. Izard (1977) proposes an emotional triad that comprises subjective feelings, physiological activation, and motor expressions. In a model by Scherer (1984), this triad is connected to two other components, i.e. cognitive appraisals and behavioral tendencies (Figure 3.6). Other authors integrate motor expressions and behavioral tendencies in one component and call it 'conative' (Lazarus, 1991) or 'behavioral' (Larsen & Fredrickson, 1999). Irrespectively of the exact composition of these models, they presume that all components are important to understand human emotions.

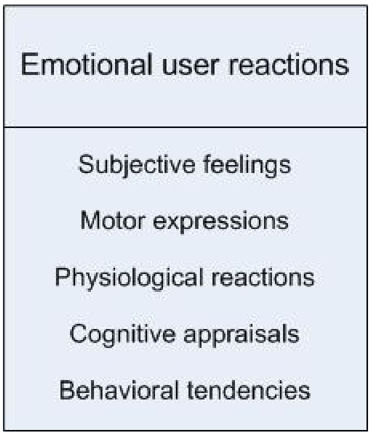


Figure 3.6: Emotional user reactions.

Scherer (1984, 2001) connects each of the components in Figure 3.6 to an organismic subsystem and proposes that each system has a special emotional function: the function of the subjective feeling component is to monitor the internal state and organism-environment interactions, while physiological reactions represent activation and regulation processes both of the neuroendocrine and the autonomic system. The role of behavioral tendencies is to prepare reactions, while motor expressions serve to communicate behavioral tendencies. Scherer (2001) places a focus on cognitive appraisals that are relevant for the evaluation of objects and events and are thereby modeled in more detail in his approach.

He characterizes the appraisal process as a sequence of stimulus evaluation checks based on five dimensions: intrinsic pleasantness, novelty, goal conduciveness, coping potential, and norm/self compatibility. Novelty is connected to familiarity and predictability of the occurrence of a stimulus, while the intrinsic pleasantness dimension describes whether a stimulus is likely to result in a positive or negative emotion. A goal relevance check establishes the importance of a stimulus for the momentary hierarchy of a person's goals and needs. The dimension of coping potential captures the extent to which an event can be controlled or influenced and norm/self compatibility is connected to internal and external standards. As already mentioned, other authors have proposed different dimensions (e.g. Lazarus, 1991; Ortony et al., 1988), but they also argue that any emotion is regarded as a specific pattern of cognitive appraisals and specific states of the other components. In comparison to contribution that explain the development of product-specific emotions (Desmet & Hekkert, 2002; Rafaeli & Vilnai-Yavetz, 2004), Scherer's model has the advantage that it explains the appraisal of emotions more generally.

Summarizing, a multi-component approach to emotions in human-technology interaction research is proposed that considers five aspects of emotions defined by Scherer (1984): subjective feelings, physiological reactions, motor expressions, cognitive appraisals, and behavioral tendencies. Furthermore, Scherer's (2001) model to further define cognitive appraisals is applied and Russell's (1980) dimensional approach to describe emotional qualities is used to study the quality of subjective feelings. So emotional user reactions are defined in more detail then in other contributions like Norman (2004) and specific emotional states like fun of use (Carroll & Thomas, 1988) or pleasure (Jordan, 2000) are integrated.

3.6 Consequences of user experience

Perceptions of instrumental and non-instrumental qualities as well as emotional user reactions determine the consequences of user experience (Figure 3.1). Consequences incorporate the acceptance of the system and usage behavior. Acceptance ratings can be seen as overall judgments of a product or system. Next to overall ratings, the choice between alternatives can play a role if more than one system is available for a specific purpose. If only one system is available, the intention to use this system and the actual usage behavior can be considered as consequences of user experience. Therefore, three categories of consequences of user experience are discussed in the following: overall judgments, choices between alternatives, and usage behavior (Figure 3.7).

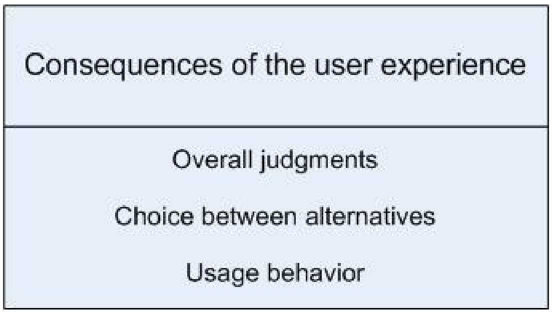


Figure 3.7: Consequences of the user experience.

3.6.1 Overall judgments

An overall judgment of an interactive product can be one consequence of user experience. Acceptance or overall ratings are forms to assess users' overall judgments (e.g. Kollmann, 2004). Hassenzahl et al. (2000) define the concept of judgment of appeal as a global judgment about an interactive product. They assume that weighting and combining different aspects of the quality of a system may form the judgment.

3.6.2 Choice between alternatives

If various options are available, choices between alternatives can be seen as another consequence of user experience. Decision for one alternative and rankings are forms to assess choices between various options.

3.6.3 Usage behavior

Davis (1989) uses the intention to use an interactive system as the target variable of his research on technology acceptance. He derives this concept from earlier theories in psychology that aimed at explaining why people show a certain behavior (Ajzen & Fishbein, 1980) and shows that users' intention to use a specific interactive system is a good predictor for their actual usage behavior. However, to measure usage behavior the actual interaction of a user with an interactive system has to be observed. Indeed, the collection of usage data can be automated, but actual usage behavior is complex to study, because only long-term studies can give insights regarding this consequence of user experience. Therefore, the studies described in Chapter 5 to 7 focus on overall judgments and choices between alternatives.

3.7 Interrelations of user experience components

In the last sections, the components of the research framework have been discussed in detail. Three categories of antecedents of user experience have been introduced: system properties, user characteristics, and context parameters. Various models of instrumental quality perceptions have been considered and approaches by Davis (1989; incorporating usefulness and usability as general instrumental qualities) and Kirakowski (1996; defining efficiency, controllability, helpfulness, and learnability as dimensions of usability) have been chosen for further theoretical consideration. A model of non-instrumental quality perceptions has been introduced that incorporates aesthetic, symbolic, and motivational aspects. Emotional user reactions have been defined based on the multi-component approach to emotions by Scherer (1984), which incorporates the following aspects: subjective feelings, motor expressions, physiological reactions, cognitive appraisals, and behavioral tendencies. Finally, overall judgments, choices between alternatives, and usage behavior have been introduced as three consequences of user experience. In Figure 3.7 these assumptions are integrated into the overall research framework on user experience. Three categories of influencing factors are assumed to have an impact on the human-technology interaction, which in turn determines the user experience consisting of three distinct components.

In the user experience framework, it is assumed that the process of experiencing the interaction exclusively influences the perception of instrumental and non-instrumental quality perceptions. It is self-evident that the experience of interaction determines the perception of instrumental and non-instrumental qualities - not so however the influence on emotional user reactions. Various authors discuss a direct influence of the interaction on the affective components of user experience. For example, Hassenzahl (2006) differentiates emotions as consequences of product use and affective reactions. Referring to Zajonc (1980), Schwarz and Clore (1983), Damasio (1994), and LeDoux (1994), he describes how affective reactions can influence the cognitive processing of information about the interactive product. These affective reactions may in particular play a role in the perception of aesthetic aspects since aesthetic appreciation is often described as a partly affective process (Hassenzahl, 2007).

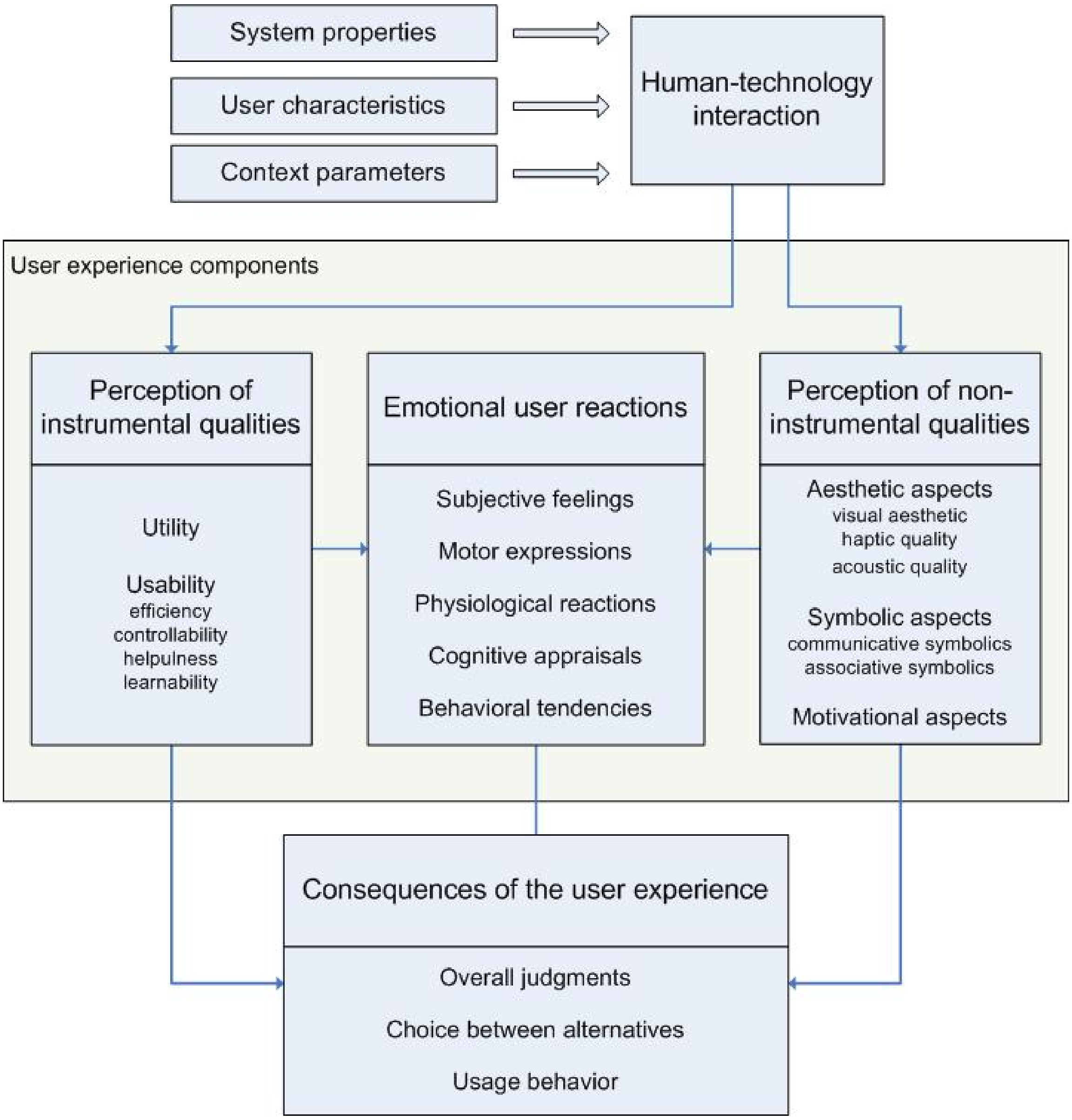


Figure 3.7: User experience research framework with sub-models.

However, no direct link between the human-technology interaction and emotional user reactions is drawn in the framework because of several reasons. First of all, affective reactions are extremely difficult to investigate, because they occur in short time intervals and are not easy to access. More importantly though, the question remains how affective reactions and emotional consequences are distinguished. As the border between these two categories proposed by Hassenzahl (2006) is unclear, only emotional user reactions are incorporated in this research framework and are not directly linked to the interaction. Thus, emotional user reactions are proposed to be influenced by both instrumental and non-instrumental quality perceptions (Rafaeli & Vinali-Yavetz, 2004).

Furthermore, no direct connection between instrumental and non-instrumental quality perceptions is postulated in the framework, although previous research has shown for example an influence of perceived visual aesthetics on perceptions of usability (Tractinsky, Katz & Ikar, 2000). However, Hassenzahl (2007) discusses these findings as a result of attribute overlap. He argues that the findings can be explained by the fact that the system attributes that have been altered to influence visual aesthetics are also related to usability. The question of a direct influence between instrumental and non-instrumental quality perceptions are addressed in the following empirical studies.

All three user experience components have an influence on the consequences of user experience (Crilly et al., 2004; Creusen & Schoormans, 2005). The actual relevance of each component is one of the research questions that are addressed in the empirical studies. All methodological and empirical research goals that result from the framework are summarized in the following.

3.8 Detailed research goals based on the framework

Based on the user experience framework a variety of methodological and empirical research questions arise. These are discussed in this section and treated in Chapters 4 to 7.

3.8.1 Methodological research goals

Instrumental and non-instrumental quality perceptions as well as emotional user reaction are defined as central user experience components. The methodological part will consider how to measure these three components (Chapter 4). The measurement of instrumental quality perceptions in human-technology interaction has been a focus of attention for a long time. Various approaches exist and can be used to study instrumental quality perceptions as part a of user experience. A selection of approaches is discussed in Section 4.1 and recommendations are given regarding the use of the associated methods. The measurement of non-instrumental quality perceptions and emotional user reactions is relatively new. Therefore, the methodological focus is set on the measurement of these components. The sub-models on both components that have been described in this chapter are used as a basis to integrate existing methods and to deliver a comprehensive measurement approach to non-instrumental quality perceptions (Section 4.2) as well as emotional user reactions (Section 4.3). Regarding both user experience components, a study has been conducted that compares the proposed dimensions of the sub-models empirically and proves the viability of the approaches for the measurement of non-instrumental quality perceptions and emotional user reactions.

3.8.2 Empirical research goals

A variety of empirical research questions arise from the user experience framework. In particular, the proposed interrelations between its components require empirical testing. Table 3.1 gives an overview of the three studies presented in Chapter 5 to 7 and the components on which they focus. The empirical research questions addressed in the studies are described in the following.

Table 3.1: Overview of the components of the research framework focused in Studies 1 to 3.

Components of the research framework	Construct	Study 1	Study 2	Study 3
Influencing factors	System properties	x	x	x
	User characteristics			x
	Context parameters			x
Human-technology interaction	Interaction characteristics	x	x	x
Instrumental quality perceptions	Perceived usefulness	x		
	Perceived usability	x	x	x
Non-instrumental quality perceptions	Aesthetic aspects	x	x	x
	Symbolic aspects	x		
	(Motivational aspects)			
Emotional user reactions	Subjective feelings	x	x	x
	Motor expressions		x	
	Physiological reactions		x	
	Cognitive appraisals			x
	(Behavioral tendencies)			
Consequences	Overall judgments	x	x	x
	Choice of alternatives	x	x	
	(Usage behavior)			

The influence of system properties on quality perceptions is investigated in all three studies. While Study 1 considers a variety of system properties (presentation, dialogue, and appearance), Studies 2 and 3 focus on selected system properties that are related to the perception of usability and visual aesthetics. The impact of user characteristics and context parameters on quality perceptions is incorporated in Study 3. By varying system properties, user characteristics, and context parameters experimentally, the impact of variations of these influencing factors on emotional user reactions and consequences of user experience is studied.

No direct influence between instrumental and non-instrumental quality perceptions has been defined in the framework. Studies 2 and 3 focus on the interrelation of these components (Tractinsky et al., 2000; Hassenzahl, 2007). Furthermore, all three studies provide data about the interrelations of quality perceptions and emotional user reactions. Study 1 focuses on subjective feelings, Study 2 adds motor expressions and physiological reactions and Study 3 concentrates on the interrelations of quality perceptions and cognitive appraisals.

All three studies question the influence of instrumental and non-instrumental quality perceptions as well as emotional user reactions on consequences of user experience. While Studies 1 and 2 incorporate both overall judgments and choices between alternatives, Study 3 focuses exclusively on overall judgments.

Motivational aspects, behavioral tendencies, and usage behavior as a consequence of the user experience are not studied in the experiments (Table 3.1). Motivational aspects as non-instrumental qualities and behavioral tendencies as one aspect of emotional user reactions are both not addressed in the experiments because of the methodological challenges to assess them. The same applies to the study of usage behavior, which requires long-term studies. For practical reasons they are not incorporated.

Summarizing, Study 1 focuses on the influence of a whole range of system properties on the perception of various instrumental and non-instrumental qualities as well as subjective feelings as one aspect of emotional user reactions. Overall judgments and the choice between alternatives are studied as consequences of user experience. Study 2 concentrates on system properties that influence the perception of usability (as an example of a perceived instrumental quality) and visual aesthetics (as an example of a perceived non-instrumental quality). The results explain whether instrumental and non-instrumental quality perceptions influence each other. Furthermore, the influence of the variation of system properties on the emotional user reaction aspects of subjective feelings, facial expressions, and physiological reactions is studied. Overall judgments and alternative choices are incorporated as consequences of user experience. In Study 3, a similar variation of system properties is complemented with a variation of a user characteristic (cultural background) and a context parameter (tasks vs. exploration). Subjective feelings and cognitive appraisals are studied as aspect of emotional user reactions. Furthermore, Study 3 focuses on overall judgments as one consequence of user experience. Finally, the centrality of visual product aesthetics is investigated as another user characteristic in Study 3.

3.9 Chapter summary

The alternative framework to existing user experience approaches that is presented in this chapter concentrates on five main components and their interrelations: influencing factors, instrumental quality perceptions, non-instrumental quality perceptions, emotional user reaction, and consequences of user experience.

System properties, user characteristics, and context parameters are defined as categories of influencing factors. Perceived usefulness and usability are aspects of instrumental qualities, while three categories of non-instrumental quality perceptions are distinguished: aesthetic, symbolic, and motivational aspects. Sub-dimensions of instrumental and non-instrumental quality categories are available to measure these quality perceptions. Emotional user reactions are categorized using a multi-component approach to emotions by Scherer (1984) that defines five aspects of emotions: subjective feelings, physiological reactions, motor expressions, cognitive appraisals, and behavioral tendencies. Russell's (1980) dimensional approach to describe emotional qualities of subjective feelings and Scherer's (2001) model of cognitive appraisal dimensions specify the approach to emotional user reactions. Finally, overall judgments, choices between alternatives, and usage behavior are defined as consequences of user experience.

The following interrelations of user experience components are highlighted in the framework. Influencing factors are assumed to have an impact on the actual interaction that is experienced by the user. Instrumental and non-instrumental quality perceptions are influenced directly, while emotional user reactions are connected to user's quality perceptions. All three components are assumed to have an impact on the consequences of user experience.

4 Methodology

Methods to measure the three central components of user experience as described in the framework are the focus of this chapter. Based on the theoretical background and their description in the research framework, various methods that are applicable for the measurement of instrumental and non-instrumental quality perceptions as well as emotional user reactions are discussed. As a long tradition in human-technology interaction research exists on the measurement of perceived instrumental qualities, only a brief description is given on existing methods in this area (Section 4.1). Since the measurement of non-instrumental qualities and emotional user reactions in human-technology-interaction is relatively new, the discussion of methods to measure these components is more comprehensive. For both components a model has been presented in the previous chapter to structure the contributing aspects. These models are used to structure available methods and a study is described for both non-instrumental qualities (Sections 4.2) and emotional user reactions (Sections 4.3) to compare different methods.

4.1 Measuring instrumental quality perceptions

Instrumental qualities have been the main focus of evaluations of interactive systems. Various methods have been developed to measure a user's perception of instrumental qualities next to the assessment of the effectiveness and efficiency of the interaction. Two different perspectives on the measurement of instrumental qualities can be found. While researchers from management information science are interested in why existing computer systems are adopted or not, their colleagues form the area of user-centered design need methods to evaluate interactive systems already during the development process to give recommendations for improvement and check for benchmarks. The first line of research focuses on the so-called technology acceptance and questionnaires are developed to measure the important concepts to explain it. User satisfaction on the other hand is the main concept in the area of user-centered design. Selected measurement tools taken from each of the perspectives are introduced and discussed in the following.

4.1.1 Instrumental qualities and technology acceptance

The Technology Acceptance Model (TAM) by Davis (1989) is the most established approach in the technology acceptance literature. As already described in Chapter 2, it is a theory that models how users come to accept and use a technology. The model suggests that two factors influence users' decisions about how and when they will use a new system: perceived usefulness and ease of use. Perceived usefulness is defined as the degree to which a person believes that using a particular system would enhance his or her job performance, and perceived ease-of-use is described as the degree to which a person believes that using a particular system would be free from effort.

Several researchers have replicated Davis's original study (1989) to provide empirical evidence on relationships that exist between usefulness, ease of use, and system use (Adams, Nelson & Todd, 1992; Hendrickson et al., 1993; Szajna, 1994). Adams et al. (1992) replicated the work of Davis (1989) to demonstrate the validity and reliability of his instrument and his measurement scales. They also extended it to different settings and demonstrated the internal consistency and replication reliability of the two scales. Hendrickson et al. (1993) found high reliability and good test-retest reliability. Szajna (1994) demonstrated that the instrument has predictive validity for intent to use, self-reported usage, and attitude toward use. The sum of this research confirms the validity of the instrument and supports its use with different populations of users and different interactive system choices.

4.1.2 Instrumental qualities and user satisfaction

Several questionnaires have been developed to measure user satisfaction with focus on instrumental qualities. Three of the most common questionnaires have already been mentioned in Chapter 2 and are presented in the following: the System Usability Scale (Brooke, 1996), the Questionnaire for User Interaction Satisfaction (Chin et al., 1988), and the Subjective Usability Measurement Inventory (Kirakowski, 1996).

The System Usability Scale (SUS) is a simple, ten-item attitude scale giving a global view of subjective assessments of usability (Brooke, 1996). It has been developed as a tool to be used in usability engineering of electronic office systems. SUS is generally considered as providing a high-level subjective view on usability and is often used to compare the usability of different systems. SUS is freely available, easy to apply, and does not take much time to fill in. However, in comparison to other questionnaires the user's judgment is very superficial.

The Questionnaire for User Interaction Satisfaction (QUIS) has been developed based on the scale for 'User evaluation of interactive computer systems' presented by Shneiderman (1986). Many versions have been introduced with different amounts of subscales, items and levels of reliability (Chin et al. 1988). The dimensions of QUIS version 7 are: screen factors, terminology and system information, learning factors, system capabilities, technical manuals and on-line help, multimedia, and system installation. Quite high reliability coefficients have been reported for all dimensions (overall reliability for version 4 Cronbach's alpha 0.89, Chin et al. 1988).

The dimension screen factors refers to beliefs concerning interface properties on the lexical level, fonts, and highlighting, but also covers the logic of the interface, like the sequence of screens, user control, error recovery, and compatibility of operational sequences. Terminology and system information measures the understandability of the messages with related items. Learning covers not only the experience of learning, but also addresses beliefs concerning specific system characteristics such as feedback, logic of sequences, and intuitiveness. System capabilities refer to the users' experiences regarding the speed of performance, reliability, noise, error handling capabilities, and the flexibility of the system in relation to the user's experience.

Many of the items in QUIS resemble a selection from an expert evaluation checklist rather than questions measuring user satisfaction. One may suspect that users are not likely to consider these kinds of attributes spontaneously if not explicitly asked. Thus, QUIS operates between the designer domain of concrete product attributes and the user domain of subjective experience. Due to its many references to concrete product attributes, QUIS cannot be adapted for other interactive devices than software in visual display terminals.

The Software Usability Measurement Inventory (SUMI) aims at measuring the perceptions and feelings of a typical user (Kirakowski, 1996). In addition to its rating scales, SUMI provides software for scoring and a standardized reference database to support evaluation. This allows relating the scores of an individual measurement to the SUMI database to get an overview of the usability of a product without having to compare several alternatives. The five subscales of SUMI are efficiency, helpfulness, control, learnability, and affect. A sixth dimension measures an overall satisfaction value. Each sub-scale consists of ten items answered according to the alternatives agree-undecided-disagree. Reliability levels of the subscales range from Cronbach's alpha 0.71 to 0.85, and Cronbach's alpha 0.92 for the global usability measurement.

Efficiency is a measure of the user's perception of temporal efficiency and mental workload caused by the interaction. Helpfulness refers to the perceived quality of the messages the system provides. Control addresses the responses the product gives to the user's actions. Learnability refers to the perceived effort of learning, memorability, and quality of documentation. At last, affect refers to *"… the user feeling good, warm, happy or the opposite as a result of interacting … independent of operational aspects and to be about plain feelings"* (Kirakowski, 1996, p. 172). Even though the items which measure affect already relate to non-instrumental and emotional aspects, the dimension does not provide a comprehensive approach to these aspects of user experience.

4.1.3 Conclusions

The approach taken by Davis (1989) in his Technology Acceptance Model (TAM) integrates the user's perspective on utility and usability of an interactive product and offers a measurement tool to assess both aspects of instrumental qualities. With the goal to receive a more detailed view on perceived usability, Brooke (1996) introduced the System Usability Scale, which was one of the first user satisfaction questionnaires in the area of usability, although it differs not much from the perceived ease of use scale introduced by Davis (1989). The Questionnaire for User Interaction Satisfaction (Chin et al., 1988) measures various sub-dimension of usability and gives a more detailed view on a user's perception of instrumental qualities, but cannot be adapted for other interactive devices than software products. The Software Usability Measurement Inventory (Kirakowski, 1996) is today the most used subjective usability instrument. It can be used for a detailed assessment of perceived usability and applied to different domains of interactive systems. Accordingly, to measure perceived usability in detail, SUMI offers a practical and well-grounded approach.

In summary, the TAM and SUMI questionnaires can be seen as practical measurement tools to assess instrumental qualities on different levels of detail. While TAM provides an overall perspective on instrumental qualities, SUMI offers a detailed view on perceived usability. However, when using SUMI, it has to be kept in mind that the dimension called affect already incorporates emotional and non-instrumental aspects of the user experience. To measure non-instrumental quality perceptions and emotional user reactions in detail more comprehensive approaches should be applied that are discussed in the following sections.

4.2 Measuring non-instrumental quality perceptions

Non-instrumental qualities are defined as quality aspects of an interactive system that address user needs beyond efficient task accomplishment. In Section 3.4.2, a sub-model has been introduced that defines three categories of non-instrumental quality perceptions: aesthetic, symbolic, and motivational aspects. In this section, the focus is on methods to measure these dimensions of non-instrumental quality perceptions of interactive systems.

4.2.1 Methods to measure non-instrumental quality perceptions

As already discussed in Chapter 2, a variety of models and frameworks stress the importance of non-instrumental qualities. Although, there is a broad discussion of non-instrumental quality aspects and their application to design, only a few validated approaches for their quantitative measurement exist. This fact complicates further research on their importance and interplay with other aspects of user experience. Available methods to measure the discussed dimensions of non-instrumental quality are described below. For dimensions that are rarely focused in the field of human-technology interaction, also measurement approaches from contiguous fields are discussed.

Aesthetic aspects

Visual aspects of products have often been stated as most relevant for users' aesthetic response (Bloch, 1995). Various approaches exist to assess the visual aesthetics of interactive products. For example, Kleiss and Enke (1999) used 18 pairs of bipolar attributes to assess the visual appearance of automotive audio systems. Nonetheless, like in other approaches some of the items also represent instrumental and symbolic qualities. Schenkman and Jönsson (2000) used seven variables to assess visual aesthetics: complexity, legibility, order, beauty, meaningfulness, comprehension, and overall impression. However, each variable is only represented by one item and the names of the concepts are ambiguous. Lavie and Tractinsky (2004) present the most validated approach to the measurement of visual aesthetics in human-technology interaction. They developed a questionnaire based on four empirical studies that consists of two main dimensions of visual aesthetics, which they named 'classical aesthetics' and 'expressive aesthetics'. The classical aesthetics dimension pertains to aesthetic notions that emphasize orderly and clear design. The expressive aesthetics dimension is manifested by the designers' creativity and originality and by the ability to break design conventions. To measure each of the dimensions they give a five-item scale. One weakness of this approach is outlined by Hassenzahl (2007). He argues that the dimension of expressive aesthetics measures more symbolic or motivational aspects that are conveyed by visual attributes of an interactive product than directly focusing on aesthetic aspects. Nonetheless, the dimension of classical aesthetics proposed by Lavie and Tractinsky (2004) can be considered as one validated dimension to measure visual aesthetics in human-technology interaction.

Haptic quality is defined as a second aspect of aesthetic quality of interactive products. Although haptic and especially tactile aspects of product use are generally seen as important (MacDonald, 2001), not many tools exist to assess users' perceived haptic quality of interactive products. Jordan (2000) introduces the concept of physio-pleasure that focuses mostly on haptic aspects of product perception. He proposes a couple of items like, '… the product feels good in the hand', '… the buttons feel good to touch', or '… the product can be comfortably carried'. These recommendations can be used to measure haptic quality of interactive products.

Acoustic quality is also considered in different areas of technology use. For example, speech quality plays an important role in the evaluation of spoken dialogue systems (Möller, 2005; Jekosch, 2004). Acoustic quality is also studied as an aspect of multimedia quality (Watson & Sasse, 1998). In these areas, measurement approaches are used to assess subjective quality of speech and audio that have been standardized and recommended for example by the International Telecommunications Union (ITU, 2004). However, for the assessment of speech quality, single 5-point rating scales are recommended, which only give a general assessment of acoustic quality. In the general area of sound quality, more detailed approaches can be found. For example, Farina (2001) used 14 pairs of attribute descriptions to assess perceived acoustic quality.

Symbolic aspects

Symbolic aspects are defined as another category of non-instrumental qualities in Chapter 3 and an associative and a communicative dimension are distinguished. Although, this distinction can be theoretically justified, existing measurement approaches on symbolic qualities in human-technology interaction do not apply this differentiation. Tractincky and Zmiri (2006) used a five-item scale to measure symbolism. The scale mixes associative ('… the product represents likeable things', '… creates positive associations') and communicative ('… the product communicates a positive message about user', '… communicates desirable image', '… fits personality') aspects. Hassenzahl (2004b) introduced the concept of identification as a symbolic quality that is associated with communicative aspects. Summarizing, new measurement scales are needed that focus separately on associative and communicative aspects of symbolic quality of interactive products.

Motivational aspects

Motivational qualities are integrated in the sub-model of non-instrumental qualities, although most other approaches to user experience do not consider them (Crilly et al., 2004; Rafaeli & Vilnai-Yavetz, 2004). This might be one reason why almost no approach to measure motivational aspects of interactive products exists. The dimension of stimulation proposed by Hassenzahl (2004b) is an example of motivational qualities. He defines stimulation as the product's ability to satisfy human needs for novelty and curiosity. These are only some aspects of motivational qualities. As more work is needed to measure motivational quality, the studies presented here can not consider them.

4.2.2 Empirical study on non-instrumental quality perceptions

A number of methods associated with non-instrumental qualities have been discussed. Various empirical questions arise from this discussion as well as from the proposition of the model on non-instrumental quality perceptions in Section 3.4.2: Which dimensions of non-instrumental qualities are important for interactive product experience? Does the approach presented here explain more variance of overall judgments than other approaches to non-instrumental qualities (like e.g. Hassenzahl, 2004b)?

A study on non-instrumental qualities of mobile phones comparing the proposed model with Hassenzahl's (2004b) model is based on the assumption that various sub-dimensions of aesthetic and symbolic quality represent independent and relevant factors for the perception of non-instrumental aspects of product quality (Mahlke, Lemke & Thüring, 2007). Furthermore, the consideration of aesthetics and symbolic quality aspects should lead to better results predicting overall judgments than focusing on specific non-instrumental qualities.

Method

Participants: Sixty individuals (25 men, 35 women) participated in the study. Almost all of them were students at Berlin University of Technology. They were between 17 and 44 years old (*M* = 25.5, *SD* = 5.6). Most of the participants (n = 57) used a mobile phone regularly and had an average of six years experience. Six of the participants used a mobile phone from the same brand at the time the experiment was conducted, and another eleven had used one of this brand before. Participants were paid five euros for taking part in the study.

Figure 4.1: Mobile phones used in the study (from the left PEBL, RAZR V3 & T191).

Materials: Three mobile phones were used as stimuli (PEBL, RAZR V3 and T191 developed by Motorola, Figure 4.1). Since all were from the same manufacturer the influence of brand needed not to be considered. All three were similar with respect to instrumental qualities. However, the three mobile phones differed regarding non-instrumental quality aspects. Differences in aesthetic and symbolic qualities were assured in a pretest with seven experts of usability and product design, who received a description of all non-instrumental quality dimensions and gave a rating for each dimension. Furthermore, the experts confirmed the minor differences regarding instrumental qualities.

Independent variables and design: The factor PRODUCT was the independent variable in the study. Each of the three mobile phones represented one condition. The independent variable PRODUCT was a between-subjects factor. Each condition was completed by twenty participants.

Dependent variables: Aesthetics aspects were measured with the following questionnaire dimensions: classical visual aesthetics (Cronbach's alpha .70) as recommended by Lavie & Tractinsky (2004) to assess visual aesthetics, a scale based on Jordan (2000) to measure haptic quality (Cronbach's alpha .82) and a scale taken from Farina (2001) to measure acoustic quality (Cronbach's alpha .90). Symbolic aspects were surveyed using a scale that focused on the communicative sub-dimension (Cronbach's alpha .82). Each of the scales consisted of five items, and ratings ranged from 0 to 6 (low to high). To compare the model of non-instrumental qualities proposed here with a more focused approach to non-instrumental qualities, Hassenzahl's (2004b) dimensions of identification and stimulation (Cronbach's alpha .77 and .90, respectively) were measured. The scales consisted of seven items each and ratings ranged from 0 to 6 (low to high). Overall judgments were assessed using a one-item scale that ranged from 0 to 6 (low to high). Furthermore, pragmatic quality (Hassenzahl 2004b) was surveyed to verify that the products did not differ with respect to instrumental qualities. The materials can be found in the Appendix A.

Procedure: The study was conducted at the UseLab at the Center of Human-Machine-Systems at Berlin University of Technology. At the beginning of the experiment, participants received a description of the study and were assigned to one of the three conditions. To experience the interaction with the products, seven typical tasks were given to the participants for each product (ranging from turning on the phone to changing date and time or saving a phone book entry). Participants had ten minutes to solve the tasks. After accomplishing all the tasks, participants filled out the questionnaire that assessed their ratings regarding the different quality dimensions and the overall judgment. A session lasted about 30 minutes.

Results

The relationships between the assessed dimensions of non-instrumental quality are reported in Table 4.1. No significant correlation between the three dimension that focus on aesthetic aspects is found. Symbolic quality is correlated significantly with all aesthetic scales. The two dimensions identification and stimulation correlate significantly with each other and almost all of the other non-instrumental quality dimensions.

Table 4.1: Correlations between the dimensions of non-instrumental quality.

Dependent variables	Visual aesthetics	Haptic quality	Acoustic quality	Symbolic quality	Identification
Visual aesthetics	1				
Haptic quality	0.25	1			
Acoustic quality	0.21	0.25	1		
Symbolic quality	0.54**	0.36**	0.41**	1	
Identification	0.48**	0.28*	0.52**	0.61**	1
Stimulation	0.40**	0.18	0.45**	0.47**	0.47**

* p < .05; ** p < .01, *** p < .001

Regression analyses explain the influence of the various dimensions of non-instrumental quality on overall judgments. First, the aesthetic dimensions of visual aesthetics as well as haptic and acoustic quality and the used dimension of symbolic quality are used to predict participants' overall judgments. Table 4.2 reports the results of the analysis. All four dimensions contribute significantly to participants overall ratings. 72% of the variance of the judgments is explained using the four dimensions of non-instrumental quality.

Table 4.2: Regression of overall judgments based on the proposed dimensions of non-instrumental quality.

Predictors	Overall rating
Perceived visual aesthetics	0.22*
Perceived haptic quality	0.33***
Perceived acoustic quality	0.31***
Perceived symbolic quality	0.32**
R^2	.72
* p < .05; ** p < .01, *** p < .001	

In a subsequent regression analysis, the model proposed by Hassenzahl (2004b) using the two dimensions identification and stimulation is applied. The results are presented in Table 4.3. Both concepts contribute significantly to the overall rating. However, only 38% of the variance of the overall judgments is explained using the two dimensions of hedonic quality.

Table 4.3: Regression of overall judgments based on the model of Hassenzahl (2004b).

Predictors	Overall rating
Identification	0.43**
Stimulation	0.31*
R^2	.38
* p < .05; ** p < .01, *** p < .001	

Discussion

Based on the sub-model of non-instrumental quality aspects (Section 3.4.2), the study focuses on the relationship between the proposed dimensions of non-instrumental quality and their importance for overall judgments. Four dimensions of non-instrumental quality are incorporated in the study: three aspects of aesthetic quality and one dimension to measure symbolic aspects of product quality. Interestingly, no significant correlations between the three quality dimensions focusing on aesthetic aspects, which seem to be perceived independently, are found. However, the aesthetic scales are all related to the symbolic quality dimension. Therefore, a relationship between aesthetic and symbolic quality perceptions can be assumed.

The comparison to the model on non-instrumental qualities by Hassenzahl (2004b) demonstrates that the consideration of diverse dimensions of non-instrumental qualities better explains overall judgments. However, it has to be kept in mind that more variables to predict overall ratings are used than in the compared approach. Nonetheless, the extension increases the variance of overall judgments that is explained. The results support the findings by Mahlke (2002) who also found that aesthetic and symbolic aspects contribute to the explanation of overall judgments.

The study has the following limitations. Using real products that differ on various design dimensions makes it impossible to identify which system attributes influence non-instrumental quality perceptions. A more detailed approach is necessary to answer this question. Only one dimension of symbolic quality is incorporated in the study, although further aspects are discussed in the model. Additionally, the dimension of symbolic quality introduced in this study and Hassenzahl's (2004b) dimension of identification show the highest correlation and seem to measure identical symbolic aspects. Also, the relationship between aesthetics and symbolic aspects has to be clarified further. However, the results of this study give first hints regarding the connection of these two categories of non-instrumental qualities.

4.2.3 Conclusions

In this section, a model of non-instrumental qualities has been applied that aimed at combining the advantages of more focused contributions (Hassenzahl 2004b; Lavie & Tractinsky 2004) and broader, conceptual approaches (Creusen & Schoormans 2005; Crilly et al., 2004). The results of a study on mobile phones demonstrate that it is reasonable to integrate diverse dimensions of non-instrumental quality to evaluate interactive products and that this approach has a prognostic advantage for the users' overall judgments over more focused approaches.

In conclusion, the evaluation of the non-instrumental quality of interactive systems should incorporate a diversity of dimensions to better understand users' perception of qualities that go beyond the instrumental value of a product. It is demonstrated how existing questionnaires can be combined to achieve a measurement of various non-instrumental quality aspects. While the quality of different aesthetic aspects (visual, acoustic, haptic) is relatively independent, these qualities can be evaluated individually and early during the development process. Symbolic qualities result from the interplay of aesthetic and probably other quality dimensions. Therefore, results regarding symbolic qualities may be more reliable when they are assessed in later phases of the development process.

4.3 Measuring emotional user reactions

In this section, the measurement of emotional user reactions is discussed. A multi-component model to emotional user reactions has been introduced in Section 3.5.2 that defines five aspects of emotions: subjective feelings, physiological reactions, motor expressions, cognitive appraisals, and behavioral tendencies. To use this approach empirically, methods need to be identified that measure emotion-related changes on the five components. The diversity of methods and assessment scales for emotions is remarkable. Therefore in this section, a selected variety of measurement approaches is discussed, and a focus is on applications of methods to the area of human-technology interaction.

4.3.1 Methods to measure emotional user reactions

Larsen and Fredrickson (1999) point out that every emotion measurement type has its strengths and weaknesses and that when measuring emotions a working definition of emotions should be the basis to choose relevant methods. The multi-component model proposed by Scherer (1984) its five aspects subjective feelings, physiological reactions, motor expressions, cognitive appraisals and behavioral tendencies serves as basis for the discussion of emotion measurement approaches. Although, emotions can be seen as multi-faceted processes that unfold over time, the dynamic aspects of emotion measurement are neglected for now to reduce complexity and be able to take a first step to emotion measurement in human-technology interaction. Russell and Feldman Barrett (1999) point out that it is necessary to take a specification like this into account because measures suitable for one presumption may be unsuitable for another. Schorr (2001) discusses the advantages and disadvantages of subjective and objective measures of emotions and it can be reasoned that a combination would lead to best results. Incorporating different components of emotions guarantees a consideration of more subjective (subjective feelings, cognitive appraisals) and more objective measures (physiological reactions, motor expressions, behavioral tendencies) of emotions. A selection of methods is discussed on the basis of the multi-component model discussed in the previous chapter.

Subjective feelings

To assess subjective feelings, a variety of self-assessment scales is available, which assume that the individual is the best source of information on the emotions they experience. The SAM scales (Self-Assessment-Manikin), introduced by Lang (1980), consist of pictures of manikins for each of the dimensions valence and arousal (Figure 4.2). The manikins represent five states from happy to unhappy and excited to calm. Individuals rate their feeling either on a manikin or in the space between two manikins, which results in nine graduations per dimension. Desmet (2003b) presented an extension of this approach (Figure 4.2). The non-verbal assessment is supposed to reduce intercultural differences, especially those that result from semantic verbalizing of emotions.

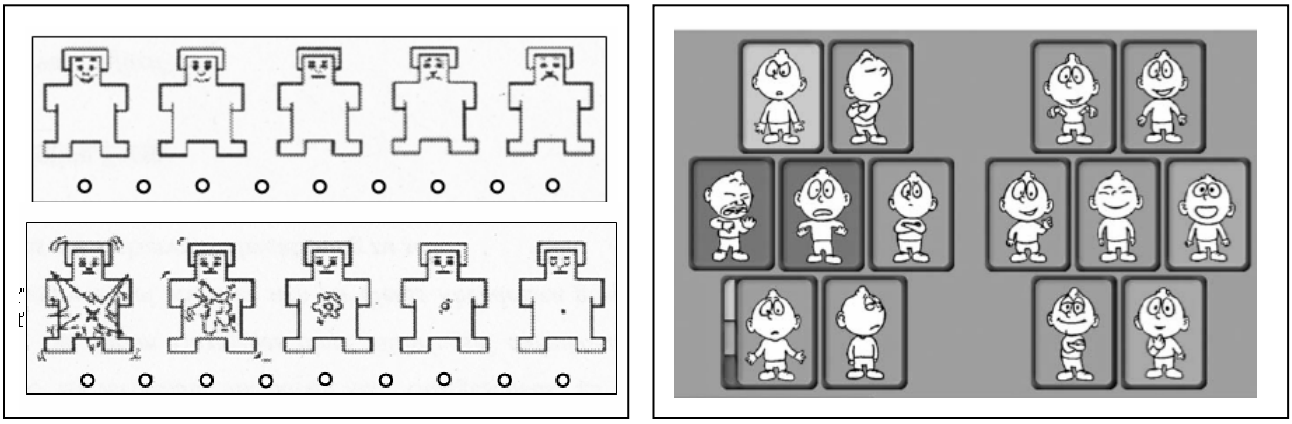


Figure 4.2: Measurement tools by Lang (1980) and Desmet (2003b).

The affect grid (Russell, Weiss & Mendelsohn, 1989) is a semantic questionnaire to assess emotional states. In contrast to SAM, the affect grid is a single scale questionnaire. It consists of a 9 x 9-matrix that is surrounded by eight adjectives describing emotional feelings. However, the adjectives are also arranged by the dimensions valence and arousal, like the ones in Russell's circumplex model of emotion (1980). Individuals are instructed to rate their feeling by setting a cross in one field of the matrix.

Physiological reactions

Several methods can be used to gain information on physiological reactions. The most promising way to determine emotional connotations is the measure of electrodermal activity (EDA). Common parameters are skin conductance response, skin resistance response, and skin potential response. EDA is merely controlled by sympathic activation. Previous research suggests that higher decreases in EDA are correlated with more negatively valenced situations (Ward & Marsden, 2003).

Another way to gain information on physiological activation is to record heart activity by an electrocardiogram. There are a variety of parameters for analyzing and interpreting the raw signal. Common time-related parameters are heart rate, inter-beat-interval, and heart rate variability (Fahrenberg, 2001). However, these show inconsistent results for predicting emotional valence in human-technology interaction. While Ward and Marsden (2003) describe a decrease of heart rate in negative valenced situations, other authors found a positive correlation between heart rate and valence (Bradley, Greenwald & Hamm, 1993). Summarizing, heart activity seems to be a more reliable indicator for arousal and mental workload than for emotional valence (see Fahrenberg, 2001).

Previous research suggests consistently that pupillometry is a powerful measure for autonomic responses and mental workload. The more demanding a process is, the larger the pupil is supposed to be (Beatty, 1982). Additionally, Hess and Polt (1960) found a significant correlation between dilatation and the valence of a stimulus. Thus, more pleasant stimuli are susceptible for generating more dilated pupils.

Motor expressions

Common measurements of motor expressions are FACS (Facial Action Coding System), electromyography (EMG), and speech analysis. The Facial Action Coding System (FACS) is based on the analysis of 44 facial muscles. A trained person categorizes the observed pattern of activity in respect to six basic emotions fear, anger, joy, disgust, grief, and surprise (Ekman, 1992). To gain reliable information, FACS requires an intensive training. Computer-based analysis of facial activity does not yet lead to comparable results (Cohen, Sebe, Chen, Garg & Huang, 2000).

The measurement of spontaneous muscle activity is called electromyography (EMG). Two sensors placed on the muscle region detect sensitively minimal voltage caused by activity. Facial EMG studies have found that activity of the corrugator supercilii muscle, which lowers the eyebrow and is involved in producing frowns, varies inversely with the emotional valence of presented stimuli and reports of emotional state. The activity of the zygomaticus major muscle, which controls smiling, is positively associated with positive emotional stimuli and positive affect (Cacioppo, Petty, Losch & Kim, 1986; Dimberg, 1990).

Another approach based on measuring motor expressions is the analysis of speech characteristics, like speed, intensity, melody, and loudness. Empirical research suggests that these qualities are highly correlated with emotional feelings, and are therefore reliable indicators for emotional reactions (Banse & Scherer, 1996).

Cognitive appraisals

To assess cognitive appraisals, both quantitative and qualitative methods can be used. As a quantitative approach the GAF (Geneva Appraisal Questionnaire) by Scherer (2001) measures retrospectively the quality of an emotional episode as antecedent of a relevant connoted event. The items of the GAF represent the five dimensions of Scherer’s cognitive appraisal theory: intrinsic pleasantness, novelty, goal conduciveness, coping potential, and norm/self compatibility (Scherer, 1984). Additionally, qualitative descriptions about event specific experiences can be given. The GAF is a rather long questionnaire. Therefore the application of the original version in human-technology interaction is less suitable.

As a qualitative approach, the thinking aloud method can be used. People are encouraged to state and describe every emotional reaction they feel during interaction with a technological system. The statements have to be recorded properly, reduced in respect to the focus of research, and analyzed by a qualitative procedure. To prevent non-ecological interaction between usage and assessment, the thinking aloud method can be applied retrospectively, e.g. by presenting a video.

Behavioral tendencies

The measurement of performance and behavior has a long tradition in human-technology interaction research. Central indicators of performance are speed of reaction (e.g. the time required for single input operations or completing a defined goal), the accuracy of reaching a goal, the number of errors, and the number of creative ideas during interaction with a system. Findings of Partala and Surakka (2004) indicate that behavioral data are related to EMG values. The results demonstrate that low activation of the corrugator supercilii muscle is related to a high rate of successful and goal conductive reactions with a usable designed system. As further indicators of behavioral tendencies, unspecific questionnaires about the intention of use or the intention of purchase can be mentioned. However, these methods have problems of reliability (e.g. Brave & Nass, 2001).

4.3.2 Empirical study on emotional user reactions

A number of methods that are associated with the five components of emotion have been discussed. The question remains to what extent a combination of methods based on the component approach offers a comprehensive way to understand different aspects of the emotional user experience in the context of human-technology interaction.

The aim of the following study is to investigate the relations that exist between the five components of an emotional experience in an interactive context (Mahlke, Minge & Thüring, 2006). Therefore, a combination of various methods representing the full range of components of the model is composed. Moreover, participants of the study are instructed to interact with two versions of a computer-based simulation of a mobile phone while emotion-related changes on the components are recorded.

Method

Participants: Thirty individuals (15 men, 15 women) took part in the study. Most of them were students at Berlin University of Technology. They were between 20 and 41 years old (M = 25.9, SD = 3.9), were familiar with usage of mobile phones and had moderate to high computer experience. Participants were paid a variable amount between five and fifteen euros based on their performance.

Materials: Two versions of a computer-based simulation of a mobile phone were designed that varied in the degree of usability. The user interface of the two versions differed in multiple ways. To induce differences in emotional user reactions, the variations were designed according to Mentis and Gay (2003): response times of the less usable version were delayed, information on the screen was less readable, and the dialogue structure was confusing.

Figure 4.3: Mobile phone simulations used in the study (well designed left, ill designed right).

Independent variables and design: The factor PRODUCT was the only independent variable in the study. The independent variable PRODUCT was a within-subjects factor. So each condition was completed by all thirty participants. Presentation order of the stimuli was balanced.

Dependent variables: To measure emotion-related changes on the components, heart rate, electrodermal activity, electromyographic activity of zygomaticus major and corrugator supercilii, and the time required for input operations were recorded during task completion to gain information on physiological reactions, motor expressions, and behavioral tendencies. Furthermore, the dimensions activation and valence of SAM (Self-Assessment-Manikin) were used to measure subjective feelings. To collect data on cognitive appraisals, both the retrospective thinking aloud method and a short questionnaire based on the Geneva Appraisal Questionnaire were used (Scherer, 2001). The questionnaire consisted of one item for each of the five dimensions. All materials are available in the Appendix B.

Procedure: The study was conducted at the UseLab at the Center of Human-Machine-Systems at Berlin University of Technology. At the beginning of the experiment, sensors for measuring physiological reactions and facial expressions were attached, and baseline values were recorded. The prototypes of mobile phones were presented on a computer monitor. A mouse was used as input device. Two sets of five tasks typical for mobile phone usage were chosen to be used in the experiment ranging from short ones, like reduce the volume of your mobile phone, to more complex ones, like add a new number to your telephone list. Participants started with one version and completed the first set of tasks. Then, they switched to the other system to solve the remaining tasks. Maximum time for each task was two minutes. Heart rate, EDA, and EMG were measured during task completion. Participants filled in the SAM scales subsequently to each task. After the electrodes were removed, the video confrontation started. The participants watched their videotaped task completion behavior and were asked to explain what they felt during system use. After the presentation of each task, they filled in the short appraisal questionnaire. To ensure a realistic emotional involvement, participants were paid depending on their performance. They started with a credit of fifteen euros, which was reduced by one euro whenever a task could not be completed. Participants were informed about each reduction and were constantly aware of the amount of money that was left. A session lasted about 75 minutes. Time for task completion was about fifteen minutes overall.

Data preparation: Heart rate and EDA were measured as differences from the individual baseline level in order to reduce inter-individual differences and allow comparisons between subjects. For the heart rate data the time series data were converted to single points through averaging the time series for every task. Regarding EDA, the maximum values for each task were interpreted and averaged over all tasks. The EMG data were integrated and t-transformed. All utterances received from the retrospective thinking aloud method were categorized with respect to the appraisal dimensions. Affirmative utterances were offset against negating ones and means were calculated for each dimension and all participants. For indicating the behavior intention, the time for task completion was divided by the number of inputs to get the average time per input. Delayed system responses in the less usable condition were deducted.

Results

The results of a correlation analysis of the elements of the emotional triad are presented in Table 4.4. Both physiological measures as well as the measures of facial expression correlate significantly with the arousal dimension of the subjective feelings questionnaire (SAM). EDA as well as the activity of the corrugator supercilii and the zygomaticus major are also significantly correlated with the valence dimension. Physiological measures and facial expression measures do not correlate significantly.

Table 4.4: Correlations between dependent variables of the emotion triad.

Dependent variables	SAM valence	SAM arousal	Heart rate	EDA	corrugator supercilii
SAM - valence	1				
SAM - arousal	-0.32**	1			
Heart rate	0.02	0.25**	1		
EDA	-0.14*	0.26**	0.01	1	
corrugator supercilii	-0.16**	0.12*	0.11	0.01	1
zygomaticus major	0.19**	0.25**	0.06	0.06	0.10

* p < .05; ** p < .01, *** p < .001

The results demonstrate a significant correlation between the valence dimension and the arousal dimension of SAM (r = -0.32, p < .01). This connection of the two theoretically independent dimensions may be caused by the stimuli chosen for the study. The less usable version leads to high arousing reactions with negative valence, while positive and low arousing emotions are experienced when the well-designed version is used.

Differences are found regarding the two methods used to assess cognitive appraisals. Correlations between intrinsic pleasantness, goal/need conduciveness, and coping potentials lie between r = 0.44 and r = 0.71 and are highly significant (p < .001). However, no significant correlations are found for the dimensions of novelty and norm/self compatibility.

In another step, the relations between the elements of the emotion triad and the other two components are analyzed. The dimensions of the appraisal questionnaire are highly correlated with the valence dimension of the self-assessment manikin (see Table 4.5). Valence correlates positively with pleasantness (r = 0.73), goal/need conduciveness (r = 0.64), coping potential (r = 0.64), and norm/self compatibility (r= 0.64). Valence and novelty are negatively correlated (r = -0.44). Smaller correlations are found between the arousal dimension of subjective feelings component and the appraisal dimensions. Physiological and motor expression data correlate with some of the appraisal dimensions slightly (between r = 0.13 and r = 0.23). The correlations between the data gained with the retrospective think aloud method and the emotion triad differ for the two appraisal dimensions novelty and norm/self compatibility. Correlations are smaller for these dimensions with respect to all components of the emotion triad.

Table 4.5: Correlations between dependent variables of the emotion triad and data from the cognitive appraisal questionnaire.

Dependent variables	SAM valence	SAM arousal	Heart rate	EDA	corrugator supercilii	zygomaticus major
Pleasantness	0.73**	-0.36**	-0.06	0.13**	-0.19**	-0.23**
Novelty	-0.44**	0.41**	0.04	0.19**	0.07	0.18**
Goal relevance	0.61**	-0.31**	-0.15**	0.10	-0.15*	-0.25**
Coping potential	0.64**	-0.34**	0.11	0.08	-0.15*	-0.23**
Norm/self capability	0.64**	-0.28**	0.06	0.08	-0.14*	-0.23**

* p < .05; ** p < .01, *** p < .001

The average time per input – the measure of the behavioral component – is significantly higher in situations that are experienced as less pleasant, less goal conductive, less capable, and less norm/self compatible (0.30 < r < 0.35). The behavioral data also correlates with the valence and arousal dimension of the subjective feelings component (r = 0.23 and r = 0.14).

No significant correlations are found between the behavioral component and the physiological or expressive ones.

Discussion

The results support the assumption that emotional reactions are determined by a number of different but related components. Summarizing the correlations between the components, high correlations between cognitive appraisal and subjective feelings data are found. Both are connected significantly but with smaller correlations to the other three components of emotions. No significant correlations are found between physiological and expressive reactions, and both components do not show any connection to behavioral tendencies either.

Looking at the correlations in more detail, the results regarding valence are consistent with the expectations. Measures show lower EDA values and less activity of corrugator supercilii when experienced emotions are rated as rather positive. These results are consistent with earlier findings (Ward & Marsden, 2003; Partala & Surakka, 2004). Moreover, EDA measures and heart rate correlate positively with the arousal dimension.

Although the detected pattern of correlations is rather coherent and consistent, not all methods lead to expected results. Especially the results regarding the activity of the zygomaticus major differ from most other studies that found higher activity in relation to positive emotions (e.g. Partala & Surakka, 2004). Instead, the data point in the same direction as other experiments, which detected high activity of the zygomaticus major for negative emotions (Lang, Greenwald, Bradley & Hamm, 1993). Hence, it seems that the activity of the zygomaticus major is not a reliable indicator for positive feelings. An alternative explanation is that strong positive emotions are not induced in this setting.

Another point for discussion is the extent of the correlations that are found between subjective feelings, physiological reactions, and expressive measures. Other studies on emotions show similar correlations between physiological measures and ratings and discuss this as a problem of emotion research (Herbon, Peter, Markert, van der Meer & Voskamp, 2005). However, these results may not only be caused by measurement uncertainties, but also by the theoretical premise that the components of emotions represent different aspects of emotions that are only correlated in a specific way. The second assumption leads to the conclusion that only a combination of measures gives a good description of the quality of an experienced emotion.

Another aspect concerns the relevance of cognitive appraisals and the behavioral component as parts of emotional user reactions. Appraisal processes of emotions in human-technology interaction have rarely been studied experimentally. Summarizing, the results of this study suggest that goal conductive, capable, and norm/self compatible appraisals are associated with positive emotions. However, the measurement of cognitive appraisals is a first methodological step to deal with this topic in the area of human-technology interaction. With respect to behavioral tendencies, the study hints at an interesting point concerning the efficiency of system usage. Since the average time required per input is significantly higher for the system with usability flaws, negative emotions may contribute to slowing down the user. Nonetheless, the relation between negative emotions and performance can also be in the opposite direction: low performance may have caused negative emotions. More experiments are necessary to clarify this relation. However, the behavioral data in this experiment are connected to the subjective feelings and cognitive appraisal data. Nonetheless, differences in the behavioral data can be interpreted as antecedent or consequence of changes on the other components of emotions.

4.3.3 Conclusions

Based on the approach proposed by Scherer (1984), the measurement of different components of users' emotional reactions by a combination of self-assessment ratings, physiological and expression measures as well as cognitive appraisal questionnaires and analysis of behavioral data has been discussed. In addition, a study has been presented that demonstrates the measurement of multiple components of emotions in an interactive context and illustrates that this combination offers a sound methodological basis for experimental studies of emotions in human-technology interaction.

The results show that the components of emotions are only slightly related. Although valence and arousal of the subjective feelings are correlated in the presented study because of the chosen conditions, the results point out a higher correlation of physiological reactions and the arousal of subjective feelings and a higher connection between motor expression data and the valence of subjective feelings. Cognitive appraisals measuring the user's interpretation of a situation as basis for the experience of an emotion are strongly connected to the actual experienced subjective feelings.

The study demonstrates that each of the methods associated with the different components has advantages and disadvantages. Physiological and expressive measures provide continuous data, while subjective feeling ratings are very easy to apply. Cognitive appraisal data give background information about the reasons of the development of a specific emotion in a given situation. A main issue arising from the multi-component approach is which components need to be measured to get acceptable results. The more components are measured the more information is available to interpret the user's reactions. The information gained from the components can sometimes be contradictory, but together should deliver more reliable results as if only one component is measured. The measurement of subjective feelings may be enough for rough estimations if an emotional user reaction is positive or negative. However, to understand emotional user reactions in more detail, the study of more than one component is needed.

4.4 Chapter Summary

The measurement of instrumental qualities has been a research topic for a long time and various established approaches and methods exist. Davis' (1989) approach to technology acceptance (TAM) that integrates users' perceived usefulness and usability as instrumental quality aspects is recommended to measure instrumental qualities as defined in the research framework in Chapter 3. Furthermore, Kirakowski's (1996) questionnaire to measure subjective usability (SUMI) is suggested to measure perceived usability in more detail.

Based on the model of non-instrumental qualities that is integrated in the overall framework and that differentiates aesthetic, symbolic, and motivational aspects, existing questionnaire dimensions are integrated to measure these non-instrumental quality aspects. The results of a study on non-instrumental qualities demonstrate that a diversity of non-instrumental qualities have to be considered to understand the relevance of non-instrumental qualities as part of user experience sufficiently.

A variety of methods exist to measure emotions that are related to one of the five aspects of emotional user reactions (subjective feelings, physiological reactions, motor expressions, cognitive appraisals, and behavioral tendencies). Each of the methods associated with the different components has advantages and disadvantages. Physiological and expressive measures provide continuous data, while subjective feeling ratings are very easy to apply. Cognitive appraisal data give background information about the reasons of the development of a specific emotion in a given situation. The results of a study applying a selection of these methods demonstrate that the five aspects of emotional user reactions are only slightly connected and applying more than one method helps to better understand emotional user reactions in detail.

After discussing existing approaches to user experience in Chapter 2, presenting a framework that specifies the major components of user experience and their possible interrelations in Chapter 3, and summarizing methods to measure these components in his chapter, three empirical studies are presented in the following Chapters 5 to 7. They apply the identified methods to test some of the assumptions made in the research framework by analyzing which factors influence the user experience and how the components of user experience interrelate.

5 Study 1: System properties of existing products

Study 1 is a first application of the user experience framework to test selected assumptions of the model empirically. One assumption of the framework is that properties of an interactive system influence interaction characteristics, quality perceptions (instrumental and non-instrumental aspects), emotional user reactions, and overall judgments. Four different portable audio players are used in this study to analyze whether differences in system properties have the assumed influences on user experience components. Another central assumption is that emotional user reactions are explained by considering quality perceptions regarding instrumental and non-instrumental aspects. In this study, subjective feelings are focused as one aspect of emotional user reactions to test these interrelations. Furthermore, the assumption is addressed that overall judgments and choices between alternatives depend on quality perceptions and emotional reactions during the interaction.

5.1 Method

5.1.1 Participants

Thirty individuals (twenty women, ten men) participated in the study. Almost all of them were students at Berlin University of Technology. They were between 21 and 31 years old (M = 25.5, SD = 3.6). Most of the participants were experienced in using portable audio players. 24 stated that they owned one and used it regularly. Participants were paid five euros for taking part in the study.

5.1.2 Materials

Four portable audio players were used in the study (MuVo², Zen Micro, Zen Touch and Zen Xtra developed by Creative, Figure 5.1). The players were selected for heterogeneity, i.e. to maximize variance of user experience with the systems. All players were from the same manufacturer, so the influence of brand was prevented. Nonetheless, players varied in terms of design aspects. Regarding the system property categories introduced in Section 3.2.1, players differed with respect to three categories: presentation (menu design), dialogue (input and interaction style), and appearance (product design and body size).

Figure 5.1: Portable audio players used in the study (from the left MuVo² [A], Zen Micro [B], Zen Touch [C] and Zen Xtra [D]).

Information presentation in the displays and the display size differed. While in Player A icons were used to symbolize the menu options, the other players only used text. The menu structure was quite similar for the Players B, C, and D and differed for Player A. The display was smallest for Player A and largest for Players C. Player A and D were operated with buttons, while Player B and C had a slider combined with various buttons. For Player A, navigation through the menu was from left to right, while it was from top to down for the other players. Functionality – the fourth system property category proposed in Section 3.2.1 – was similar with respect to the tasks participants had to accomplish during the experiment. Detailed information about the four players can be found in the Appendix C.1.

5.1.3 Independent variables and design

The four players were the only variation used in the study. As already described, several system properties were varied using these existing products. As all participants tested each product, a within-subject design resulted in the factor PRODUCT (Table 5.1). Presentation order of the players was counterbalanced.

Table 5.1: Overview of the design used in Study 1.

Player	A	B	C	D
	N = 30	N = 30	N = 30	N = 30

5.1.4 Dependent variables

The dependent variables used in the study were based on the user experience framework and selected methods discussed in the previous chapter. The following components were operationalized: interaction characteristics, instrumental and non-instrumental quality perceptions, emotional user reactions as well as overall judgments and alternative choice as consequences of user experience. Table 5.2 gives an overview of the dependent variables.

Table 5.2: Overview of dependent variables used in Study 1.

User experience component	Construct	Variable
Interaction characteristics	Performance	No. of accomplished tasks
	Performance	Average time on task
Instrumental qualities	Perceived usefulness	Davis, 1989
	Perceived ease of use	Davis, 1989
Non-instrumental qualities	Perceived visual aesthetics	Classical visual aesthetics (Lavie and Tractinsky, 2004)
	Perceived haptic quality	Jordan, 2000
	Perceived symbolic quality	Identification (Hassenzahl, 2004b)
Emotional user reactions	Subjective feelings	SAM – valence (Lang, 1980)
		SAM – arousal (Lang, 1980)
Consequences	Overall judgment	Overall rating (Kollmann, 1999)
	Alternative choice	Ranking

Task completion rates and time on task were recorded to assess whether the players had an effect on interaction characteristics. Usefulness and ease of use were operationalized based on Davis (1989) as global categories of instrumental quality. Each of the scales consisted of five items. The answering format ranged from 0 (low) to 6 (high). Cronbach's alpha was .82 for perceived usefulness and .93 for perceived ease of use.

Based on the approach presented in Section 4.2, various dimensions of non-instrumental quality were surveyed. Aesthetics aspects were measured with the dimension recommended by Lavie and Tractinsky (2004) to assess visual aesthetics (classical visual aesthetics: Cronbach's alpha .81) and the scale based on Jordan (2000) to measure haptic quality (Cronbach's alpha .65). Each of the scales consisted of five items and ratings ranged from 0 to 6 (low to high). Acoustic quality was not incorporated as it did not play a role in the tasks used in this study. Symbolic aspects were surveyed using Hassenzahl's (2004b) dimension of identification (Cronbach's alpha .78). The scale consisted of seven items and ratings ranged from 0 to 6 (low to high).

In this study, subjective feelings were focused as one aspect of emotional user reactions. To measure subjective feelings, the self-assessment manikin (SAM) by Lang (1980) was used. SAM provided one graphical item to measure each of the dimensions valence and arousal, and ratings ranged from 0 to 8 (low to high valence or arousal).

As consequences of user experience, overall judgments and choices between alternatives were measured. A three-item scale based on Kollmann's (2004) acceptance model was used to obtain an overall rating (Cronbach's alpha .84). Ratings ranged form 0 to 6 (low to high). Additionally, at the end of the study, participants gave a ranking of all players to choose between the alternatives. An overview of the materials can be found in the Appendix C.2.

5.1.5 Hypotheses

The following hypotheses resulted from the research goals addressed in this study[1]:

H1: The factor PRODUCT has an effect on interaction characteristics (task completion rates and time on task), users' quality perceptions (perceived usefulness and ease of use as well as perceived visual aesthetics, haptic and symbolic quality), their emotional reactions (subjective feelings) and consequences of user experience (overall judgments and choices between alternatives).

H2: Emotional user reactions are predicted by users' quality perceptions (perceived usefulness and ease of use as well as perceived visual aesthetics, haptic and symbolic quality).

H3: Overall judgments are influenced by users' quality perceptions (perceived usefulness and ease of use as well as perceived visual aesthetics, haptic and symbolic quality) and emotional reactions (subjective feelings).

5.1.6 Procedure

The study was conducted at the UseLab at the Center of Human-Machine-Systems at Berlin University of Technology. The experiments lasted 60 minutes on average. All participants tested each of the four products. Presentation order was counterbalanced. A set of four short tasks was given to the participants for each product (see Table 5.3 for one example set).

Table 5.3: Tasks of one set used in Study 1.

Task	Description
1	You would like to listen to the album *Philtre by Nitin Sawhney*. Choose it!
2	Good music! Increase the volume!
3	What time is it? Find the time function of the player!
4	You saw a poster announcing that *Nitin Sawhney* is giving a concert on August 4th. Have a look at your player's calendar to see which day of the week this is!

Participants had one minute for each task. The interaction with the system was noted to analyze user behavior. After accomplishing all four tasks, participants filled in a questionnaire that assessed their subjective feelings, their ratings regarding the different quality dimensions, and the acceptance rating. After using each of the players, participants made a ranking list.

[1] All hypotheses represent the alternative hypothesis, H1; the H0 is always contrary.

5.2 Results

The presentation of the results is based on the components and their connections described in the framework presented in Chapter 3. First, behavioral data as measured interaction characteristics are presented. Then, participants' perception of instrumental and non-instrumental qualities is described followed by the data on emotional user reactions, i.e. subjective feelings. Afterwards, the results on overall judgments are reported. The presentation of the factor-based results that uses analyses of variances for repeated measures to test for differences between the four systems (H1) is followed by an analysis of the interrelations between the various components of the framework (H2 and H3). At this point, regression analyses are presented. Table 5.4 gives an overview of the data for all dependent variables for the four conditions of the factor PRODUCT. Tables displaying all relevant analyses outcomes can be found in the Appendix C.3. Data of emotional user reactions measured with SAM was missing for four participants.

Table 5.4: Mean scores and standard deviations on all dependent variables for the four systems.

Component & Dependent variable	Player A		Player B		Player C		Player D	
	M	SD	M	SD	M	SD	M	SD
Interaction characteristics								
No. of accomplished tasks (0-4)	2.1	0.7	2.3	1.1	2.9	0.6	2.9	0.7
Average time on task [s]	41.7	6.9	40.3	11.4	36.1	8.4	37.6	7.6
Instrumental qualities								
Perceived usefulness (0-6)	2.7	1.0	3.1	1.3	3.9	0.7	3.6	1.1
Perceived ease of use (0-6)	1.7	1.4	2.0	1.5	3.3	1.3	2.9	1.4
Non-instrumental qualities								
Perceived visual aesthetics (0-6)	2.7	1.1	3.7	1.1	3.7	1.1	3.0	1.3
Perceived haptic quality (0-6)	3.4	1.0	4.1	1.0	3.6	1.0	2.7	1.2
Perceived symbolic quality (0-6)	2.8	0.9	3.6	0.8	3.3	0.7	3.0	1.0
Emotional user reactions								
SAM – valence (0-8)	2.3	2.0	3.3	2.6	4.2	1.8	4.0	1.9
SAM – arousal (0-8)	4.5	2.2	4.4	2.1	3.9	1.8	3.9	1.9
Overall judgments								
Acceptance rating (0-6)	2.5	1.4	3.1	1.8	3.6	1.3	2.9	1.6
Average ranking	2.9		2.5		1.9		2.8	

5.2.1 Interaction characteristics

The behavioral data is an indicator of participants' performance with the four players. Two analyses of variance with the factor PRODUCT as independent variable reveal that the systems differ with respect to the average number of completed tasks, $F(3,87)=8.2$, $p<.001$, and the average time on task, $F(3,87)=3.0$, $p<.05$. Within-subject contrasts show that participants solve significantly fewer tasks with Players A and B than with Players C and D. Furthermore, participants need significantly longer using Player A in comparison to Player C and D.

5.2.2 Instrumental and non-instrumental quality perceptions

Regarding instrumental quality perceptions, the results show that participants rated the players differently with respect to usefulness, $F_{3,87}=8.2$, $p<.001$, and ease of use, $F_{3,87}=10.5$, $p<0.001$. Within-subject contrasts reveal that Player A is rated as less useful than Players C and D and Player B gets lower ratings regarding usefulness than Player C. Both Players A and B were rated lower than Player C and D regarding perceived ease of use. The results regarding non-instrumental qualities show differences of the ratings on visual aesthetics, $F_{3,87}$ 8.4, $p<.001$, haptic quality, $F_{3,87}=10.9$, $p<.001$, and symbolic quality, $F_{3,87}=8.4$, $p<.001$. The within-subject contrasts show that Players B and C are rated higher with respect to visual aesthetics than Players A and D. They also reveal that the haptic quality of Player B is rated significantly better in comparison to the three other players and Players A and C got better ratings than Player D. Players B and C are rated significantly higher than Players A and D with respect to symbolic quality.

5.2.3 Emotional user reactions

The data regarding subjective feelings reveal differences in emotional user reactions. An analysis of variance with the valence dimension as dependent variable indicates a significant effect of the factor PRODUCT, $F_{3,/\%}=4.4$, $p<.01$. The within-subject contrasts show that participants rate their subjective feelings after the interaction with Player A as less positive in comparison to Players C and D. No significant effect is found for the dimension arousal.

5.2.4 Consequences of user experience

For consequences of user experience, the data reveal significant differences with respect to the overall ratings, $F_{3,87}=3.9$, $p<.05$, and the ranking, $F(3,87)$ 3.7, $p<.05$. Within-subject contrasts for the overall judgment show that Player C is rated significantly better than Players A and D. The analysis of the ranking data shows the same.

5.2.5 Interrelation of components

A regression analysis to predict participants' subjective feelings using their quality ratings as predictors reveals the results presented in Table 5.5. The analysis shows that 66% of the variance of valence is predicted. The ease of use ratings contribute most while also the usefulness ratings explain a significant amount of the variance. For arousal, 17% of the variance is predicted. Here, only perceived ease of use contributes significantly.

Table 5.5: Regression analysis of subjective feelings using instrumental and non-instrumental ratings as predictors.

Predictors	Subjective feelings	
	Valence	Arousal
Perceived usefulness	.21 *	.03
Perceived ease of use	.58 ***	-.44 **
Perceived visual aesthetics	.13	.01
Perceived haptic quality	.07	.08
Perceived symbolic quality	.08	.10
R^2	66 %	17 %
* p < .05; ** p < .01, *** p < .001		

A regression analysis to predict participants' overall judgments using their quality ratings (instrumental and non-instrumental qualities) and their subjective feelings as predictors reveals the results presented in Table 5.6. 73% of the variance of the overall judgments is predicted. Participants' perceived usefulness has a main influence on the overall ratings and also perceived haptic and symbolic quality contribute significantly.

Table 5.6: Regression analysis of overall judgments using instrumental and non-instrumental quality ratings as well as subjective feelings as predictors.

Predictors	Overall rating
Perceived usefulness	.47 ***
Perceived ease of use	.09
Perceived visual aesthetics	.03
Perceived haptic quality	.23 ***
Perceived symbolic quality	.25 ***
Subjective feelings - valence	.06
Subjective feelings - arousal	.07
R^2	.73
* p < .05; ** p < .01, *** p < .001	

5.3 Discussion

Study 1 is the first step towards addressing how system properties influence users' experience of interaction with interactive products. Four products with differing system properties are used to study these influences on the perception of instrumental and non-instrumental qualities, emotional user reactions, and consequences of user experience.

5.3.1 Influences of system properties on user experience

The results of the study show that the differences of system properties of the four portable audio players have an effect on participants' experience of the interaction (H1). Table 5.7 summarizes the results regarding instrumental and non-instrumental qualities as well as emotional reactions and overall judgments for the four players.

Table 5.7: Summary of the results for the four players regarding perceived instrumental and non-instrumental qualities as well as emotional user reactions and overall judgments (+ positive, o neutral, - negative ratings).

Player	Instrumental qualities	Non-instrumental qualities	Emotional user reactions	Overall judgments
A	-	-	-	-
B	-	+	o	o
C	+	+	+	+
D	+	-	+	o

Overall judgments for Player C are best. Tasks are completed fastest with this player and perceived usability and usefulness ratings are highest. A clear menu design and an easy to learn interaction style may be reasons for these results. Although the product design of Player B led to the highest ratings regarding non-instrumental quality, the ratings for Player C are only slightly worse. This combination of perceived instrumental and non-instrumental quality perception leads to the most positive subjective feelings for Player C.

The user experience framework proposes that instrumental and non-instrumental quality perceptions are independently influenced by properties of an interactive system (Hassenzahl, 2007). The results of Study 1 support this assumption as all possible combinations of instrumental and non-instrumental quality ratings can be found: products that are rated low or high on both user experience components and products that are rated high on one and low on the other component (Table 5.7).

However, the design of the study does not make it possible to explain the extent to which the various system properties influenced the perception of instrumental and non-instrumental quality perceptions. To address this question, an experimental design is necessary that focuses on a variation of system properties that influence specific quality dimensions. Furthermore, participants' ratings of system qualities for the four different systems are relatively similar. Average ratings are quite near to the theoretical middle of the rating scales. To get a better insight into the interrelations between system properties and the components of user experience, greater differences between stimuli could be helpful.

5.3.2 Interrelations of user experience components

The results of the study give first insights into the assumed interrelations of the components of user experience proposed in the framework described in Chapter 3. The consequences of differences in instrumental and non-instrumental quality perceptions for emotional user reactions and overall judgments can already be estimated using the summarized results in Table 5.7. While emotional user reactions depend mostly on the perception of instrumental qualities, overall judgments are also influenced by non-instrumental quality perceptions.

The results of the regression analyses to predict emotional user reactions and overall judgments show the same pattern in more detail. The prediction of participants' subjective feelings by their instrumental and non-instrumental quality ratings reveals that perceived ease of use in particular and also perceived usefulness influence emotional user reactions (H2). However, while two thirds of the variance of valence is predicted, only about one fifth of the variance of arousal is explained. Surprisingly, none of the three dimensions of non-instrumental qualities incorporated in the study have either an influence on the valence or arousal of participants' subjective feelings. This result contradicts the assumption proposed in the user experience framework that non-instrumental qualities have an influence on emotional user reactions and is contradictory to previous studies (Rafaeli & Vilnai-Yavetz, 2004; Tractinsky & Zmiri, 2006). The fact that differences between the four players regarding non-instrumental qualities were rather small may be an explanation (Desmet, 2003b). Furthermore, in this study only subjective feelings are studied as one aspect of emotional user reactions. Different results could be found if further aspects of emotional reactions were integrated.

The prediction of overall judgments shows that instrumental and non-instrumental quality perceptions both have an influence (H3). These results are consistent with previous findings (e.g. Hassenzahl, 2004b). Perceived symbolic quality of the players has the highest impact and also haptic quality perceptions contribute significantly to the overall rating. The perception of visual aesthetics does not have a verifiable influence. This is surprising because visual aesthetics is often seen as the most important aspect of non-instrumental qualities (Norman, 2004; Tractinsky, 2004).

Furthermore, no influence of subjective feelings is found on overall judgments. These results contradict the assumption proposed in the framework that emotional user reactions have an influence on the consequences of user experience. One reason might be that instrumental quality perceptions determine both subjective feelings and overall judgments to such a great extent that subjective feelings are not able to explain any more variance of the overall judgments other than instrumental quality perceptions already do (Rafaeli & Vilnai-Yavetz, 2004). This is supported by further results on correlations, which show that valence of the subjective feelings correlates significantly with the overall judgment measures.

5.3.3 Limitations

Two limitations of Study 1 are apparent. First, when using existing products with various differences of system properties, it is not possible to relate specific properties to quality perceptions and other components of user experience. Furthermore, it is not possible to demonstrate in which way system properties influence instrumental and non-instrumental quality perceptions independently. Therefore, for the next study two sets of system properties are varied to obtain product prototypes that vary with respect to selected instrumental and non-instrumental qualities. In this way, it is also possible to generate higher differences in quality perceptions to get clearer effects. Second, only subjective feelings were incorporated in Study 1. In the model on emotional user reactions, further aspects were introduced. In the next study, physiological reactions and motor expression are studied in addition to subjective feelings.

5.4 Chapter Summary

In Study 1, four portable audio players differing in various design dimensions are used as stimuli to test the influence of differences in system properties on the proposed components of user experience. The results show that instrumental as well as non-instrumental quality perceptions differ with respect to the system used by the participants. Further differences are found regarding participants' subjective feelings as an aspect of emotional user reactions as well as their overall judgments and choices between the alternative systems as consequences of user experience. In addition, assumed interrelations between the components of user experience that are proposed in the user experience framework are confirmed. The results show that participants' subjective feelings are mainly based on their perception of instrumental qualities. However, overall judgments are influenced by both instrumental and non-instrumental quality perceptions. In contradiction to the assumption made in the research framework, emotional user reactions do not play a role for the overall judgments.

6 Study 2: Experimental variation of system properties

The products used in Study 1 differ in various system properties and the perception of a variety of dimensions of instrumental and non-instrumental qualities has been investigated. In Study 2, the focus is on two selected quality dimensions, perceived usability and perceived visual aesthetics, to get a deeper insight into the relations between system properties and user experience. Based on the literature, design factors are identified that lead to differences in the perceptions of these selected qualities. Computer-based simulations of portable audio players are used to realize these variations. System properties related to perceived usability concern the property category of presentation, while the design dimensions associated with perceived visual aesthetics are connected to the category of appearance.

In the user experience research literature, disagreements exist as to whether non-instrumental quality perceptions influence the perception of instrumental quality aspects. Tractinsky et al. (2000) claim that what is beautiful is usable, but other studies give contradictory evidence (Lindgaard & Dudek, 2003; Hassenzahl, 2004b). In the user experience framework presented in Chapter 3, no direct influence is assumed between perceived instrumental and non-instrumental qualities. To test this assumption, the choice of design factors to influence the perception of usability and visual aesthetics in this study is led by the idea to choose system properties that influence only one of the qualities – an approach that previous studies lack.

Study 1 has revealed that differences in system properties influence subjective feelings as one aspect of emotional user reactions and has demonstrated that these influences are mediated by instrumental and non-instrumental quality perceptions. To test if this is also true for other aspects of emotional user reactions, physiological reactions and motor expressions are incorporated in this study in addition to subjective feelings.

As in the previous study, it is assumed that overall judgments and choices between alternatives are influenced by instrumental and non-instrumental quality perceptions as well as emotional user reactions. As all three components of user experience should vary based on differences in system properties, this variation should also impact consequences of user experience.

6.1 Method

6.1.1 Participants

Forty-eight individuals (24 women, 24 men) participated in the study. Almost all of them were students at Berlin University of Technology. They were between 20 and 34 years old (*M* = 25.5, *SD* = 3.6). While two thirds of the participants owned a portable digital audio player and used it regularly, the other third had at least some experience with such devices. Participants were paid ten euros for taking part in the study.

6.1.2 Materials

Portable digital audio players were again used as the domain of study, but in this case simulated on a computer. To produce two versions with different impact on perceived instrumental qualities, three system features were varied that were related to the property category of presentation (Figure 6.1): the number of simultaneously discernible menu lines (five versus two), a scrollbar on the left side as indicator for available but hidden menu items (given or not), and a cue about the actual position in the menu hierarchy at the top of the display (given or not). These design dimensions were derived from the literature on menu design (Paap & Cooke, 1997).

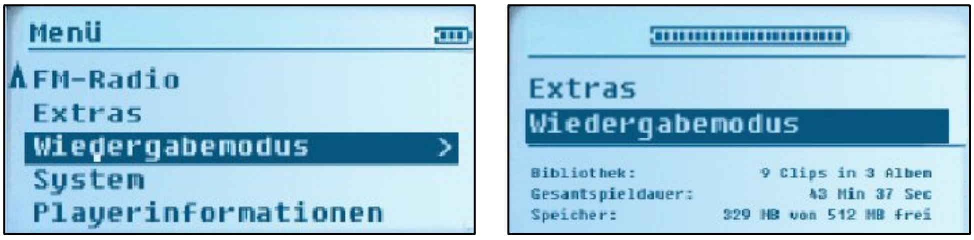


Figure 6.1: Variations of information presentation used in the study (high usability left, low usability right).

In a pretest with ten participants, it was assured that interaction characteristics were generated which affected the usability of the systems differently, i.e. the first version was of higher usability in terms of performance and subjective ratings than the second one. Participants tested each of the two versions on a computer screen. A set of five tasks was given for each version, and participants had two minutes two solve each task. At the end of the pretest, they rated each of the versions regarding their usability. The version with five-line menu and navigation aids was rated higher. A detailed analysis can be found in the Appendix D.1.

With respect to system features that influence the perception of non-instrumental qualities, visual aesthetics was varied by creating two different body designs for the simulations. The following design dimensions were varied: symmetry (high or low), color combination (low or high color differences), and shape (round or square). The design dimensions were also derived from the literature (Han, Kim, Yun, Hong & Kim, 2004; Laugwitz, 2001; Leder & Carbon, 2005) and are related to the property category of appearance.

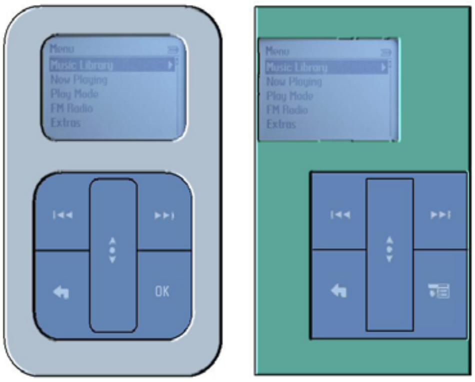


Figure 6.2: Portable audio player bodies used in the study (high aesthetics left, low aesthetics right, both high usability variation).

In a series of pretests, effective variations of symmetry, color combination, and shape were identified. The pretests were conducted as online experiments. Altogether 38 individuals took part. Participants were shown pairs of versions at a time and had to indicate the more aesthetic one. They had to do between 21 and 36 pair comparisons depending on the pretest. Two online experiments were conducted to test variations of color combination and shape separately. In a third pretest, symmetry variations of symmetry were included and it was assured that the combination of variations in symmetry, color combination, and shape led to extreme rankings (looking best vs. looking worst). A detailed analysis of the pretests can be found in the Appendix D.2 and the resulting body designs are shown in Figure 6.2.

In the main experiment, the prototypes were presented on a 7” TFT-display with touch screen functionality that participants could hold in their hands to provide input. The display was connected to a computer, which ran the simulation of the audio player. More detailed screenshots of the used systems can be found in the Appendix D.3.

6.1.3 Independent variables and design

By the variation of system features, two independent variables were created: USABILITY and VISUAL AESTHETICS. Since each had two treatments, four combinations were tested.

Table 6.1: Overview of the design used in Study 2.

		Usability	
		High	Low
Visual aesthetics	High	Group 1 (n= 12) Group 4 (n = 12) N = 24	Group 2 (n= 12) Group 3 (n = 12) N = 24
	Low	Group 3 (n= 12) Group 2 (n = 12) N = 24	Group 4 (n= 12) Group 1 (n = 12) N = 24

The four combinations were: (a) high usability and high aesthetics, (b) high usability and low aesthetics, (c) low usability and high aesthetics, (d) low usability and low aesthetics. All participants used and rated two versions of the system, either (a) and (d) or (b) and (c), according to a Latin-Square plan for repeated measures (Winer, 1971; Table 6.1). Presentation order was counterbalanced.

6.1.4 Dependent variables

Table 6.2 gives an overview of the dependent variables. Two types of behavioral data were recorded to ensure that versions of assumed high or low usability differed as planned: task completion rates and time on task.

Table 6.2: Overview of dependent variables used in Study 2.

User experience components	Construct	Variable
Interaction characteristics	Performance	No. of accomplished tasks
	Performance	Average time on task
Instrumental qualities	Perceived usability	SUMI usability dimensions (Kirakowski, 1996)
Non-instrumental qualities	Perceived visual aesthetics	Classical visual aesthetics (Lavie & Tractinsky, 2004)
Emotional user reaction	Subjective feelings	SAM – valence (Lang, 1980)
		SAM – arousal (Lang, 1980)
	Physiological reaction	Heart rate
		EDA
	Motor expressions	EMG – zygomaticus major
		EMG – corrugator supercilii
Consequences	Overall judgment	SUMI global dimension (Kirakowski, 1996)
	Alternative choice	Ranking

Questionnaires were employed to assess users' perception of instrumental and non-instrumental qualities. Selected sub-dimensions of the Subjective Usability Measurement Inventory (SUMI; Kirakowski, 1996) served to rate perceived usability (Cronbach's alpha .83 for controllability, .82 for effectiveness, .70 for helpfulness, .70 for learnability). Each of the dimensions was measured with four items and ratings ranged from 0 to 2 (low to high). The dimension of a questionnaire developed by Lavie and Tractinsky (2004), called classical visual aesthetics, was used to measure visual aesthetics (Cronbach's alpha .76). This scale consisted of five items and ratings ranged from 0 to 6 (low to high).

To study emotional user reactions, methods were used that provided data on subjective feelings, physiological reactions, and expressive behavior. To survey subjective data, the Self-

Assessment Manikin (SAM) was used that captures the quality and intensity of emotions on two distinct dimensions called valence and arousal (Lang, 1980). SAM provided one graphical item to measure each of the dimensions valence and arousal and ratings ranged from 0 to 8 (low to high valence or arousal). Electrodermal activity (EDA) and heart rate were used to measure physiological reactions (Ward & Marsden, 2003). To assess facial expressions, electromyographic responses (EMG) were recorded from the zygomaticus major and corrugator supercilii muscle sites, which control smiling and frowning, respectively (Partala & Surakka, 2004).

Two techniques served to measure consequences of user experience: the global dimension of the SUMI (Kirakowski, 1996; Cronbach's alpha .84) to assess overall judgments (five items, ratings from 0 to 2) and the choice between the two tested versions. An overview of all materials can be found in the Appendix D.4.

6.1.5 Hypotheses

The following hypotheses resulted from the research goals addressed in this study:

H1a: The factor USABILITY has an effect on interaction characteristics associated with user performance (task completion rates and time on task) and the perception of instrumental qualities (perceived usability).

H1b: The factor VISUAL AESTHETICS has an effect on the perception of non-instrumental qualities (perceived visual aesthetics).

H1c: No interaction effect is found for the factors USABILITY and VISUAL AESTHETICS regarding neither of the dependent variables perceived usability or perceived visual aesthetics, because these qualities are perceived independently.

H2a: The factors USABILITY and VISUAL AESTHETICS have an effect on emotional user reactions with respect to subjective feelings, physiological reactions, and motor expressions. The valence of subjective feelings should be higher and arousal smaller in the high usability and high visual aesthetics conditions. EDA and heart rate as well as activity of the currogator supercilii should be smaller and activity of the zygomaticus major higher in the high usability and high visual aesthetics conditions.

H2b: Emotional user reactions can be predicted by users' quality perceptions (perceived usability and perceived visual aesthetics).

H3a: The factors USABILITY and VISUAL AESTHETICS have an effect on consequences of user experience (overall judgment and alternative choice). Overall judgments should higher for the high usability and high visual aesthetics conditions. Furthermore, the high usability and high visual aesthetics conditions should be chosen more frequently.

H3b: Overall judgments are influenced by users' quality perceptions (perceived usability and perceived visual aesthetics) and emotional reactions (subjective feelings).

6.1.6 Procedure

The study was conducted at the UseLab at the Center of Human-Machine-Systems at Berlin University of Technology. The experiments lasted 60 minutes on average. At the beginning, electrodes for measuring physiological reactions and facial expressions were attached and baseline values were recorded for two minutes. Participants were assigned to one of the four experimental groups (Table 6.1) and started with the first player version completing a first set of five typical tasks (Table 6.3). They then switched to the other version to solve five tasks from a second set. Maximum time for each task was two minutes. Before accomplishing the tasks, subjects rated the visual aesthetics of each version. Heart rate, EDA, and EMG were measured during task completion. The interaction with the system was recorded to analyze user behavior. After each task, participants assessed their affective state with the SAM scales. After completing all tasks, the usability of the system was rated and the overall judgment was given. At the end of the experiment, the two versions were ranked.

Table 6.3: Tasks of one set used in Study 2.

Task	Description
1	The audio player has a radio. Please find out which channel is set.
2	Please have a look at which songs you find in the category German Punk.
3	The audio player is able to manage your contacts. Please check if any contacts are saved so far.
4	Please set the playback mode to RANDOM ONCE.
5	You are going to travel to Italy. To get you in the mood, please change the menu language to Italian.

6.1.7 Data preparation

Heart rate and EDA were measured as differences from the individual baseline level in order to reduce inter-individual differences and allow comparisons between subjects. For heart rate, the time series data was converted to single point through averaging the time series for every task. Regarding EDA, the maximum value for each task was interpreted and averaged over all tasks. The EMG data were integrated and t-transformed. Average values were computed for each perceived usability dimension and totaled (overall values ranged from 0 to 8, low to high). SAM scores for valence and arousal were averaged over all five tasks.

6.2 Results

Table 6.4 gives an overview of the data for all dependent variables. In the next sections, results on differences regarding interaction characteristics, quality perceptions, emotional user reactions, and consequences of user experience are reported. The presentation of the factor-based results that uses mixed linear models to test the hypothesized effects (H1a, H1b, H1c, H2a, H3a) is followed by an analysis of the interrelations between the components of the framework (H2b, H3b). Here regression analyses are reported. Tables presenting all relevant analyses outcomes in detail can be found in the Appendix D.5.

Table 6.4: Mean scores and standard deviations for both levels of usability and aesthetics on all dependent variables.

Component & Dependent variable	Low Usability				High Usability			
	Low aesthetics		High aesthetics		Low aesthetics		High aesthetics	
	M	SD	M	SD	M	SD	M	SD
Interaction characteristics								
No. of accomplished tasks (0-5)	3.8	1.3	3.8	1.2	4.9	0.5	4.9	0.3
Average time on task [s]	47.0	24.3	46.6	20.1	25.0	13.2	22.7	11.4
Quality perceptions								
Perceived usability (0-8)	3.1	2.0	4.0	2.3	6.6	1.0	6.6	1.5
Perceived visual aesthetics (0-6)	2.2	1.2	4.1	1.2	2.7	1.5	3.9	1.0
Subjective feelings								
SAM – valence (1-9)	3.3	1.8	3.7	1.9	5.2	1.2	6.1	1.5
SAM – arousal (1-9)	4.8	1.4	4.2	1.7	3.4	1.4	2.8	1.5
Physiological reactions								
EDA [µS]	14.9	15.4	9.1	16.2	0.6	8.1	0.9	8.2
Heart rate [bpm]	0.7	7.4	-6.8	13.8	-1.4	11.3	2.9	16.1
Motor expressions								
EMG – corrugator supercilii	7.4	15.1	7.4	15.9	2.4	15.8	2.2	15.2
EMG – zygomaticus major	1.0	11.8	0.7	11.1	4.5	15.1	2.9	13.9
Overall judgments								
Global rating (0-2)	0.5	0.5	0.8	0.7	1.4	0.4	1.6	0.5
Preference	0 %		29 %		71 %		100 %	

6.2.1 Interaction characteristics

The behavioral data ensure that the variation of usability leads to differences in interaction characteristics as planned and as indicated by the results of the pretest. The two usability versions differ with respect to central interaction characteristics. Compared to the version of lower usability, the highly usable system leads to a greater percentage of correct solutions, $F_{1,92}$=52.9, p<.001, and to faster completion, $F_{1,83}$=44.5, p<.001. No significant effect for the factor VISUAL AESTHETICS or the interaction is found.

6.2.2 Instrumental and non-instrumental quality perceptions

The analysis of the subjective usability and aesthetics data shows that the variations caused the predicted differences in users' quality perceptions (Figure 6.3). Significant differences are found for the factor USABILITY in the ratings of perceived instrumental qualities based on the SUMI questionnaire, $F_{1,92}$=70.4, p<.001. The data reveals no effect of the factor VISUAL AESTHETICS. With respect to the perception of non-instrumental qualities, there are significant differences between the two treatments of the factor VISUAL AESTHETICS, $F_{1,85}$=55.2, p<.001, but no effect is found for the factor USABILITY. The analysis reveals no interaction effects.

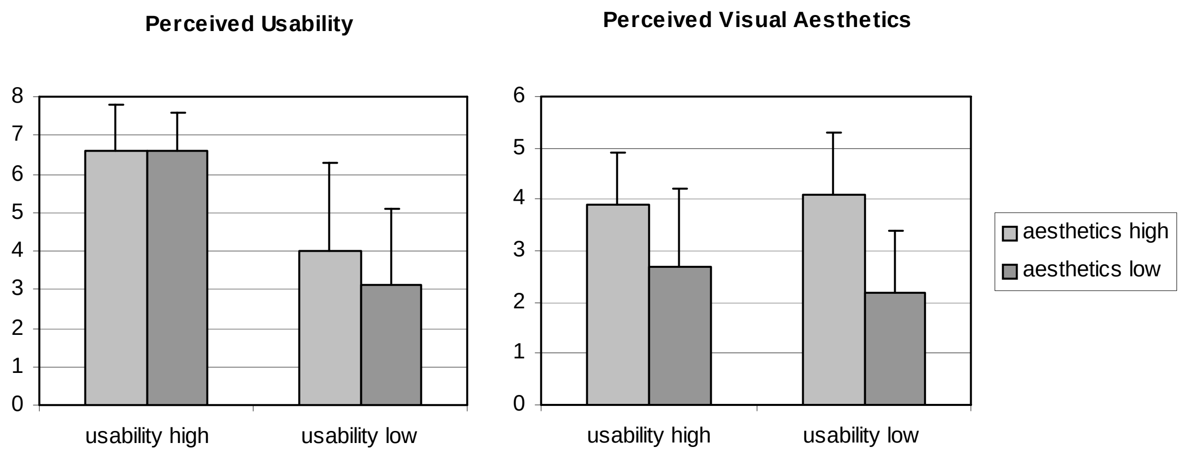


Figure 6.3: Perceived usability and visual aesthetics ratings for the four conditions.

6.2.3 Emotional user reactions

The analysis of the subjective emotional data shows significant main effects for the factors USABILITY and VISUAL AESTHETICS on the dimensions valence and arousal (Figure 6.4). The following main effects are found: usability on valence, $F_{1,90}$=38.7, p<.001, usability on arousal, $F_{1,78}$=19.2, p<.001, aesthetics on valence, $F_{1,90}$=4.7, p<.05, and aesthetics on arousal, $F_{1,78}$=5.6, p<.05. The treatment 'low' leads to less positive valence and to a higher arousal compared to the treatment 'high' for both factors. No interaction effects are found.

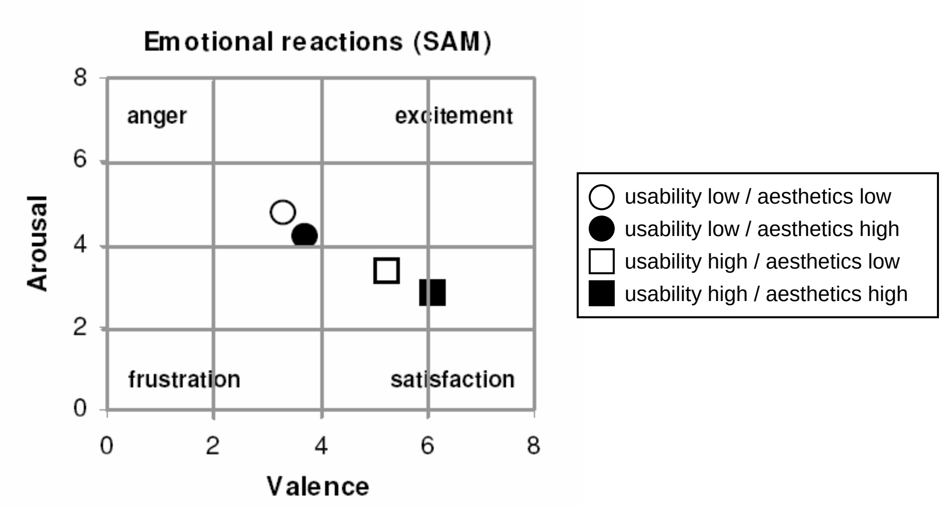


Figure 6.4: SAM ratings for the four systems
(squared high vs. round low usability; filled high vs. unfilled low aesthetics).

The physiological and expressive data partially underlines these results. With respect to users' expressive behavior as measured by EMG, a statistical trend for the factor USABILITY concerning the activity of the corrugator supercilii is found, $F_{1,89}$=2.8, p<.10. Activity tends to be higher in the low-usability conditions. No effect is found for VISUAL AESTHETICS. The analysis reveals neither an effect for the factor USABILITY nor VISUAL AESTHETICS regarding the activity of the zygomaticus major (Figure 6.5).

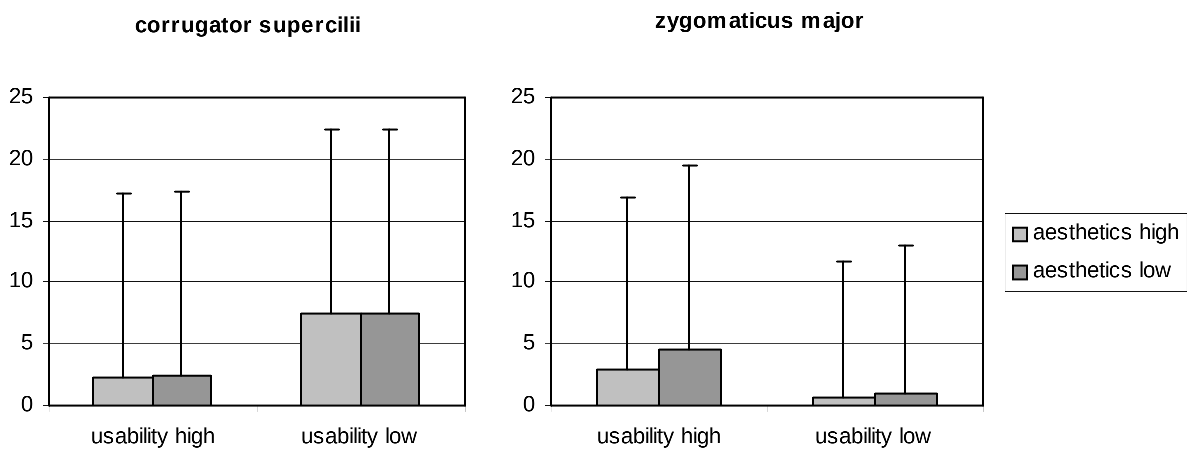


Figure 6.5: EMG corrugator supercilii and zygomaticus major for the four conditions.

Regarding physiological reactions, a significant effect of the factor USABILITY on electrodermal activity is found, $F_{1,89}$=17.6, p<.001, but no effect on heart rate. EDA is higher in case of low usability. No influence of the factor VISUAL AESTHETICS is detected for neither of the two measures of physiological reactions (Figure 6.6).

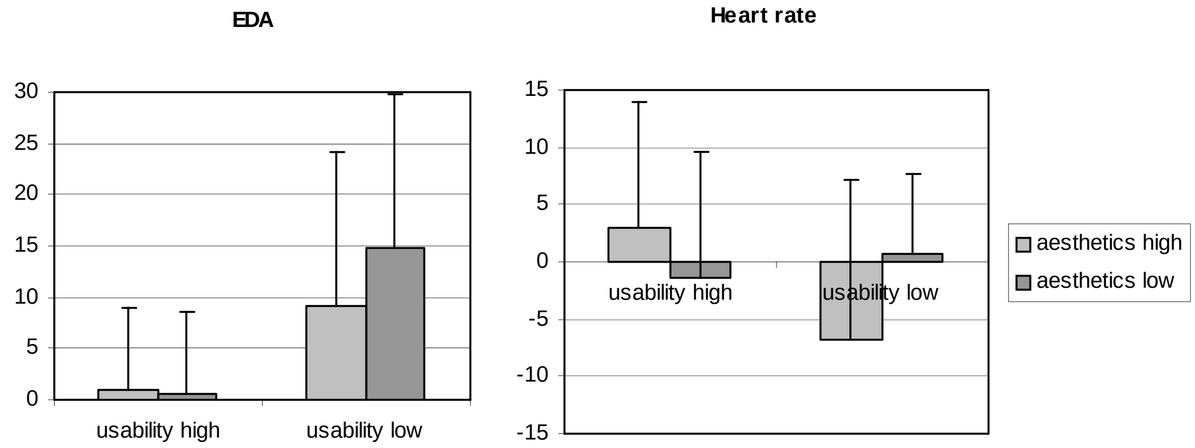


Figure 6.6: EDA and heart rate for the four conditions.

6.2.4 Consequences of user experience

The global dimension of the SUMI as the measure for overall judgments shows a significant main effect of the factor USABILITY, $F_{1,89}$=69.5, p<.001, and a trend for the factor VISUAL AESTHETICS, $F_{1,89}$=3.2, p<.10 (Figure 6.7). All participants of Groups 1 and 4 prefer the highly usable and attractive version to the version of low usability and low attractiveness. With respect to Groups 2 and 3, 71 % of the participants prefer the system of high usability and low aesthetics to the system of low usability and high aesthetics. The second combination is favored by 29% of the participants.

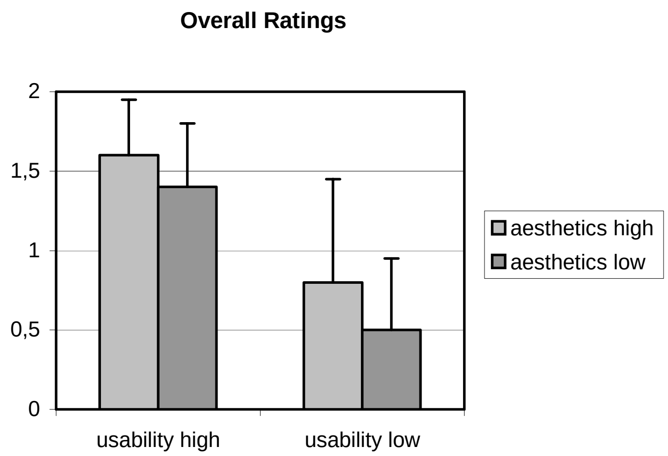


Figure 6.7: Overall ratings for the four conditions.

6.2.5 Interrelations of components

A regression analysis to predict participants' subjective feelings using their quality ratings as predictors produces the results presented in Table 6.5. The analysis shows that 46% of the variance of valence is predicted with the perceived usability ratings. 19% of the variance of arousal is predicted also by perceived usability. Quality perceptions of visual aesthetics do not explain a significant part of the variance of subjective feelings' valence or arousal.

Table 6.5: Regression analysis of subjective feelings using usability and visual aesthetics ratings as predictors.

Predictors	Subjective feelings	
	Valence	Arousal
Perceived usability	.68 ***	-.44***
Perceived aesthetics	.01	-.05
R^2	46 %	19 %
* p < .05; ** p < .01, *** p < .001		

A regression analysis to predict participants' overall judgments using their quality ratings (usability and visual aesthetics) and their subjective feelings as predictors produces the results presented in Table 6.6. 62% of the variance of the overall judgments is predicted using the four variables. Only perceived usability and the valence of users' subjective feelings have a significant influence.

Table 6.6: Regression analysis of overall judgments using usability and visual aesthetics ratings as well as subjective feelings as predictors.

Predictors	Overall rating
Perceived usability	.58***
Perceived aesthetics	.10
Subjective feelings - valence	.30***
Subjective feelings - arousal	.09
R^2	62 %
* p < .05; ** p < .01, *** p < .001	

6.3 Discussion

The rationale underlying Study 2 is to vary selected system features in order to produce interaction characteristics leading to different perceptions of instrumental and non-instrumental qualities, which in turn cause different emotional user reactions and corresponding different consequences of user experience.

6.3.1 Instrumental and non-instrumental quality perceptions

The variation of system properties associated with usability and visual aesthetics has the predicted impact on the perception of both types of qualities (H1a and H1b). Systems with features leading to a high degree of usability and visual aesthetics receive better ratings than their impaired counterparts (Hassenzahl, 2001). For the variation of usability these differences are also reflected in participants' performance with the stimuli.

However, the results raise the question if the variation of usability and aesthetics are similar in size. Participants' average ratings for perceived usability show that the high usable versions receive ratings in the top quarter of the rating scale, while the low usable versions receive ratings slightly below the theoretical middle of the scale. On the contrary, perceived visual aesthetics ratings are only slightly above the theoretical middle of the scale for the high aesthetics versions and slightly below the theoretical middle of the scale for the low aesthetics versions. Next to the general question regarding the comparability of the two constructs, the comparison of perceived usability and visual aesthetics ratings is additionally complicated because of the different ranges of scales used to measure the two quality perceptions. Even so, this aspect has to be kept in mind when discussing further results regarding the influence of the variation of usability and visual aesthetics on emotional user reactions and overall judgments.

The analysis reveals no influence of the manipulation of usability on the perception of visual aesthetics or vice versa. It can be argued that specific system properties influence the perception of instrumental and non-instrumental qualities independently (H1c). These results contradict previous findings (Tractinsky et al., 2000; Ben-Bassat, Meyer & Tractinsky, 2006). There are at least two possible explanations for the reported results. First, a main criterion for choosing design dimensions for the variation of system properties in this study was that they influence either instrumental or non-instrumental quality perceptions. This approach is to some extent artificial, but necessary to examine whether system properties influence the perception of instrumental and non-instrumental qualities independently. It may be that in other studies the variation of aesthetics also changed system properties that contribute to the usability of the system, leading also to differences in perceived usability (see for the discussion of attribute overlap in Hassenzahl, 2007). The results of Study 2 verify that the variations used here only included design dimensions that influence one of the qualities. One reason for this success may be that the choice of system properties for variations is derived from the literature of menu design and visual aesthetics of interactive systems. A second explanation is that the methods to measure quality perceptions used in this study differed from those used in other studies (Tractinsky et al., 2000; Ben-Bassat et al., 2006). In previous studies, general ratings about the perception of a system's usability and visual aesthetics are mostly assessed by asking one question for each concept. In this study, rating scales are used that consist of five items for visual aesthetics and sixteen items for perceived usability allowing a more detailed data collection. These methods may be less susceptible to be influenced by other qualities of an interactive system compared to more general assessment approaches.

6.3.2 Influences on emotional user reactions

The variation of system properties also leads to differences in participants' emotional reactions (H2a). The results of the SAM questionnaire show that both factors USABILITY and VISUAL AESTHETICS have an effect on subjective feelings. The system of high usability and appealing design is experienced as most satisfying, while the system of low usability and least attractiveness is most annoying.

Since no statistical interaction between usability and aesthetics is found, the two factors contribute to users' subjective feelings additively as assumed by Rafaeli and Vilnai-Yavetz (2004). Figure 6.4 demonstrates that participants' average subjective feelings are located on a line in the two dimensional space of emotional qualities that runs from frustration in the upper left corner to satisfaction in the lower right corner. The results correspond with the findings of the study on emotional user reactions presented in Chapter 4. Although in Study 2 both instrumental and non-instrumental qualities are manipulated to be positive in one of the conditions, participants' feelings are not in the quadrant of excitement or joy. As particularly these emotional qualities are of interest for research on emotional reactions in human-technology interaction, the question of how to generate more enthusiastic user reactions remains unresolved. To achieve this, it may be necessary to induce quality perceptions that reach beyond users' previous experiences. In this study, both the high usable and high aesthetics variations may have been not particularly outstanding.

The results on participants' subjective feelings reveal that the effect of system properties related to usability is greater than the one related to visual aesthetics for both, valence and arousal. Instrumental qualities have a higher effect on the emotional experience of the interaction than non-instrumental quality perceptions. However, as already discussed, it is hard to say if the variations of usability and visual aesthetics in this study were commensurate. However, these results support findings of a regression analysis to predict users' subjective feelings in the previous study, in which instrumental qualities also had a main effect on both valence and arousal. Accordingly in Study 2, the regression analyses predicting subjective feelings' valence and arousal dimensions also reveal a higher influence of the variable perceived usability (H2b).

It is surprising that perceived visual aesthetics has no significant influence on subjective feelings based on the results of the regression analysis. This result contradicts the finding that subjective feelings differ significantly in the condition with low and high visual aesthetics. An explanation might be that variation of the two usability conditions are more obvious compared to the differences between low and high visual aesthetics.

This interpretation is supported by the data on physiological reactions and facial expressions. Differences are found for dermal activity and the activity of the corrugator supercilii. However, only the factor USABILITY has a significant effect on both measures. In the conditions of low usability dermal activity is higher, which corresponds with a higher level of arousal. The activity of the corrugator supercilii that is responsible for frowning is higher in the low usability condition. This result underlines the lower level of valence in the conditions of low usability. No effect of the factor VISUAL AESTHETICS is found for any of the measures of physiological reactions or motor expressions. This indicates that the effect of this variation on emotional user reactions is smaller.

As in the study on emotional user reactions in Chapter 4, heart rate and the activity of the zygomaticus major do not help to answer the questions regarding emotional user reactions addressed in this study. The argumentation that these two measures are less suitable to assess emotional user reactions in interactive contexts is supported by the data gained in Study 2.

6.3.3 Influences on consequences of user experience

Finally, overall judgments and choices between alternatives point in the same direction as the ratings of perceived qualities and emotions and reveal a greater impact of the factor USABILITY on the overall appraisal of the systems (H3a). Figure 6.7 demonstrates this interpretation graphically. Also the results on the ranking of Groups 2 and 3 support these findings. These two groups used the two systems that are high for one of the factors and low for the other one (low usability/high aesthetics and high usability/low aesthetics). Here, 71% value usability more, while the remaining 29% choose the system with high aesthetics and low usability. If both aspects were equally important, about half of the participants should choose the one system and the other half the other one. As considerably more participants choose the system with high usability, this quality seems to be more important.

A regression analysis of the overall ratings shows a significant influence of perceived usability and the valence of users' subjective feelings (H3b). In contrast to the results of Study 1, no influence of perceived non-instrumental qualities is found in Study 2. Again, a smaller difference regarding visual aesthetics may be the explanation.

6.3.4 Limitations

The discussion demonstrates that it is important to try to vary system properties that are associated with instrumental and non-instrumental qualities independently and to a similar degree if conclusions are to be drawn about their relative impact. The following study provides an attempt by using the same variation of usability and improving the high aesthetics version to increase the difference between the two variations of aesthetics.

Another argument for the relatively higher importance of instrumental qualities in Study 2 that has not been considered so far might be the influence of other antecedents of user experience in addition to system properties. In the framework presented in Chapter 3, user characteristics and context parameters are proposed as other influencing factors. Previous findings demonstrate for example that the difference of the importance of instrumental and non-instrumental quality perceptions for overall judgments depends on the situation in which a user interacts with a technical product (Hassenzahl & Ullrich, 2007). Therefore, a variation of user characteristics and context parameters is incorporated in Study 3.

Furthermore, cognitive appraisals that are proposed as one aspect of emotional user reactions have not been applied in a study that varied system properties to induce different perceptions of both instrumental and non-instrumental qualities. Therefore, these are added as another measure in the following study.

6.4 Chapter Summary

Study 2 reveals that system properties independently influence instrumental and non-instrumental quality perceptions. Furthermore, variations of system properties influence not only subjective feelings but also other aspects of emotional user reactions, i.e. physiological reactions and motor expressions. The variation of system properties that are associated with the usability of the system has a higher impact than differences on design dimensions corresponding with the visual aesthetics of the products. These findings are underlined by the results connecting participants' quality perceptions with their subjective feelings; here also perceived usability has the main influence. Further results show that the variation of system properties also has an effect on overall judgments. These findings support the assumptions drawn in the user experience framework that differences in system properties influence quality perceptions and emotional user reactions, which in turn impact overall judgments and other consequences of user experience. An analysis of the influence of quality perceptions and emotional reactions on overall judgments reveals a main influence of instrumental quality perceptions and a moderate impact of the valence of participants' subjective feelings.

7 Study 3: Experimental variation of system properties, user characteristics, and context parameters

The third empirical study takes a similar approach as the previous study, but tries to find out more about the interrelations proposed in the user experience framework by additionally varying user characteristics and context parameters as other influencing factors next to system properties. As in Study 2, portable audio players are used as the domain of study and computer-based simulations differing on specific design dimensions are applied. Again, system properties that are associated with the usability of the players are varied and differences with respect to the visual aesthetics of the systems are generated. As results on quality perceptions in the previous study suggest that the differences in usability were higher than those of visual aesthetics, the difference in visual aesthetics is increased for this study.

Furthermore, user characteristics are varied in Study 3. Cultural differences have widely been studied in the area of human-technology interaction. The focus has mainly been on the improvement of system usability with respect to users with different cultural backgrounds and the relevance of cultural differences has been demonstrated. However, almost no studies exist that focus on cultural differences regarding users' experience of interaction. Therefore, cultural background is chosen as independent variable for this Study. Differences between European and North American cultures are focused, as previous studies on user experience of interaction are especially based on data from these cultural settings. Additionally, participants' centrality of visual product aesthetics is assessed as another user characteristic. Defined by Bloch, Brunel and Arnold (2003) as the level of significance of visual aesthetics of products, it is used as another variable to study the influence of user characteristics on user experience.

Context parameters are the third category of influencing variables described in the user experience framework. In this study, task demands are varied. Hassenzahl and Ullrich (2007) found that the influence of instrumental and non-instrumental quality perceptions on overall judgments differs depending on whether users are in a goal-mode or action-mode. In the goal-mode, participants are required to accomplish given tasks, while they have the same amount of time to explore the system on their own in the action-mode. This variation is applied here to investigate the effect of context parameters on emotional responses.

7.1 Method

7.1.1 Participants

One hundred sixty individuals (88 women, 72 men) participated in the study. All of them were students or employees either at Carleton University, Ottawa, Canada or at Berlin University of Technology, Germany. They were between 17 and 54 years old (M = 24.1, SD = 3.6). Most of the participants (n = 137) owned a portable audio player and used it regularly. Almost all (n = 154) used computers daily. Participants were paid or received credits for taking part in the study.

7.1.2 Materials

Again, portable audio players were chosen as the domain of study and different versions were simulated on a computer. Like in the previous study, the aim of the variation of system attributes was to influence perceived usability and aesthetics of the systems independently. To produce two versions with different levels of usability, three presentation features were varied: the number of menu lines shown (five versus two), a scrollbar indicating available but hidden menu items (given or not), a cue about the present position in the menu hierarchy (given or not). These variations had been already used in Study 2 (Figure 7.1).

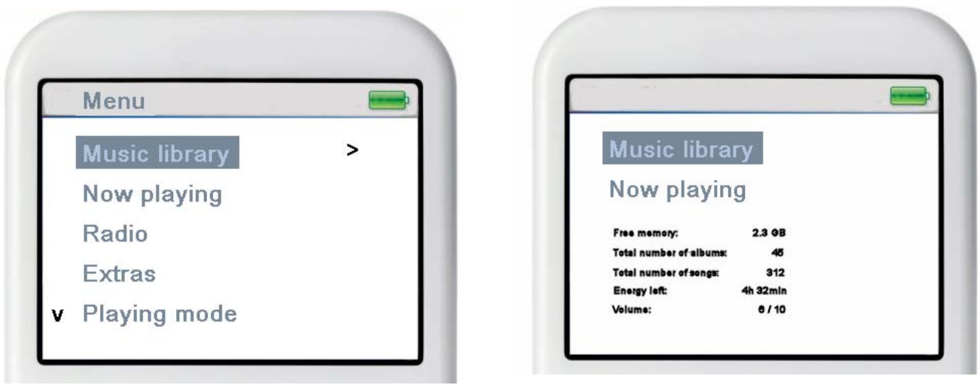


Figure 7.1: Variations of information presentation used in the study (high usability left, low usability right, both English version and high aesthetics variation).

With respect to system features designed to influence the perception of visual aesthetics, two different body designs were used in Study 2 varying in symmetry, color combination, and shape. Because these manipulations resulted in small differences in perceived visual aesthetics between the two versions, an attempt was made to improve the high-aesthetic version. Therefore, a body design was used as high-aesthetic version that was prepared by a professional designer (Figure 7.2). More detailed screenshots of the systems can be found in the Appendix E.1.

Figure 7.2: Portable audio player bodies used in the study (high aesthetics left, low aesthetics right, both English version and high usability variation).

The prototypes were presented on a 7” TFT-display with touch screen functionality that participants could hold in their hands for providing input. The display was connected to a computer that ran the simulation of the audio player.

7.1.3 Independent variables and design

Four independent variables were manipulated: USABILITY, VISUAL AESTHETICS, CULTURE and MODE. Since each of the variations of USABILITY and VISUAL AESTHETICS had two levels (high and low), four prototypes were created: (a) high usability and high aesthetics, (b) high usability and low aesthetics, (c) low usability and high aesthetics, (d) low usability and low aesthetics. The factor CULTURE had two conditions: one half of the participants were Canadians, the other half Germans. The factor MODE also had two conditions: in the goal-mode participants were required to accomplish a set of tasks and in the action-mode they were freely browsing the system for the same amount of time. All four variables were between-subjects factors (Table 7.1).

Table 7.1: Overview of the design used in Study 3.

	System properties	Usability High		Usability Low	
		Aesthetics High	Aesthetics Low	Aesthetics High	Aesthetics Low
Cultural background	Usage mode				
German	Goal-mode	N = 10	N = 10	N = 10	N = 10
	Action-mode	N = 10	N = 10	N = 10	N = 10
Canadian	Goal-mode	N = 10	N = 10	N = 10	N = 10
	Action-mode	N = 10	N = 10	N = 10	N = 10

7.1.4 Dependent variables

Table 7.2 gives an overview of the used dependent variables. Two types of behavioral data were recorded in the task condition to ensure that versions of assumed high or low usability differed as planned: task completion rates and time on task.

Table 7.2: Overview of dependent variables used in Study 3.

User experience component	Construct	Variable
Interaction characteristics	Performance	No. of accomplished tasks
	Performance	Average time on task
Instrumental qualities	Perceived usability	SUMI usability dimensions (Kirakowski, 1996)
Non-instrumental qualities	Perceived visual aesthetics	Classical visual aesthetics (Lavie and Tractinsky, 2004)
Emotional user reactions	Subjective feelings	SAM – valence (Lang, 1980)
		SAM – arousal (Lang, 1980)
	Cognitive appraisals	Intrinsic pleasantness (Scherer, 2001)
		Novelty (Scherer, 2001)
		Goal/need conduciveness (Scherer, 2001)
		Coping potential (Scherer, 2001)
		Norm/self compatibility (Scherer, 2001)
Consequences	Overall judgment	SUMI global dimension (Kirakowski, 1996)

Questionnaires were employed to assess the user’s perception of instrumental and non-instrumental qualities. Selected sub-dimensions (controllability, effectiveness, helpfulness, learnability) of the Subjective Usability Measurement Inventory (SUMI; Kirakowski, 1996) served to rate usability (Cronbach’s alpha .88 for controllability, .76 for effectiveness, .59 for helpfulness, .60 for learnability). The dimension classical visual aesthetics of a questionnaire developed by Lavie and Tractinsky (2004) was used to measure visual aesthetics (Cronbach’s alpha .80).

Subjective emotional data were obtained via the Self-Assessment Manikin (SAM; Lang, 1980) that captures the quality (valence) and intensity (arousal) of emotions. Cognitive appraisals were obtained via a questionnaire based on the Geneva Appraisal Questionnaire (Scherer, 2001). It measures the five appraisal dimensions already discussed in Chapters 3 and 4: intrinsic pleasantness, novelty, goal/need conduciveness, coping potential, and norm/self compatibility. Novelty is a measure of familiarity and predictability of the occurrence of a stimulus, while the intrinsic pleasantness dimension describes whether a stimulus event is likely to result in a positive or negative emotion. Goal conduciveness relates to the importance of a stimulus for the current goals or needs. The dimension of coping potential is connected to the extent to which an event can be controlled or influenced. Norm/self compatibility describes the extent to which a stimulus satisfies external and internal standards.

The global dimension of the SUMI (Kirakowski, 1996; Cronbach's alpha .75) was used to measure overall judgments. An overview of all materials can be found in the Appendix E.2.

7.1.5 Other variables

To assess baseline values for participants' subjective feelings, the multidimensional mood questionnaire by Steyer, Schwenkmezger, Notz and Eid (1997) was used at the beginning. The dimensions of valence and arousal were of special interest and were used to normalize the subjective feelings data that was measured during the interaction with the SAM scales.

Two usage situations were induced based on the instructions. A one-item scale (usage situation) based on Hassenzahl and Ullrich (2007) was used to ensure if the participants experienced the usage situation as intended depending on the condition. Participants were asked if they focused on the product (action-mode) or on obtaining their goals (goal-mode) while using the product.

A questionnaire by Bloch, Brunel and Arnold (2003) was used to measure individual differences in participants' centrality of visual product aesthetics (CVPA). The concept is defined as the relevance that visual aesthetics of products has for a user. Three related dimensions of CVPA were measured with the questionnaire (value, acumen, and response intensity) and were summarized to receive a CVPA score for each participant.

7.1.6 Hypotheses

The following hypotheses resulted from the research goals addressed in this study:

H1a: The factor USABILITY has an effect on interaction characteristics associated with user performance (task completion rates and time on task) and the perception of instrumental qualities (perceived usability). The factor VISUAL AESTHETICS has an effect on the perception of non-instrumental qualities (perceived visual aesthetics). No interaction effect is found for the factors USABILITY and VISUAL AESTHETICS regarding neither of the dependent variables perceived usability or perceived visual aesthetics.

H1b: The factors USABILITY and VISUAL AESTHETICS have an effect on emotional user reactions with respect to subjective feelings and cognitive appraisals. The valence of subjective feelings should be higher and arousal smaller in the high usability and high visual aesthetics conditions. The hypothesis regarding the five dimensions of the dependent variable cognitive appraisal is undirected.

H1c: The factors USABILITY and VISUAL AESTHETICS have an effect on overall judgments. Overall judgments should higher for the high usability and high visual aesthetics conditions.

H2a: The factor CULTURE has an effect on quality perceptions (perceived usability and perceived visual aesthetics), emotional reactions (subjective feelings and cognitive appraisals) and overall judgments. The hypothesis is undirected.

H2b: For participants with high centrality of visual product aesthetics the importance of perceived visual aesthetics for emotional reactions and overall judgments is higher.

H3a: The factor MODE does not have an influence on quality perceptions (perceived usability and perceived visual aesthetics), but on emotional reactions (subjective feelings and cognitive appraisals) and overall judgments.

H3b: For participants in action-mode, the influence of non-instrumental quality perceptions on subjective feelings and overall judgments are higher than in goal-mode. For instrumental quality perceptions the opposite is found.

7.1.7 Procedure

The study was conducted at the Human-Oriented Technology Lab at Carleton University, Ottawa, Canada, and in the UseLab at the Center of Human-Machine-Systems at Berlin University of Technology. The experiment took 30 minutes on average. Participants were given instructions describing the experimental procedure and the use of SAM. They were then asked to rate their subjective feelings on the multidimensional mood questionnaire. Depending on the experimental condition to which they were assigned at random, the relevant player was presented and participants rated its visual aesthetics. Next, they read a short text describing how to use the system.

Table 7.3: Tasks of one set used in Study 3.

Task	Description
1	Please set the playback mode to RANDOM ENDLESS.
2	The audio player is able to manage your contacts. Please find out if any contacts are saved so far.
3	Please have a look which songs you find on the player in the Genre Pop.
4	Please change the sound setting of the player to CLASSIC.
5	The audio player can be also used to store data. You have to reserve storage for the data. Please set the data storage to 1GB.

One half of the participants were then asked to complete the set of five given tasks (Table 7.3). The other half explored the system for a certain amount of time. In the task condition, a limit of two minutes was set for each task. The participants actually completed the five tasks in five minutes on average. Therefore, a five-minute time limit was also set for the exploring participants. In the task condition, participants filled in SAM scales after the first, third, and fifth task. In the browsing condition, they were asked to rate their current subjective feeling after one, three, and five minutes of exploration. SAM scores for valence and arousal were averaged over all three assessments. After finishing the tasks or the exploration, the cognitive appraisal questionnaire was completed and usability as well as overall ratings were obtained.

7.2 Results

The presentation of the results starts with the factor-based analyses of variance regarding interaction characteristics, quality perceptions, emotional user reactions, and consequences of user experience. These are followed by the results on interrelations between the various components of the user experience framework. Here regression analyses are presented. Perceived usability data is missing for six, perceived visual aesthetics data for one, cognitive appraisal data for one, and overall ratings for two participants, because they missed to fill in the respective parts of the questionnaire. An overview of the data for all dependent variables and tables presenting all relevant analyses outcomes can be found in the Appendix E.3 and E.4.

A 2x2x2x2 analyses of variance with USABILITY, VISUAL AESTHETICS, CULTURE, and MODE as between-subjects factors and the control variable usage situation as dependent variable shows a significant main effect of the factor MODE, $F(15,144)=6.2$, $p < .05$. Participants in exploration condition focus more on the product while subjects in the task condition concentrate on obtaining their goals. No other effects are found for the variable usage situation.

7.2.1 Interaction characteristics

A 2x2x2 analysis of variance of the data from the task conditions with USABILITY, VISUAL AESTHETICS, and CULTURE as between-subjects factors and the behavioral measures (task completion rates and time on task) as dependent variables shows a significant main effect for USABILITY only, $F_{7,72}=15.4$, $p < .001$ and $F_{7,72}=25.4$, $p < .001$, respectively. This manipulation check ensures that the variation of the factor USABILITY leads to differences in users' performance with the systems as intended.

7.2.2 Instrumental and non-instrumental qualities

Figure 7.3 shows the perceived usability and visual aesthetics ratings separated for the four system properties conditions. A 2x2x2x2 analysis of variance with USABILITY, VISUAL AESTHETICS, CULTURE, and MODE as between-subjects factors and the usability ratings as dependent variable demonstrates a significant main effect for USABILITY only, $F_{15,138}=28.1$, $p < .001$. The versions designed for high usability are experienced as more usable.

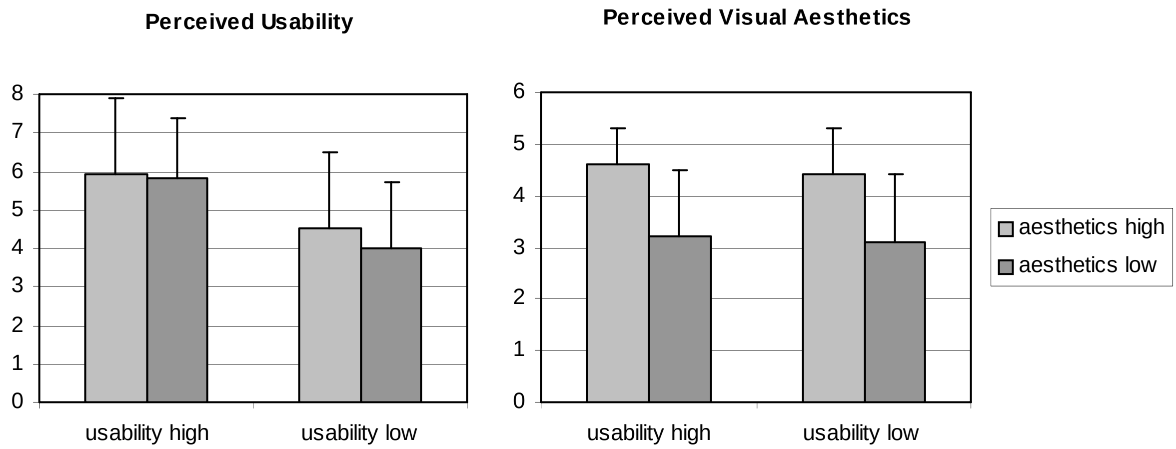


Figure 7.3: Perceived usability and visual aesthetics ratings for the four usability and visual aesthetics conditions.

Contrary, a 2x2x2x2 analysis of variance with USABILITY, VISUAL AESTHETICS, CULTURE, and MODE as between-subjects factors and the visual aesthetics ratings as dependent variable shows a significant main effect for VISUAL AESTHETICS, $F_{15,143}=64.0$, $p < .001$. The versions designed for high visual aesthetics are experienced as more aesthetic. There is also a smaller main effect for CULTURE, $F_{15,143}=4.7$, $p < .05$. The aesthetics ratings of German participants are lower than those of Canadian participants (Figure 7.4).

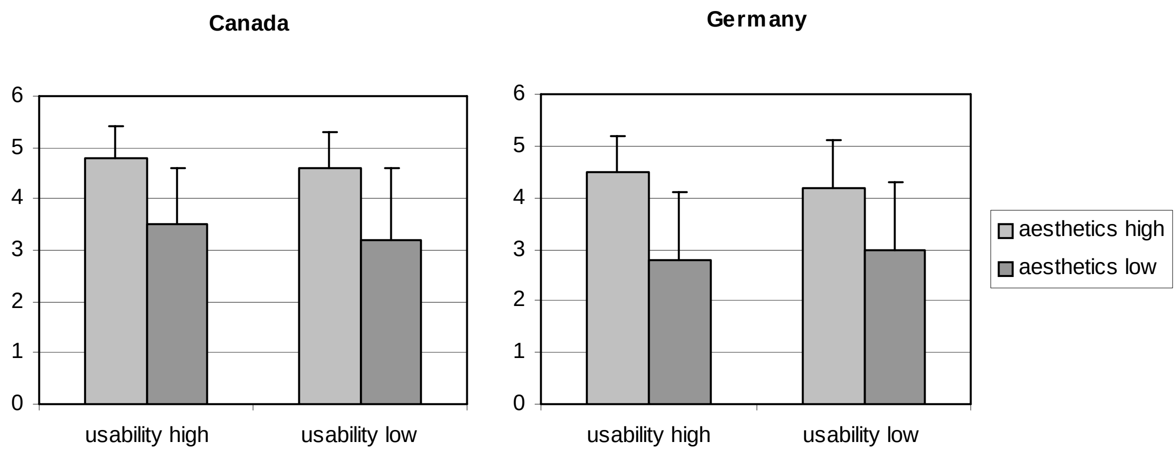


Figure 7.4: Perceived visual aesthetics ratings for the four usability and visual aesthetics conditions broken down by Canadian and German participants.

The analyses reveal that specific system properties independently influence the perception of instrumental (i.e. usability) and non-instrumental qualities (i.e. visual aesthetics). Quality perceptions are not influenced by the usage mode.

7.2.3 Emotional user reactions

A 2x2x2x2 analysis of variance with USABILITY, VISUAL AESTHETICS, CULTURE, and MODE as between-subjects factors and the averaged valence dimensions of the subjective feelings ratings as dependent variable shows a significant main effect for USABILITY, $F_{15,144}=22.1$, $p < .001$. The interaction with the high usable player versions is experienced as more positive. No significant effect is found for the factor VISUAL AESTHETICS. However, there is a significant effect of the factor MODE, $F_{15,144}=8.2$, $p < .01$. Subjective feelings are more positive in the task condition (goal-mode). Furthermore, a significant effect of CULTURE shows that Canadian participants reported more positive subjective feelings than German users, $F_{15,144}=3.8$, $p < .05$. A significant interaction effect of MODE and CULTURE demonstrates that German participants report more negative subjective feelings in the exploration condition, $F_{15,144}=5.6$, $p < .05$. No other interaction effects are significant. With respect to the averaged arousal ratings of the participants, there was only an effect of the factor CULTURE, $F_{15,144}=7.5$, $p < .01$. Canadian participants report higher arousal than German subjects. No other significant main or interaction effects are found.

Additionally to the absolute subjective feelings ratings, changes from the baseline assessment to the average subjective feelings rating during the interaction phase are calculated. Here, results of a 2x2x2x2 analysis of variance with USABILITY, VISUAL AESTHETICS, CULTURE, and MODE as between-subjects factors and the changes with respect to valence differ from the results of the analysis of the absolute values. The main effects of USABILITY and VISUAL AESTHETICS are significant, $F_{15,144}=14.5$, $p < .001$ and $F_{15,144}=5.2$, $p < .05$, respectively. Participants' subjective feelings are more positive, when they interact with systems that are more usable and visually more aesthetic (Figure 7.5).

Figure 7.5: Changes of subjective feelings compared to baseline values for the four usability and visual aesthetics conditions.

However, no main effects of the factors MODE and CULTURE are found. A significant interaction effect of MODE and CULTURE demonstrates that German participants report a change to more negative subjective feelings in the exploration condition, $F_{15,144}=5.8$, $p < .05$. No significant main or interaction effects are found with respect to changes on the arousal dimension.

Using 2x2x2x2 analyses of variance with USABILITY, VISUAL AESTHETICS, CULTURE, and MODE as between-subjects factors and the five cognitive appraisal dimensions as dependent variables various differences are found. Participants rate the intrinsic pleasantness of the interaction higher for the more usable version, $F_{15,143}=21.4$, $p < .001$, and the visually more aesthetic version, $F_{15,143}=4.0$, $p < .05$. The factor USABILITY has also a significant effect on the variable novelty, $F_{15,143}=21.0$, $p < .001$. The interaction with the low usable versions is experienced as more novel. Also the German participants experience the interaction with the systems overall as more novel than the Canadian subjects, $F_{15,143}=7.5$, $p < .01$. Furthermore, German participants rate the interaction with the systems overall as less compatible with their selves and norms than Canadian subjects, $F_{15,143}=13.1$, $p < .001$. The interaction with the systems in the exploration condition (action-mode) is experienced as more goal conducive than in the goal-mode, $F_{15,143}=7.9$, $p < .01$. No other significant main or interaction effects are found.

7.2.4 Overall judgments

The global dimension of the SUMI shows a significant main effect of the factor USABILITY, $F_{15,143}=25.2$, $p < .001$. The high usable versions are rated as better. Another significant main effect is found for the factor VISUAL AESTHETICS, $F_{15,142}=8.1$, $p < .01$. Again, the high visual aesthetic versions receive better overall judgments.

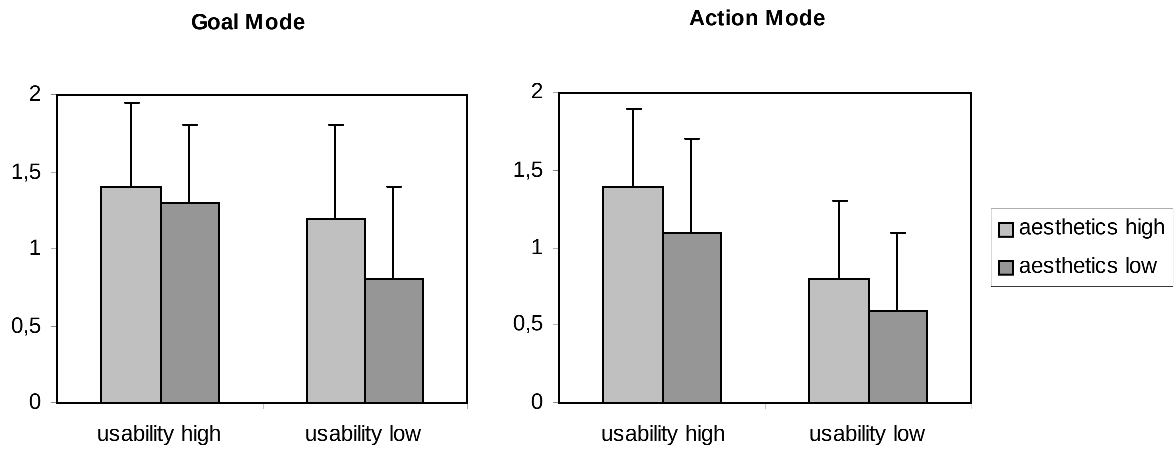


Figure 7.6: Overall judgment for the four usability and visual aesthetics conditions broken down for goal and action mode.

Furthermore, there is a main effect of the factor MODE, $F_{15,142}$= 8.1, p < .01 (Figure 7.6). In the exploration condition (action-mode) players receive a lower overall judgment in general. The analysis reveals no significant main effect for the factor CULTURE and no interaction effects.

7.2.5 Interrelations of components

A regression analysis to predict participants' subjective feelings using their quality ratings as predictors reveals the results presented in Table 7.5. 27% of the variance of valence is predicted with the perceived usability and visual aesthetics ratings. Almost no variance of arousal could be predicted. Quality perceptions of usability and visual aesthetics contribute significantly to the explanation of valence, while arousal is only influenced by perceived usability.

Table 7.5: Regression analysis of subjective feelings using usability and visual aesthetics ratings as predictors - overall, only for goal-mode and only for action-mode.

Predictors	Overall		Goal-mode		Action-mode	
	Valence	Arousal	Valence	Arousal	Valence	Arousal
Perceived usability	.44 ***	-.19 *	.57 ***	-.10	.34 **	-.30 *
Perceived aesthetics	.20 **	.12	.04	- .05	.33 **	.32 **
R^2	27 %	3 %	33 %	1 %	28 %	11 %

* p < .05; ** p < .01; *** p < .001

Analyzing the two conditions of the factor MODE separately reveals a high correlation for perceived usability and valence in the goal-mode, but not for perceived aesthetics and valence. None of the correlations is significant for arousal. For the action-mode, the results yield a moderately significant correlation of perceived usability and valence and also of perceived aesthetics and valence. 11% of the variance of arousal is explained in the exploration condition. Both usability and visual aesthetics have a significant influence.

Analyzing the two groups with different cultural background separately reveals a high correlation of perceived usability and valence for Canadian participants, but not for perceived aesthetics and valence (Table 7.6). None of the correlations was significant for arousal. For the German participants, the results yielded a moderately significant correlation of perceived usability and valence and also of perceived aesthetics and valence. Again, for arousal none of the correlations was significant.

Table 7.6: Regression analysis of subjective feelings using usability and visual aesthetics ratings as predictors - overall, only for Canadian and only for German participants.

Predictors	Overall		Canada		Germany	
	Valence	Arousal	Valence	Arousal	Valence	Arousal
Perceived usability	.44 ***	-.19 *	.49 ***	-.17	.37 **	-.23
Perceived aesthetics	.20 **	.12	.15	.13	.26 *	.05
R^2	27 %	3 %	26 %	1 %	25 %	2 %

* p < .05; ** p < .01; *** p < .001

Regression analyses of the five cognitive appraisal dimensions using perceived usability and visual aesthetics as predictors show the results summarized in Table 7.7. Thus, intrinsic pleasantness depends on both perceived usability and visual aesthetics. Furthermore, perceived usability shows a significant negative correlation with novelty. These results are compatible with the factor-based results reported in Section 7.3.3. Besides, the regression analysis of goal conduciveness reveals a significant influence of perceived usability, but only 5 % of the variance is explained. Perceived usability and visual aesthetics have no significant influence on coping potential or norm/self compatibility.

Table 7.7: Regression analysis of cognitive appraisal dimensions using usability and visual aesthetics ratings as predictors.

Predictors	Pleasantness	Novelty	Goal relevance	Coping potential	Norm/self compatibility
Perceived usability	.50 ***	-.53 ***	.26 **	.02	.07
Perceived aesthetics	.15 *	-.08	.04	.05	.11
R^2	31 %	30 %	5 %	1 %	1 %

* p < .05; ** p < .01; *** p < .001

A regression analysis to predict participants' overall judgments using their quality ratings (usability and visual aesthetics) and their subjective feelings (valence and arousal) as predictors reveals the results presented in Table 7.8. Based on the data of all conditions, 57% of the variance of the overall judgments is predicted using the four variables. Perceived usability and visual aesthetics as well as the valence of the subjective feelings show a significant correlation with the overall judgment.

Table 7.8: Regression analysis of overall judgments using usability and visual aesthetics ratings as well as subjective feelings as predictors.

Predictors	Overall	Goal-mode	Action-mode	Canada	Germany
Perceived usability	.55 ***	.70 ***	.45 ***	.52 ***	.59 ***
Perceived aesthetics	.17 **	.14 *	.24 **	.22 **	.12
Subjective feelings - valence	.23 ***	.11	.26 **	.23 *	.25 **
Subjective feelings - arousal	.03	.13	-.17 *	.03	.01
R^2	57 %	63 %	57 %	52 %	61 %

* p < .05; ** p < .01; *** p < .001

The perception of usability has a major influence in the goal-mode and also perceived visual aesthetics shows a significant, but small correlation. 63% of the variance of the overall judgments is explained in the task condition. For the action-mode, all four variables, perceived usability, perceived visual aesthetics, and the valence as well as the arousal of users' subjective feelings contribute to the explanation of 57% of the overall judgments.

There are also differences between Canadian and German participants. The influence of perceived aesthetics is higher for Canadian participants. However, this may be caused by the higher influence of perceived visual aesthetics on the valence of the subjective feelings for German participants (Table 7.6).

7.2.6 Influence of covariates

Centrality of visual product aesthetics (CVPA) is considered as an additional user characteristic. A selection of results regarding CVPA is presented in the following.

An overall CVPA score is computed for each subject. The mean CVPA score is 3.28 (*SD* = .84). To test whether a high CVPA score has an influence on the interrelations of user experience components the sample is divided into two groups depending on the CVPA score. The group with high CVPA score has a mean score 3.95 (SD = .40) and the other group has a mean score of 2.60 (SD = .58).

Analyzing the interrelations of quality perceptions and subjective feelings for the two groups with different CVPA separately reveals a high correlation of perceived usability and valence and no significant correlation for perceived aesthetics and valence for participants with low CVPA (Table 7.9). None of the correlations for this group is significant for arousal. For the participants with high CVPA the results yield an equally significant correlation for perceived usability and also perceived aesthetics with valence. Again, for arousal none of the correlations is significant for this group.

Table 7.9: Regression analysis of subjective feelings using usability and visual aesthetics ratings as predictors – overall, only for high and only for low CVPA.

Predictors	Overall		High CVPA		Low CVPA	
	Valence	Arousal	Valence	Arousal	Valence	Arousal
Perceived usability	.44 ***	-.19 *	.32 **	-.15	.54 ***	-.23
Perceived aesthetics	.20 **	.12	.32 **	.21	.08	.02
R^2	27 %	3 %	25 %	2 %	30 %	3 %

* p < .05; ** p < .01; *** p < .001

For the interrelations between overall judgments and the user experience components only slight differences are found for the high and low CVPA groups (Table 7.10). For the participant with high CVPA scores, the influence of perceived visual aesthetics on overall judgments is slightly higher than for participants with low CVPA. The impact of the valence of participants' subjective feelings is higher for the latter group of participants.

Table 7.10: Regression analysis of overall judgments using usability and visual aesthetics ratings as well as subjective feelings as predictors – overall, only for high and only for low CVPA.

Predictors	Overall	High CVPA	Low CVPA
Perceived usability	.55 ***	.53 ***	.55 ***
Perceived aesthetics	.17 **	.21 *	.15 *
Subjective feelings - valence	.23 ***	.16	.30 **
Subjective feelings - arousal	.03	.01	.03
R^2	57 %	50 %	64 %

* p < .05; ** p < .01; *** p < .001

7.3 Discussion

In Study 3, system properties, user characteristics, and contextual parameters are varied to investigate their influence on quality perceptions, emotional user reactions, and overall judgments.

7.3.1 Instrumental and non-instrumental quality perceptions

As hypothesized system properties independently influence instrumental and non-instrumental quality perceptions (H1a). Both usability and visual aesthetics manipulations affect subjective perceptions in the predicted directions. As in Study 2 and in contrast to other studies (Tractinsky et al., 2000; Ben-Bassat et al., 2006), no influence of the visual aesthetics variation on perceived usability is found. Two possible explanations have already been discussed in Section 6.4.1. First, the variation of usability and visual aesthetics in Study 2 and 3 is based on the criterion that variations either influence instrumental or non-instrumental quality perceptions. Second, a detailed measurement of perceived usability in these studies produces more detailed data that may be less influenceable by other experience dimensions.

No effect of the factor MODE is found on quality perceptions (H3a) as expected based on the findings of Hassenzahl et al. (2002) as well as Hassenzahl and Ullrich (2007). However, the analysis reveals differences of the perceived visual aesthetics ratings depending on participants' cultural background (H2a). German participants give lower aesthetics ratings than Canadian participants. This result supports earlier assumptions on cross-cultural differences regarding users' perceptions of interface aesthetics (Tractinsky, 1997).

7.3.2 Influences on emotional user reactions

Subjective feelings differ depending on the variation of system properties that influence the perception of instrumental and non-instrumental qualities (H1b). However, the analyses demonstrate that it is especially necessary to assess baseline values for subjective feelings when data are gathered in different cultural contexts. While the analysis of the absolute subjective feelings ratings reveals an influence of the factor culture, the data that normalized participants' subjective feelings during the interaction with their subjective feelings ratings at the beginning of the experiment do not show an influence of culture. Canadian participants report more positive subjective feelings than German users when the absolute values are examined (Matsumoto, 1993). A comparison with the baseline assessment makes it possible to relate these differences to cultural differences.

Surprisingly, in comparison to Study 2 the arousal dimension of participants' subjective feelings is not significantly influenced by variations of system properties, neither by usability or visual aesthetics. However, already in Study 2 the effect of variations of system properties on arousal is smaller than the effect on valence.

Furthermore, the improvement of the differences between the low and high visual aesthetic condition in comparison to Study 2, shows no higher effect of the variation on subjective feelings. Nonetheless, the analysis of the correlations between perceived usability and visual aesthetics with participants' subjective feelings shows a higher correlation of visual aesthetics and valence than in Studies 1 and 2. Although the differences between the two visual aesthetics conditions have been improved and the quality ratings support the assumption that differences in perceived usability and visual aesthetics are more of similar amount in this study than in Study 2 (Tables 6.3 and 7.3), the influence of instrumental qualities on emotional user reactions is still higher in comparison to the effect of non-instrumental qualities.

This assumption is also supported by the results on cognitive appraisals. The effect of the usability variation on intrinsic pleasantness and novelty is highly significant. A smaller effect is found for visual aesthetics on intrinsic pleasantness. The regression analyses of the cognitive appraisal dimensions predicted by perceived usability and visual aesthetics support the more important role of instrumental qualities (Table 7.7).

The other three cognitive appraisal dimensions – goal relevance, coping potential, and norm/self compatibility – do not differ depending on the system properties condition, but are affected by contextual parameters and user characteristics. The usage situation has an influence on the goal relevance of the participants' experience. Participants in the exploration condition rate the goal conduciveness higher than subjects in the task mode. This might be because participants think that the exploration would help them better to assess the interactive systems.

The most interesting differences with respect to the usage situation as an example of contextual parameters are found in the analyses of the interrelations of the user experience components (H3b). The variation of usage mode reveals differences in the connections between quality perceptions and participants' subjective feelings. These differences are clearest for the subjective feelings dimension of valence. While there is a high correlation between the valence of users' subjective feelings and the perceived usability of a system and no correlation with the perceived visual aesthetics when participants focus on given tasks, moderate correlations between valence and both perceived usability and aesthetics are found when participants explore the system without given tasks. Differences are also apparent for arousal. In the goal-mode, arousal is not correlated with perceived usability and visual aesthetics at all, while a small amount of arousal's variance is explained by both quality perceptions in the exploration condition.

As already mentioned, absolute subjective feelings ratings differ depending on participants' cultural background (H2a). Also the interrelations between quality perceptions and subjective feelings vary depending on the cultural background (Table 7.6). The perception of visual aesthetics is more relevant for the subjective feelings experienced by German participants. Furthermore, cognitive appraisals are influenced by the factor culture. German participants experienced the interaction with the systems overall as more novel and as less compatible with their selves and norms than Canadian subjects. These differences have to be taken into account when products are evaluated in several countries.

Differences of user experience component interrelations are also found with respect to participants' centrality of visual product aesthetics (CVPA, H2b). This variable is considered as an additional user characteristic. While the impact of perceived usability and visual aesthetics on the valence of subjective feelings of participants with a high CVPA score is equal, the subjective feelings of the participants with a low CVPA score are only influenced by perceived usability.

7.3.3 Influences on overall judgments

Overall judgments are significantly affected by both variations of system properties – usability and aesthetics. The variation of visual aesthetics has a higher effect on overall judgments than in Studies 1 and 2. Interestingly, overall judgments differ between exploration and task condition. In general, players receive lower overall judgments in the exploration condition. This can be explained by the fact that participants in the exploration condition are able to test all aspects of the system while subjects in the other condition focus on the given tasks that are all solvable with the system. Some qualitative statements by the participants suggest that while participants in the task condition only focus on tasks that are accomplishable, users in the action-mode miss some functions, like a calendar or better sound settings, what may lead to a general lower valuation of the system usefulness.

Differences of the influence of user experience components on overall judgments are found depending on the usage mode (Table 7.8). Perceived usability is the most important predictor of overall judgments in the task condition. Perceived visual aesthetics contribute only slightly to the explanation of overall judgments' variance. In the exploration condition, perceived visual aesthetics and also the valence and arousal dimensions of participants' subjective feelings have a much higher impact on overall judgments. These results have most of all practical implications for system evaluation. Depending on the usage situation in a test scenario, overall judgments as well as emotional user reactions can be significantly different. Regarding the results from Studies 1 and 2, it has to be taken into account that in these studies all participants accomplished given tasks.

7.4 Chapter Summary

Like in the previous studies, variations of system properties that have an influence on the experience of usability and visual aesthetics are incorporated and results replicated. Additionally, Study 3 demonstrates the relevance of user characteristics and contextual parameters for user experience of interaction. The influence of cultural background and centrality of visual product aesthetics is demonstrated. Cultural background leads to a difference in subjective feelings ratings. Centrality of visual product aesthetics has an influence on the interrelations of user experience components, e.g. the influence of perceived visual aesthetics on subjective feelings and overall judgments is higher for participants with a high centrality of visual product aesthetics. Furthermore, the usage situation as an example of context variation shows additional impact. The influence of perceived usability on subjective feelings and overall judgments is higher when participants have to accomplish given tasks. The results demonstrate that it is important to take the interactive system properties and also characteristics of the user and the usage situation into account when analyzing, designing, and evaluating interactive systems. Cognitive appraisals are measured as another aspect of emotional user reactions. The results show that differences in system properties in particular have an influence on the perceived pleasantness and novelty of the usage situation.

To recapitulate, a theoretical framework for the study of user experiences of interactive systems that goes beyond classical approaches has been proposed in Chapter 3. Methods to measure instrumental and non-instrumental qualities as well as emotional user reactions have been discussed in Chapter 4. Chapters 5 to 7 have described three empirical studies that used selected methods to test the theoretical model. In Chapter 8, the results of the three studies are related to the assumptions made in the user experience framework and in Chapter 9, consequences of the theoretical, methodological, and empirical results are discussed for the development of interactive systems.

8 Framework reconsidered

Studies 1, 2 and 3 focus on the empirical investigation of selected assumptions proposed in the user experience framework presented in Chapter 3 using the methods to assess the three central components of user experience discussed in Chapter 4. The studies and their key findings are summarized in Table 8.1 (pp. 122). In the following, the main results of the three studies are discussed and related to the research framework.

The empirical research questions, which are deduced based on the research framework in Section 3.8, can be divided into two categories. Figure 8.1 (p. 124) gives an overview of the research questions addressed in the three studies. The first group of research questions includes assumptions about the role of influencing factors. Three categories of influencing factors are proposed in the framework: system properties, user characteristics, and context parameters. All three empirical studies deliver results regarding the influence of system properties on user experience. Additionally, Study 3 investigates the role of user characteristics and context parameters. The results regarding the role of influencing factors of user experience are summarized in Section 8.1.

The second group of research questions concerns interrelations of the user experience components and their influence on consequences of user experience. Empirical results regarding these research questions are discussed in Section 8.2. A first assumption of the framework that has been addressed in the empirical studies is that instrumental and non-instrumental quality perceptions do not influence each other and are therefore perceived independently (Section 8.2.1). Furthermore, emotional user reactions are assumed to be influenced by instrumental and non-instrumental quality perceptions (Section 8.2.2). At last, the framework proposes that consequences of user experience are based on instrumental and non-instrumental quality perceptions as well as on emotional user reactions (Section 8.2.3).

In summary, the results of the three studies do not provide any reasons to extend or modify the overall framework. However, some theoretical questions remain open since they have not been addressed in the empirical studies. Examples are discussed in Section 8.3.

Table 8.1: Overview on studies and key findings.

	Study 1	Study 2	Study 3
	Chapter 5	Chapter 6	Chapter 7
Influencing factors	System properties (various)	System properties (regarding usability and visual aesthetics)	System properties (regarding usability and visual aesthetics) User characteristics (cultural background and centrality of aesthetics) Context parameters (usage mode)
Instrumental quality perceptions	Perceived usefulness Perceived ease of use	Perceived usability	Perceived usability
Non-instrumental quality perceptions	Perceived visual aesthetics Perceived haptic quality Perceived symbolic quality	Perceived visual aesthetics	Perceived visual aesthetics
Emotional user reactions	Subjective feelings	Subjective feelings Physiological reactions Motor expressions	Subjective feelings Cognitive appraisals
Consequences of user experience	Overall judgments Choice between alternatives	Overall judgments Choice between alternatives	Overall judgments

Table continued on the next page

	Study 1	Study 2	Study 3
Key findings	- Components and consequences of user experience are influenced by variations in system properties - Subjective feelings are mainly based on the perception of instrumental qualities - Overall judgments are influenced by both instrumental and non-instrumental quality perceptions	- System properties independently influence instrumental and non-instrumental quality perceptions - System properties influence not only subjective feelings, but also other aspects of emotional user reactions, i.e. physiological reactions and motor expressions - Perceived usability has a main influence in predicting subjective feelings - Variations of system properties regarding usability and aesthetics have an effect on overall judgments - Instrumental quality perceptions and valence of subjective feelings determine overall judgments	- System properties independently influence instrumental and non-instrumental quality perceptions as in Study 2 - System properties impact cognitive appraisals - Perceived usability AND perceived visual aesthetics influence subjective feelings - Instrumental AND non-instrumental quality perceptions as well as the valence of subjective feelings impact overall judgments - Cultural background and centrality of visual product aesthetics influence the interrelations of the user experience components - Usage mode influences the interrelations of the user experience components - Better overall judgments in goal-mode
Publication	Mahlke (2006a) Mahlke (2006b)	Mahlke and Thüring (2007)	Mahlke and Lindgaard (2007)

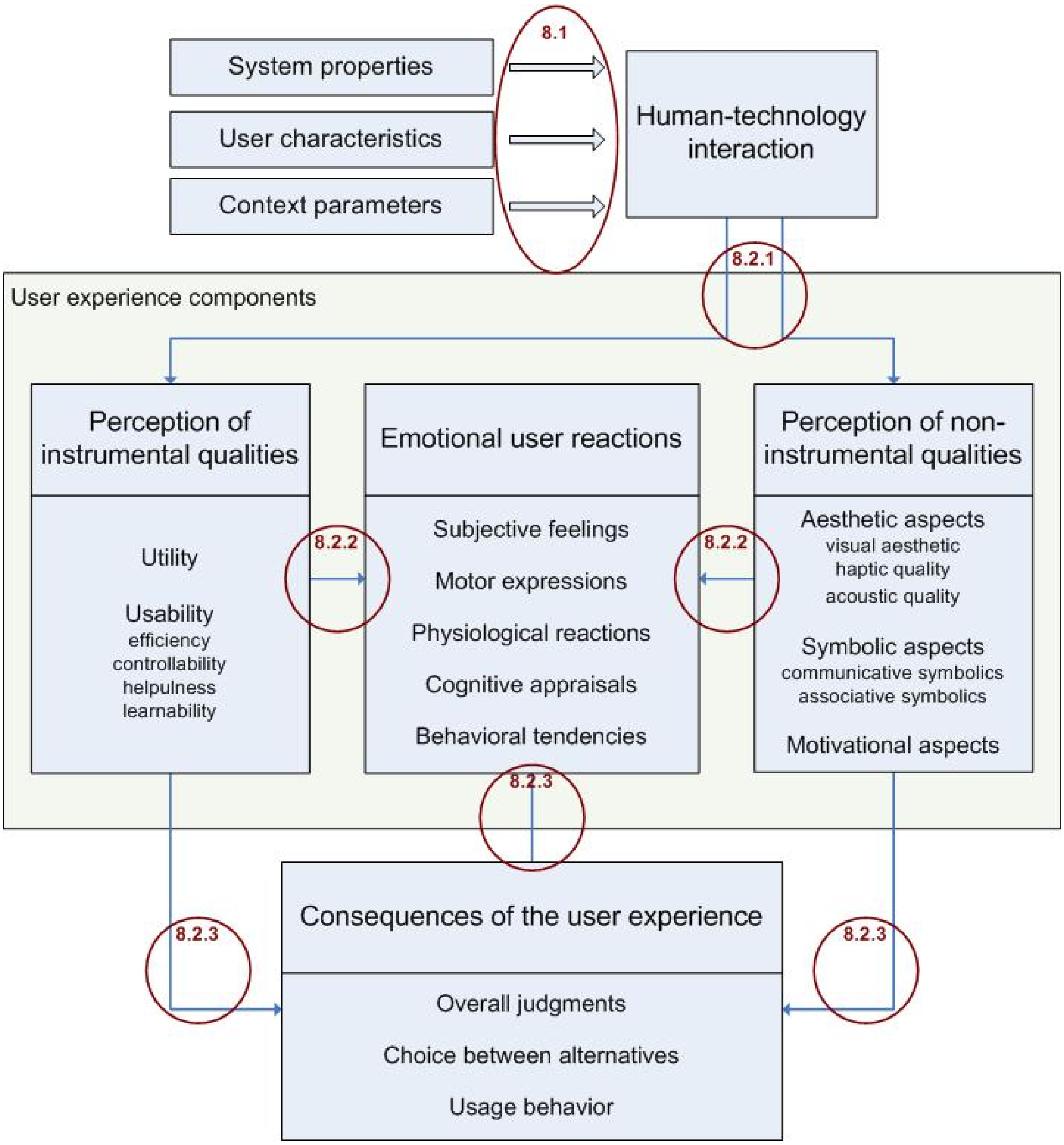


Figure 8.1: User experience research framework and empirical research foci.

8.1 Impact of influencing factors

System properties, user characteristics, and context parameters are defined as categories of factors that influence the human-technology interaction and thereby determine the user's experience. The influence of system properties is investigated in all three studies. While in Study 1 a whole range of system properties regarding presentation, dialogue, and appearance vary between the used systems, Studies 2 and 3 focus on the systematic variation of selected presentation and appearance properties that are assumed to relate to instrumental and non-instrumental quality perceptions, respectively.

The results of Study 1 demonstrate that variations in system properties lead to differences in objective measures of the interaction (number of accomplished tasks and time on task) as well as differences in user experience (instrumental and non-instrumental quality perceptions as well as emotional user reactions) and consequences of the experience (overall judgments and alternative choice). Studies 2 and 3 reveal that not all system properties impact performance measures. While the variation of presentation properties results in objective differences of the interaction, variations regarding appearance factors do not have any impact. However, variations of both property groups lead to differences in quality perceptions, emotional user reactions, and consequences of user experience. Nonetheless, instrumental and non-instrumental quality perceptions are determined by different properties. While selected presentation properties influence the perception of instrumental qualities, appearance properties have an impact on non-instrumental quality perceptions. The studies verify the assumption that system properties have a considerable impact on user experience as assumed by Crilly et al. (2004) or Creusen and Schoormans (2005) and deliver results regarding the influence of selected presentation and appearance factors.

The influence of user characteristics and context parameters is investigated in Study 3. Overall, they have no direct impact on the interaction and influence only some aspects of user experience. Performance measures are not influenced by differences in the user characteristics that have been studied, i.e. cultural background and centrality of visual product aesthetics, although this has been assumed from previous studies (Plocher et al., 1999). However, cultural background has an influence on the perception of visual aesthetics and users' subjective feelings. Other user characteristics might have a higher direct influence on the interaction and the experience of interaction. However, cultural background and centrality of visual product aesthetics have an impact on the interrelations of the user experience components and their individual influence on the consequences of user experience. The role of user characteristics for the interrelation of these variables is discussed in Section 8.2.2 and 8.2.3.

The variation of usage mode that is incorporated in Study 3 directly influences overall judgments. Furthermore, differences in context parameters have an impact on the interrelations of the user experience components and their individual influence on the consequences of user experience. The results of Hassenzahl et al. (2002) regarding the influence of context parameters on the relation of quality perceptions and overall judgments have been replicated and new assumptions are made regarding emotional user reactions, which are also discussed in Section 8.2.2 and 8.2.3.

Concluding, the studies verify the assumption that all three categories of influencing factors have an effect on user experience (Forlizzi & Ford, 2000; Hassenzahl & Tractinsky, 2006). While system properties have an explicit impact, user characteristics and context parameters particularly influence the interrelations of user experience components and their effect on consequences of user experience.

8.2 Interrelations of user experience components

Three main assumptions are made in the research framework about interrelations of the user experience components and their relationship to consequences of user experience. First, no direct link between instrumental and non-instrumental quality perceptions is drawn (Section 8.2.1). Second, emotional user reactions are assumed to be influenced by instrumental and non-instrumental quality perceptions (Section 8.2.2). Third, it is proposed that consequences of user experience are based on instrumental and non-instrumental quality perceptions as well as emotional user reactions (Section 8.2.3).

8.2.1 Independence of instrumental and non-instrumental quality perceptions

No direct link between instrumental and non-instrumental quality perceptions is made in the research framework, although previous empirical studies have shown an influence of visual aesthetics on perceptions of usability (Tractinsky et al., 2000). However, Hassenzahl (2007) explains these findings as a result of attribute overlap. He argues that it is possible that already the system attributes that have been varied to influence visual aesthetics are also related to usability. Furthermore, in other studies these interrelations have not been replicated (Lindgaard & Dudek, 2003).

The findings of Studies 2 and 3 demonstrate that it is possible to manipulate groups of system properties, which either influence instrumental or non-instrumental quality perceptions. In this case, properties that are associated with information presentation have an impact on the perception of usability and system properties related to product appearance determine users' perceived visual aesthetics. In this way, it is possible to resolve the problem of attribute overlap and to demonstrate that instrumental and non-instrumental quality perceptions occur independently. Therefore, the suggestion by Tractinsky et al. (2000) who claim what is beautiful is usable has to be reconsidered. Additionally, future studies should incorporate other qualities like perceived utility as well as symbolic and motivational aspects to further clarify relations of instrumental and non-instrumental qualities.

8.2.2 Influence of quality perceptions on emotional user reactions

In the user experience framework, it is assumed that emotional user reactions are influenced by instrumental and non-instrumental quality perceptions. The results of the three studies demonstrate that emotional user reactions can be predicted to a high proportion by instrumental and non-instrumental quality perceptions. In all three experiments, users' quality perceptions explain a significant amount of subjective feelings variance. The results verify the assumptions of Rafaeli and Vilnai-Yavetz, (2004) about the complementary influence of quality perceptions on emotional user reactions.

While in Studies 1 and 2 only perceived instrumental qualities have a significant influence on subjective feelings, both instrumental and non-instrumental quality perceptions play a significant role in Study 3. The influence of the variation of context parameters and user characteristics on the interrelations of the studied components helps to explain these results. While in Studies 1 and 2 all participants use the systems in the same context (accomplishment of tasks), a variation of the context (tasks vs. exploration) is applied in Study 3. For the task-group in Study 3, the same pattern is found as in the previous studies: subjective feelings are predicted only by perceived instrumental qualities. In the exploration condition however, users' subjective feelings are determined by both instrumental and non-instrumental quality perceptions. This finding expands the assumptions by Hassenzahl et al. (2002) about the role of contextual factors for the relation of quality perceptions and overall judgments to the influence of quality perceptions on emotional user reactions.

Further results show that subjective feelings of users with a high centrality of visual product aesthetics (CVPA) are influenced by both instrumental and non-instrumental quality perceptions, while for users with a low CVPA score only perceived instrumental qualities play a role. This demonstrates the moderating role of user characteristics on the interrelations of the user experience components as assumed by Bloch et al. (2003).

8.2.3 Influence of quality perceptions and emotional user reactions on consequences of user experience

The framework proposes that consequences of the user experience are influenced by instrumental and non-instrumental quality perceptions as well as emotional user reactions. Results regarding these relations differ between the three studies. While in Study 1 instrumental and non-instrumental quality perceptions predict overall judgments, in Study 2 perceived instrumental qualities and the valence of participants' subjective feelings play a significant role. Thus, non-instrumental quality perceptions show a relevant influence in Study 1, but not in Study 2. However, in Study 1 perceived haptic and symbolic quality are the relevant non-instrumental qualities for the prediction of overall judgments. Perceived visual aesthetics that is the focus of Study 2 does not show a significant impact on overall judgments in Study 1. The difference between the used systems regarding visual aesthetics may be rather small in the first two studies. This explanation is supported by the results of Study 3. Here, the variation of visual aesthetics is enhanced, and perceived visual aesthetics shows an influence on overall judgments. Accordingly, the results of Study 3 show an influence of all three user experience components. These results demonstrate the relevance of other aspects next to instrumental qualities (Davis, 1989) and show that emotional user reactions and overall judgments are not independent consequences of quality perceptions as assumed for example by Hassenzahl (2003).

In Study 3, the variation of context parameters also shows a moderating role of the relevance of user experience components for the prediction of overall judgments as proposed by Hassenzahl et al. (2002). Perceived usability is the most important predictor of overall judgments in the task condition. Perceived visual aesthetics contributes only slightly to an explanation of overall judgments' variance. In contrast, in the exploration condition, perceived visual aesthetics and also the valence and arousal dimensions of participants' subjective feelings have a much higher impact. This finding demonstrates the moderating impact of contextual parameters on the relevance of the three user experience components for consequences of user experience.

8.3 Conclusions

The discussion of the results of the three studies shows that most of the assumptions made in the theoretical framework are supported by empirical data. The role of influencing factors on user experience and the interrelations between user experience components as well as their influence on consequences of user experience are revealed in the experiments as expected. All of the marked relations in Figure 8.1 are supported by the empirical results. Therefore, it can be argued that no extension or modification of the overall framework is necessary.

Nonetheless, a few questions remain open. For example, no direct link between the interaction and emotional user reactions has been drawn in the framework as for example assumed by Norman (2004) in his discussion of a visceral level of information processing. The reasons of this decision have already been discussed in Section 3.7. However, the design of the three experiments does not make it possible to answer the question if this direct link really does not exist. Additionally, the results show that variations of influencing factors effect emotional user reactions. Yet, it is not possible to answer the question if these influences are totally moderated by quality perceptions as assumed in the framework.

Furthermore, it is likely that the experience process is much more dynamic and changes over time than indicated in the framework. Emotional user reactions may be seen as an intermittent factor between the perception of instrumental and non-instrumental qualities. This relation could explain an indirect mutual influence of both types of perceptions on each other. The perception of a positive non-instrumental quality may cause a pleasant emotional episode, which in turn may influence the perception of instrumental qualities. Also, overall judgments may feedback on components of user experience. Further empirical research has to address these open questions to better understand the user experience of interaction.

8.4 Chapter summary

The results of the three studies support most of the assumptions made in the research framework. Therefore, it is argued that no extension or modification of the overall framework is necessary. All three categories of influencing factors have a significant influence on user experience. While system properties affect instrumental and non-instrumental quality perceptions, user characteristics and context parameters show a particular influence on the interrelations of the user experience components and their impact on consequences of user experience. With respect to interrelations of the studied components, the results support the assumptions that instrumental and non-instrumental qualities are perceived independently, emotional user reactions are determined by instrumental and non-instrumental quality perceptions, and consequences of user experience are influenced by all *three* components of user experience. Some assumptions made in the research framework have not been tested in the empirical studies, e.g. the absence of a direct influence of the interaction on emotional user reactions. Future studies need to address these issues.

9 Application

In this chapter, the question is discussed of how the theoretical framework, the proposed methods, and the results of the three studies can be applied in the development process of interactive systems. Therefore, existing development process models are reviewed. As a variety of approaches exist for specific purposes, only a selection that is applied in interactive system design projects is presented (Section 9.1). Based on similarities of the process models, recommendations are formulated. The suggestions address three categories of activities that are found in all approaches: analysis, design generation, and evaluation (Section 9.2).

9.1 Product development processes

Design tasks are of central importance to companies. Design determines the properties of every product, system, or service. A variety of recommendations propose a process to structure various design tasks. They range from very general to more specific process models. In the following sections, three approaches are described that are applied in interactive system design projects. First, the engineering design process proposed by Pahl, Beitz, Feldhusen and Grote (2007) is a general system product development process that is applicable to a variety of domains and is also used to design interactive systems. Second, user-centered design (ISO 13407) and third, usability engineering processes (e.g. Mayhew, 1999) focus exclusively on interactive system design and explicitly take the user of the interactive product into consideration. Similarities and differences of the process models are discussed and used as a basis for recommendations to apply the user experience approach during the development process of interactive systems.

9.1.1 Engineering design

Pahl et al. (2007) describe a systematic approach to product development that is applicable to the design of a whole range of technical products and systems. It is described as a problem-directed approach that is applicable to every type of design activity, no matter which specialist field it involves, and that fosters inventiveness and facilitates the search for optimum solutions. The process described in Pahl et al. (2007) has similarities with other approaches to systematic development processes like VDI 2221 (VDI, 1993).

The general process model proposed in Pahl et al. (2007) differentiates four major phases in the product development process: task clarification, conceptual design, embodiment design, and detailed design (Figure 9.1). The aim of the task clarification and planning phase is the specification of information that is the basis for the design activities, while the three design phases focus on the specification of a principle solution (concept), the specification of the layout (embodiment), and the specification of the production (detailed).

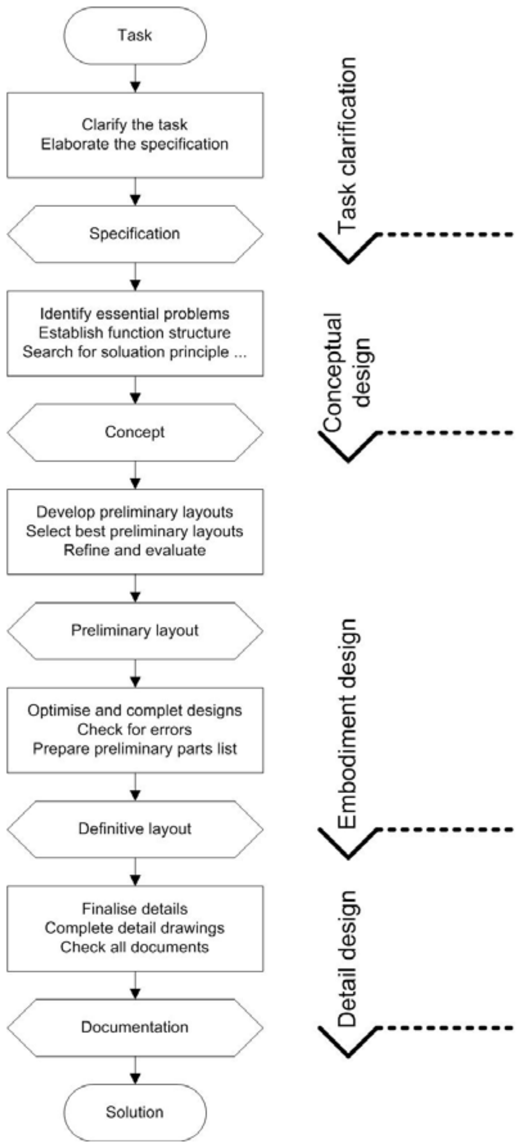


Figure 9.1: Engineering design process (Pahl et al., 2007, p.68).

Next to the process from the start of the design project to a detailed design solution at the end of the project, a general problem solving process is described that has to be applied in almost all process stages. Analysis/clarification, solution finding, and evaluation/selection are essential task categories in each of the phases. Analysis and clarification tasks include the initial confrontation of the problem, a definition of the essential problems on an abstract level as well as information gathering about the task, the constraints, and known solutions for similar problems. During solution finding activities, design ideas are generated, varied, and combined using methodological guidelines. If different solutions are found, an evaluation helps to select the best variant through a decision. Similar activities are proposed in user-centered design processes.

9.1.2 User-centered design

User-centered design (UCD) is a design approach that grounds the development process on information about the people who will use the product. UCD processes focus on users during the planning, design, and development of a product. ISO 13407 is an international standard that is the basis for many UCD methodologies (ISO, 1999). This standard defines a general process for including user-centered activities throughout a development life cycle, but does not specify exact methods.

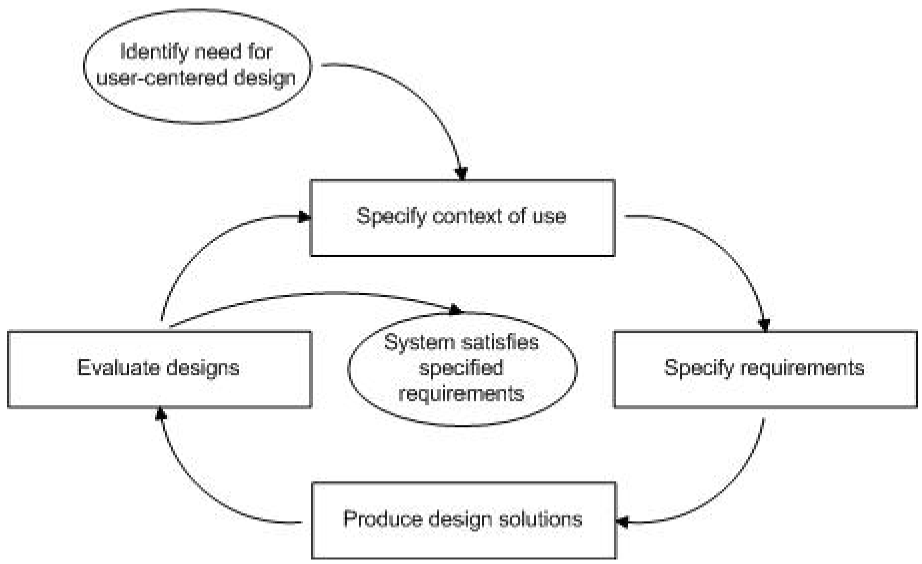


Figure 9.2: User-centered design process (ISO 13407, p. 6).

In this model, once the need to use a human centered design process has been identified, four activities form the main cycle of work (Figure 9.2):

- Specify the context of use: identify the people who will use the product, what they will use it for, and under what conditions they will use it.
- Specify requirements: identify any business requirements or user goals that must be met for the product to be successful.
- Create design solutions: this part of the process is accomplished in stages, building from a rough concept to a complete design.
- Evaluate designs: evaluation - ideally through testing with actual users - is an integral part of the process.

Most user-centered design methodologies that are based on ISO 13407 are more detailed in suggesting specific activities and the time within a process when they should be completed. A process recommended by the Usability Professionals Association (UPA, 2007) is divided into four phases: analysis, design, implementation, and deployment. Starting from the beginning with defining users and their requirements to the conclusion with usability testing, a complete user-centered design process is laid out based on the activities described in ISO 13407.

9.1.3 Usability engineering

In comparison to UCD processes, usability engineering (UE) models explicitly focus on usability as main design goal and consider the integration of a usability assuring process in the technical development activities. Mayhew (1999) describes a comprehensive usability life cycle that is displayed in Figure 9.3.

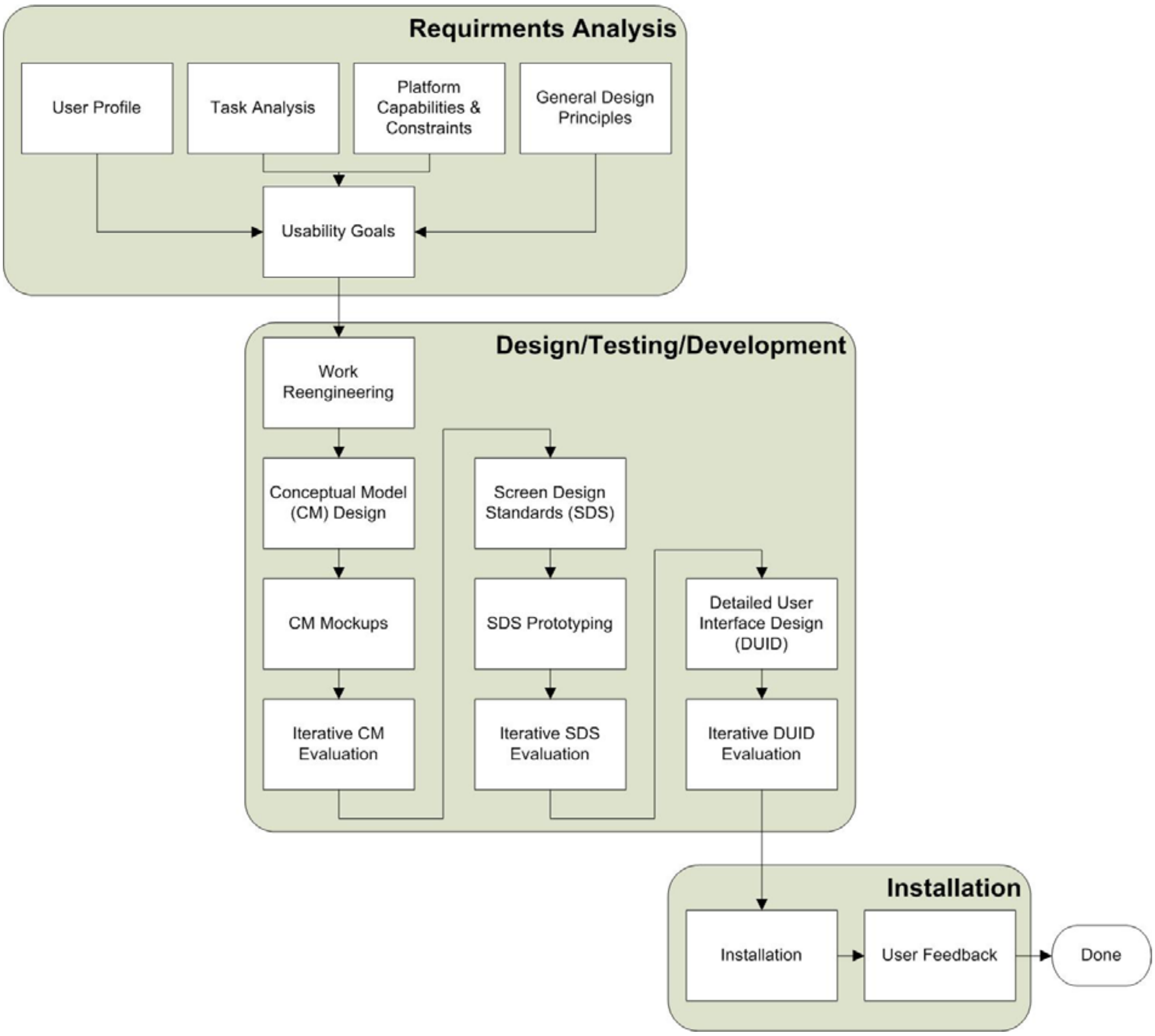


Figure 9.3: Usability engineering process (Mayhew, 1999, p. II).

Three major phases are distinguished in the process model: requirements analysis, design/testing/development, and installation (Figure 9.3). In the requirements analysis stage, a detailed analysis of the tasks that the system supports, the context in which the system is used, and the work-flow patterns that are involved as well as a collection of information about the intended user population are in the focus. For software projects, also platform capabilities and constraints have to be considered. Furthermore, specific qualitative and quantitative goals regarding user performance and acceptance are set as an evaluation basis. The main activities in the requirements analysis stage are analysis and clarification tasks.

In the design/testing/development stage, three levels are differentiated: conceptual model, screen design standards, and detailed user interface design. From one level to the next level, the design activity and the working prototype are getting more detailed. On all three levels, design and prototype generation activities alternate with evaluation and selection tasks.

The installation stage follows the completion of the development tasks in the product life cycle. However, Mayhew (1999) underlines that feedback from the actual user of the product helps to improve future releases.

9.1.4 Conclusions

The presented development processes have a different focus. While the engineering design model (Pahl et al., 2007) is a general approach to product development, user-centered design and usability engineering processes specifically focus on interactive system design. Additionally, usability engineering concentrates on usability as main design goal. However, the models have various similarities. Development stages or phases are similar:

- Engineering design (ED): task clarification and three design phases.
- User-centered design (UCD, applied in the UPA model): analysis and three design phases (design, implementation, and deployment).
- Usability engineering (UE): requirements analysis and three design phases (conceptual model, screen design standards, and detailed user interface design) plus installation.

Next to similarities in temporal stages, three main groups of activities are found in all process models. ISO 13407 defines these three major activities in the development process most explicitly: analyze context and requirements, produce design solutions, and evaluate designs. While an analysis phase is explicit in all described process models, design generation, and evaluation activities are iteratively integrated in the design phases. As these three activities (analysis, design generation, and evaluation) are the main tasks on various levels of the development process, recommendations for the applications of an approach to user experience are given for each of these categories of activities in the next section.

9.2 Implications of the user experience approach for product development

In this section, theoretical, methodological, and empirical contributions to user experience are summarized to be integrated into the development process of interactive systems. The recommendations are divided according to the three main task categories that are relevant during the development process: analysis, design generation, and evaluation.

9.2.1 User experience in analysis phases

Analysis activities play an important role in the very early stages of the development process. The user experience framework in particular can be used as a reference to gather and clarify information that is the basis for design generation and evaluation activities. In engineering design processes, requirements lists are the most important tool in the analysis phase. A variety of categories of system properties are recommended to be considered in these lists. However, these properties are mostly related to the usefulness and usability of the system. Although, attractiveness requirements are stated as useful differentiators between competing products, relevant categories are not discussed in detail. Here, non-instrumental qualities like aesthetic, symbolic, and also motivational aspects should be included and design goals regarding these qualities should be set early in the development process. The proposed subdimensions help to identify system properties that support a design for high non-instrumental quality. Furthermore, a comparison of competing products offers an opportunity to find ideas to design for improved non-instrumental qualities. This becomes particularly important when no differentiation regarding the functionality of the product is possible and other qualities have to be used as unique selling points.

Context parameters are one influencing factor in the user experience research framework. The user-centered design process explicitly incorporates a specification of the context of use. As the empirical studies demonstrated, context parameters have an influence on the experience of the interaction. Therefore, detailed information about the context help to better understand the usage situation, to keep it in mind during the design phases, and to consider context parameters when prototypes and mock-ups are evaluated. However, the information that is typically assessed in a context analysis as basis for a design for usability has to be expanded. When the whole user experience is taken into account, information about further contextual issues has to be provided, e.g. usage of the system in social context, mandatory or voluntary use, etc.

Mayhew’s (1999) usability engineering process explicitly integrates a user analysis and profiling during the analysis phase. Study 3 showed the relevance of user characteristics for the experience of interaction. When taking non-instrumental qualities into account in addition to usefulness and usability, further user characteristics have to be considered, e.g. centrality of visual product aesthetics, preferred interaction styles, etc.

9.2.2 User experience in design generation phases

The results of the analysis phase are the informational basis for the design generation activities. If the user experience framework has been used during the analysis to formulate requirements and design goals, the consideration of user experience is assured in the design phase. In addition, the use of the framework during the design phase to anticipate user reactions to design ideas and concepts can also help the designer to estimate the quality of user experience in early stages of the design process. The designer is supported by a model of the user that describes the holistic experience with a product incorporating instrumental and non-instrumental quality perceptions, emotional user reactions as well as their interrelations.

Especially aesthetic, symbolic, and motivational qualities and their detailed description can offer the designer ideas and guidelines to design for the whole user experience and to consider more than just functionality and usability. However, more research is necessary to find design principles and patterns that help to design for non-instrumental qualities. Visual aesthetics have been focused as one example of non-instrumental qualities in the empirical studies. Plenty of contributions in the literature and experiences from practice exist on the design for visual aesthetics. Other qualities, like acoustic or haptic quality and in particular symbolic and motivational aspects lack this broad collection of knowledge.

The empirical studies have delivered some results regarding the importance of the various instrumental and non-instrumental quality perceptions for users' overall judgments and decisions between alternatives. Although these results are domain- and product-specific, further studies can deliver data that help to make better decisions in prioritizing design activities related to different quality aspects.

Next to the prioritization of design goals based on empirical results regarding the relevance of specific qualities, the design activities relating to specific qualities can be associated with different stages of the design phase. While today decisions about the realization of the functionality of a product are made early in the design process (conceptual design), ergonomic and especially aesthetics aspects are mostly addressed in later phases (detailed design). This approach can be helpful when the main focus of the product development is on new functionality. However, if ergonomic or aesthetic aspects are on the top of the requirements list, they have to be integrated earlier in the design process. Additionally, symbolic and motivational qualities are not aspects that can be added late in the process, although this may be more complicated as they are interconnected in a more complex way with other quality perceptions.

9.2.3 User experience in evaluation phases

Engineering design, user-centered design, and usability engineering processes propose to evaluate outcomes of design activities as often as possible and at different stages during the development process. User-centered design and usability engineering focus on evaluations with users. Certainly, user tests are the best way to evaluate user experience. In Chapter 4, a variety of methods is discussed to measure instrumental and non-instrumental qualities as well as emotional user reactions. These methods can be used one-to-one in user studies during the development process.

The user experience framework is the basis to select the relevant methods in a specific evaluation situation. Studies 1 to 3 demonstrate how the methods can be combined and applied to evaluate user experience. While in Study 1 finished products are assessed, in Studies 2 and 3 simulations are used that are similar to product prototypes. This demonstrates that the proposed methods can already be used in early phases of the product development process to evaluate user experience with prototypical realizations of the product. Questionnaires are easily applicable in very early stage of the development process and can also be used with mock-ups that offer less interactivity. As physiological measures are more costly, there application may be more appropriate in later evaluations.

The idea of the user experience approach is to consider all aspects of the interaction with a product that are important from the user’s perspective. In contrast, when focusing for example on usability in a user test during the development process only specific aspects of the product are relevant. To consider the whole user experience in evaluations during early stages, a test situation has to be created, which is similar to the interaction with the finished product. This is a challenge if only first mock-ups of the product or even design ideas are available. Nonetheless, when focusing on user experience it is essential to create a situation that allows the user to experience all aspect of the interaction that will be relevant when using the finished product.

Some of the qualities of the product can be evaluated separately. As already mentioned, usability aspects can be the focus and also functionality as well as aesthetics – as for example demonstrated in the pre-test of Study 2 – can be addressed in separated studies. However, symbolic and motivational qualities as well as emotional user reactions are hard to separate from user experience as a whole.

Results of user tests provide a product-specific relevance schema regarding the various components of user experience. This can be helpful for future projects when prioritizing design goals and planning design activities.

Heuristic evaluations are another possibility next to user tests to assess design ideas. Especially in the area of usability, a variety of approaches are proposed that allow experts to evaluate prototypes using lists of heuristics. These approaches are very helpful if it is not possible to conduct a user test either because of financial or temporal limitations. The user experience framework can be used as a basis for expert evaluations of user experience. A heuristic approach has already been used in a pre-test to select the products for the empirical study on non-instrumental quality measurement that has been described in Chapter 4. However, the heuristics that have been used by the experts are just a first step in this direction. Heuristics to evaluate non-instrumental qualities have to be enhanced to offer a useful and promising approach to evaluate user experience early during the development process with experts.

9.3 Chapter summary

A comparison of development processes from engineering design, user-centered design, and usability engineering reveals similarities regarding the main categories of activities. Analysis, design generation, and evaluation activities are differentiated. Recommendations to incorporate user experience design goals in the development process of interactive systems have to address these three categories of activities.

In the analysis phase, the user experience framework in particular can support the set up of requirement lists regarding system properties. Next to instrumental qualities especially non-instrumental and emotional aspects offer a new way of thinking about additional categories of design goals. The context and user analysis has to take into account additional variables like social context or centrality of visual product aesthetics if the aim is to consider the whole user experience.

The user research framework is also helpful during the design phases to anticipate user reactions to design ideas and concepts and estimate the quality of user experience early in the design process. Especially aesthetic, symbolic, and motivational qualities and their detailed description offer ideas and guidelines to design for the whole user experience.

User tests are the best way to evaluate for user experience. The methods described in Chapter 4 that have been applied in the empirical studies can be used in user studies during the development process. However, when focusing on user experience it is essential to create a test situation that allows the user to experience all aspect of the interaction that will be relevant for the finished product. Heuristic evaluations by experts are another possibility next to user tests to assess the user experience of prototypes during the development process. However, existing heuristics have to be extended.

10 Summary

Norman and Draper (1986) describe the question of the quality of experience from the user's perspective as the ultimate criterion of user-centered design. Nonetheless, design of interactive systems still focuses mostly on users' effective and efficient goal accomplishment. Without doubt, these design goals are still important, especially for interactive systems that are used in professional settings. However, researchers and practitioners realize that a consideration of aspects beyond usability becomes more important as interactive systems are used in a growing variety of contexts.

A variety of approaches have been proposed over the past decade to address this problem. However, most of the existing contributions have shortcomings. They lack empirical evidence, focus on specific aspects and therefore disregard important interrelations with other relevant facets of user experience, or do not differentiate properly between various new and relevant concepts. Especially four major issues have been addressed to overcome some of these shortcomings. First, the approach that has been described combines empirical evidence and comprehensiveness. Second, non-instrumental quality perceptions and emotional user reactions are considered as separate aspects of user experience that are strongly linked to instrumental quality perceptions. Third, a more comprehensive analysis of influencing factors of user experience offers a basis for experimental research and facilitates empirical studies to test various theoretical assumptions. Finally, this approach to user experience in human-technology interaction addresses four building blocks and therefore covers issues ranging from theory to application: theoretical considerations (Chapter 2, 3 and 8), methodological contributions (Chapter 4), empirical results (Chapter 5, 6 and 7), and recommendations for their application (Chapter 9).

In this chapter, the substantive theoretical, methodological, and empirical as well as the application-oriented contributions are summarized in Section 10.1 by reconsidering the research goals formulated at the beginning. An outline of future work is given in Section 10.2.

10.1 Research goals revisited

Incorporating user experience goals in the development process of interactive systems poses several challenges. In Chapter 1 this problem space has been introduced and structured and four research goals to define the scope and guide the research approach have been formulated. Below, these research goals are revisited and the contributions related to each research goal are presented.

Research Goal 1

Creating a framework to describe user experience of interaction

The framework presented in Chapter 3 accommodates existing research and identifies the key components that determine user experience. It is of high relevance to researchers as it supports the planning of studies, the formation of appropriate generalization from results, and provides well-founded approaches to measuring user experience. It is also beneficial to practitioners as it can be used to structure the design space in search for solutions and may guide the evaluation of user experience.

In the user experience framework, system properties, user characteristics, and context parameters are discussed as categories of influencing factors. Three main components of user experience are defined: instrumental and non-instrumental quality perceptions as well as emotional user reactions. Perceived usefulness and usability are introduced as aspects of instrumental quality. A hierarchical approach to non-instrumental quality perceptions defines three categories: aesthetics, symbolic, and motivational aspects. Sub-dimensions of these categories are defined that can be used to measure non-instrumental quality perceptions. Furthermore, a multi-component approach to emotions is introduced that defines five aspects of emotions defined by Scherer (1984): subjective feelings, physiological reactions, motor expressions, cognitive appraisals and behavioral tendencies. Additionally, Russell's (1980) dimensional approach to describe emotional qualities of subjective feelings and a model to further define cognitive appraisals by Scherer (2001) are proposed. Overall judgments, choices between alternatives, and usage behavior are defined as consequences of user experience.

Additionally, interrelations between the components are defined. Influencing factors are assumed to determine the interaction that is experienced by the user. Instrumental and non-instrumental qualities are directly perceived during the interaction, while emotional user reactions depend on these quality perceptions. Consequences of user experience are influenced by instrumental and non-instrumental quality perceptions as well as emotional user reactions. These assumptions have been verified in three empirical studies (Research Goal 3).

Research Goal 2

Developing a toolbox of methods to assess the central components of user experience

In the user experience framework, instrumental and non-instrumental quality perceptions as well as emotional user reactions are defined as central components of user experience. Davis'

(1989) approach to technology acceptance that integrates users' perceived usefulness and usability as instrumental quality aspects is recommended to measure instrumental qualities as defined in the user experience framework. Kirakowski's (1996) questionnaire to measure subjective usability (SUMI) is suggested to measure perceived usability in more detail.

A toolbox for measuring non-instrumental quality perceptions is presented that is based on a hierarchical model of non-instrumental qualities and differentiates sub-dimensions of aesthetic, symbolic, and motivational aspects. Existing questionnaires to measure these dimensions are proposed and integrated. The results of an empirical study demonstrate that a diversity of non-instrumental qualities has to be taken into account to understand the relevance of non-instrumental qualities sufficiently.

A toolbox for measuring emotional user reactions is described that is based on a multi-component model of emotions and defines five aspects of emotional user reactions: subjective feelings, physiological reactions, motor expressions, cognitive appraisals, and behavioral tendencies. A selection of methods to measure these five aspects of emotional user reactions is presented. Proposed methods range from questionnaires and physiological measure (EMG, EDA, heart rate) to video, sound, and behavioral data analysis. The results of a study applying a selection of these methods demonstrate that the five aspects of emotional user reactions are only slightly connected and it is recommended to incorporate different aspects of emotional user reactions to understand emotional user reactions in detail.

Research Goal 3

Investigating influencing factors, the interrelations of the central components, and their influence on consequences of user experience

In all three studies different influencing factors of user experience are varied. The results show that system properties have a direct influence on quality perceptions and emotional user reactions. User characteristics (culture: Europe vs. North America; centrality of visual product aesthetics) and context parameters (situation: task- vs. exploration) have an impact on the interrelations of user experience components. The results of the studies show that instrumental and non-instrumental qualities can be perceived independently. Instrumental and non-instrumental quality perceptions influence emotional user reactions. The impact of instrumental and non-instrumental quality perceptions on emotional user reactions depends on the context of the interaction. The results demonstrate that overall judgments and alternative choice mainly depend on instrumental quality perceptions, but that non-instrumental quality perceptions and emotional user reactions have an influence that varies depending on contextual factors and user characteristics.

In summary, the results of the three studies support most of the assumptions made in the user experience framework. Therefore, it can be argued that no extension or modification of the overall framework is necessary. All three categories of influencing factors have a significant influence on user experience. User characteristics and context parameters show a particular influence on the interrelations of the user experience components and their impact on consequences of user experience. With respect to interrelation of the studied components, the results of the three studies support the assumptions that (1) instrumental and non-instrumental qualities are perceived independently, (2) emotional user reactions are determined by instrumental and non-instrumental quality perceptions, and (3) consequences of user experience are influenced by all *three* components of user experience.

Research Goal 4

Compiling recommendations regarding the use of the theoretical, methodological, and empirical contributions in the development process of interactive systems

Recommendations to take into account user experience are formulated for analysis, design generation, and evaluation activities during the development process. In the analysis phase, the user experience framework in particular can support the set up of requirement lists regarding system properties. Next to instrumental qualities especially non-instrumental and emotional aspects offer a new way to think about additional categories of design goals. The context and user analysis has to consider additional variables like social context or centrality of visual product aesthetics.

The user research framework can also be helpful during the design phases to anticipate user reactions to design ideas and concepts as well as to estimate the quality of user experience early in the design process. Especially aesthetic, symbolic, and motivational qualities and their detailed description can offer ideas and guidelines to design for the whole user experience and to consider more than functionality and usability.

User tests are the recommended way to evaluate user experience. The toolbox of methods that is an outcome of Research Goal 2 can be applied in user studies during the development process. Furthermore, it is essential to create a situation that allows the user to experience all aspects of the interaction that will be relevant when using the finished product. Heuristic evaluations by experts are an additional possibility to assess the experience of prototypes. First heuristics to support experts evaluating user experience of interactive system are available, but have to be improved.

10.2 Directions for future work

The user experience framework has successfully been used to overcome shortcomings, clarify some of the ambiguities of existing approaches, compose a toolbox of methods to assess the user experience, and guide empirical research to test general assumptions about the interrelations of user experience components. However, it still needs to be further tested and elaborated. This requires testing the predicted interrelations in different application domains using more framework variables. Suggestions for application areas in which the framework could be used are for example in-vehicle information systems (Mahlke, 2007a) or web technologies (Mahlke, 2005). Visual aesthetics and usability have been focused in the empirical part of this research. A focus on other aesthetic qualities as well as on symbolic and motivational aspects could lead to further interesting results and is necessary to fully understand user experience. Especially, system properties that relate to symbolic and motivational qualities are not very well understood yet.

Another area for future work lies in the adaptation of methods for applied contexts. A first attempt is the workshop 'Now Let's Do It in Practice – User Experience Evaluation Methods in Product Development' held as part of CHI 2008 (organized by Väänänen-Vainio-Mattila, Roto & Hassenzahl). Especially, methods to measure aspects of emotional user reactions can be improved in a way to be more practical. First technologies are available that for example measure facial expressions based on video and are integrated in eye tracking systems (Zaman and Shrimpton-Smith, 2006). Approaches to the measurement of cognitive appraisals – as another aspect of emotional user reactions – have to be adapted to be successfully applied in further areas of human-technology interaction.

Additionally, more work is needed to improve methods to measure non-instrumental qualities. Lavie and Tractinsky's (2004) approach to assess visual aesthetics is a first step, but further research has to test certain assumptions of the measurement approach, like the relation of the concept of expressive aesthetics and symbolic aspects (Mahlke, 2007b). First steps have been taken to assess acoustic and haptic quality, but the fact that validated tools to measure symbolic and motivational aspects are missing complicates research for a better understanding of these concepts.

Unfortunately, these qualities are in particular promising with respect to the design for more positive experiences. All studies – especially Study 2 – demonstrate that emotional user reactions in human-technology interaction mostly range from frustration to satisfaction, but that it is hard to create enjoyable and exciting experiences. A better understanding of the interplay of instrumental and non-instrumental qualities is needed to learn more about designing for more positive reactions.

One suggestion formulated in the discussion of Study 2 is that it was not possible to generate positive and arousing emotions because the used systems were not particularly outstanding and it might be necessary to induce quality perceptions that reach beyond users' previous experiences to produce enjoyment and excitement. This interpretation assumes that users' previous experience plays an important role with respect to positive emotional user reactions.

Temporal aspects are very promising variables to better understand the dynamics of user experience (Hassenzahl & Tractinsky, 2006). Temporality plays a role on different levels of user experience. Short interactive episodes that last from minutes to hours are one level. Hassenzahl and Sandweg (2004) used an approach to the summary assessment of experience from decision making (Ariely & Carmon, 2003) to study users' evaluations of usability after they used an interactive system for about one hour. They measured usability related data repeatedly during the usability test, related these measurements to the overall usability assessment at the end, and found that the perceived usability at the end of the session had a significant influence on the overall usability assessment. Approaches to emotional episodes (e.g. Russell & Feldman Barrett, 1999) offer a comparable theoretical basis for dynamic studies of emotional user reactions.

On a different level, research on usage periods that last from days to months could explain the importance of various qualities of interactive systems during different usage stages. For example, a simple and plausible hypothesis for the domain of consumer electronic products is that during the purchase process aesthetic and symbolic aspects play an important role while later issues regarding usability are more relevant. However, such hypotheses have to be studied empirically to gain validated knowledge that better explains user experience of interaction on a larger time scale.

Concluding, a variety of open questions and challenging research issues remain for the concept of user experience in human-technology interaction. Nonetheless, this work contributes a framework that restructures relevant components of user experience, proposes a methodological approach to the assessment of user experience and demonstrates the applicability of the framework and the methods in a variety of empirical studies. Furthermore, first recommendations are formulated to use these contributions during the development process of interactive systems.

References

Adams, D. A., Nelson, R. R. & Todd, P. A. (1992). Perceived usefulness, ease of use, and usage of information technology: A replication. *MIS Quarterly*, *16,* 227-247.

Ajzen, I. & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Alben, L. (1996). Quality of experience - Defining the criteria for effective interaction design. *Interactions*, *3(3),* 11-15.

Ariely, D. & Carmon, Z. (2003). Summary assessment of experiences: The whole is different from the sum of its parts. In G. Loewenstein, D. Read, and R. F. Baumeister (Eds.), *Time and decision. Economic and psychological perspectives on interpersonal choice* (pp. 323-349). New York: Russel Sage.

Ashby, M. & Johnson, K. (2002). *Materials and design.* Oxford, UK: Heinemann.

Banse, R. & Scherer, K. R. (1996). Acoustic Profiles in Vocal Emotion Expression. *Journal of Personality and Social Psychology*, *70,* 614-636.

Batra, R. & Ahtola, O. T. (1990). Measuring the hedonic and utilitarian sources of consumer choice. *Marketing Letters*, *2,* 159-170.

Battarbee, K. (2003). Co-experience: The social user experience. In *CHI'03 Extended Abstracts* (pp. 730-731). New York: ACM Press.

Beatty, J. (1982). Task-evoked pupillary responses, processing load, and the structure of processing resources. *Psychological Bulletin*, *91,* 276-292.

Ben-Bassat, T., Meyer, J. & Tractinsky, N. (2006). Economic and subjective measures of the perceived value of aesthetics and usability. *ACM Transactions on Computer-Human Interaction*, *13,* 210-234.

Belk, R. (1988). Possessions and the Extended Self. *Journal of Consumer Research*, *15,* 139-168.

Bevan, N. (1995). Measuring usability as quality of use. *Software Quality Journal*, *4,* 115-130.

Bevan, N., Kirakowski, J. & Maissel, J. (1991). What is usability? In H.-J. Bullinger (Ed.), *Human aspects in computing: design and use of interactive systems and work with terminals* (pp. 651-655). Amsterdam: Elsevier.

Bevan, N. & Macleod, M. (1994). Usability measurement in context. *Behaviour and Information Technology*, *13*, 132-145.

Bloch, P. H. (1995). Seeking the ideal form - product design and consumer response. *Journal of marketing*, *59*, 16-29.

Bloch, P. H., Brunel, F. F. & Arnold, T. J. (2003). Individual differences in the centrality of visual product aesthetics: Concept and measurement. *Journal of Consumer Research*, *29*, 551-565.

Blythe, M., Overbeeke, K., Monk, A. & Wright, P. (2003). *Funology: from usability to enjoyment.* Dordrecht: Kluwer.

Blythe, M., Reid, J., Wright, P. & Geelhoed, E. (2006). Interdisciplinary criticism: analysing the experience of riot! a location-sensitive digital narrative. *Behaviour & Information Technology*, *25*, 127-139.

Boehner, K., DePaula, R., Dourish, P. & Sengers, P. (2007). How emotion is made and measured. *International Journal of Human-Computer Studies, 65,* 275-291.

Bradley, M. M., Greenwald, M. K. & Hamm, A. O. (1993). Affective Picture Processing. In N. Birbaumer & A. Öhman (Eds.), *The structure of Emotion* (pp. 48-65). Toronto: Hogrefe & Huber Verlag.

Brave, S., & Nass, C. (2003). Emotion in Human-Computer Interaction. In J. Jacko & A. Sears (Eds.), *The Human-Computer Interaction Handbook* (pp. 81-96). Mahwah, NJ: Lawrence Erlbaum Associates.

Brooke, J. (1996). SUS: A Quick and Dirty Usability Scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester & I. L. McClelland (Eds.), *Usability Evaluation in Industry* (pp. 189-194). London: Taylor & Francis.

Burmester, M., Platz, A., Rudolph, U. & Wild, B. (1999). Aesthetic design - just an add on? In H.-J. Bullinger & J. Ziegler (Eds.), *Human Computer Interaction: Ergonomics and User Interfaces* (pp. 671-675). Mahwah, NJ: Lawrence Erlbaum.

Cacioppo, J. T., Petty, R. E., Losch. M. E. & Kim, H. S. (1986). Electromyographic activity over facial muscle regions can differentiate the valence and intensity of affective reactions. *Journal of Personality and Social Psychology, 50,* 260-268.

Cakir, A., Hart, D. J. & Stewart, T. F. M. (1979). *The VDT Manual.* Darmstadt: IFRA.

Carroll, J. M. (2004). Beyond fun. *Interactions*, *1(5),* 38-40.

Carroll, J. M. & Thomas, J. C. (1988). FUN. *SIGCHI Bulletin*, *19(3)*, 21-24.

Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience*. New York: Harper & Row.

Chen, H., Wigand, R. & Nilan, M. (1999). Optimal experience of web activities. *Computers in human behavior, 15*, 585-608.

Chin, J. P., Diehl, V. A. & Norman, K. L. (1988). Development of an Instrument Measuring User Satisfaction of the Human-Computer Interface. In *CHI'88 Conference Proceedings*. (pp. 213-218). New York: ACM Press.

Cohen, I., Sebe, N., Chen, L., Garg, A. & Huang, T. S. (2003). Facial Expression Recognition from Video Sequences: Temporal and Static Modeling. *Computer Vision and Image Understanding, 91,* 160-187.

Compeau, D., Gravill, J., Haggerty, N. & Kelley, H. (2006). Computer Self-efficacy: A Review. In P. Zhang & D. Galetta (Eds.), *Human-Computer Interaction and Management Information Systems: Foundations*. Armonk, NY: M. E. Sharpe.

Creusen, M. & Schoormans, J. (1998). The influence of observation time on the role of the product design in consumer preference. *Advances in consumer research, 25,* 551-556.

Creusen, M. & Schoormans, J. (2005). The different roles of product appearance in consumer choice. *Journal of product innovation management, 22*, 63-81.

Crilly, N., Moultrie, J. & Clarkson, P. J. (2004). Seeing things: consumer response to the visual domain in product design. *Design Studies, 25,* 547-577.

Cushman, W. H. & Rosenberg, D. J. (1991). *Human factors in product design.* Amsterdam: Elsevier.

Damasio, A. R. (1994). *Descartes' Error: Emotion, Reason and the Human Brain.* New York: Grosset/Putnam.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*, 319-340.

Davis, F. D., Bagozzi, R. P. & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35,* 982-1003.

Davis, F. D., Bagozzi, R. P. & Warschaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology, 22,* 1111-1132.

Davis, S. B., Davies, G., Haddad, R. & Lai, M. (2006). Smell me: engaging with an interactive olfactory game. In N. Bryan-Kinns, A. Blanford, P. Cruzon & L. Nigay (Eds.), *People and Computers XX - Engage* (pp. 25-40). London: Springer.

Desmet, P. M. A. (2003a). A multilayered model of product emotions. *The design journal, 6(2)*, 4-13.

Desmet, P. M. A. (2003b). Measuring emotions: Development and application of an instrument to measure emotional responses to products. In M. Blythe, K. Overbeeke, A. Monk & P. Wright (Eds.), *Funology: from usability to enjoyment* (pp. 111-124).

Dordrecht: Kluwer Academic.

Desmet, P. M. A. & Hekkert, P. (2002). The basis of product emotions. In W. Green & P. Jordan (Eds.), *Pleasure with Products, beyond usability* (pp. 60-68). London: Taylor & Francis.

Dimberg, U. (1990). Facial electromyography and emotional reactions. *Psychophysiology*, *19,* 643-647.

Draper, S. W. (1999). Analysing fun as a candidate software requirement. *Personal and Ubiquitous Computing*, *3*, 1-6.

Dzida, W. (1983). Das IFIP-Modell für Benutzerschnittstellen [The IFIP model of user interfaces]. *Office-Management, 31,* 6-8.

Ekman, P. (1992). Are there basic emotions? *Psychological Review*, *99*, 550-553.

Ellsworth, P. C. & Scherer, K. R. (2004). Appraisal processes in emotion. In R. J. Davidson, H. Goldsmith & K. R. Scherer (Eds.), *Handbook of the Affective Sciences* (pp. 572-595). New York: Oxford University Press.

Fahrenberg, J. (2001). Physiologische Grundlagen und Messmethoden der Herz-Kreislaufaktivität [Physiological fundamentals and measuring methods of cardiovascular activity]. In F. Rösler (Ed.), *Grundlagen und Methoden der Psychophysiologie* (pp. 317-454). Göttingen: Hogrefe.

Farina, A. (2001). Acoustic quality of theatres: correlations between experimental measures and subjective evaluations. *Applied acoustics, 62,* 889-916.

Finneran, C. M. & Zhang, P. (2003). A person-artifact-task (PAT) model of flow antecedents in computer-mediated environments. *International Journal of Human-Computer Studies*, *59*, 475-496.

Foley, J. D. & Van Dam, A. (1982). *Fundamentals of interactive computer graphics.* Reading, MA: Addison-Wesley.

Forlizzi, J. & Battarbee, K. (2004). Understanding experience in interactive systems. In *DIS'04 Conference Proceedings* (pp. 261-268). New York: ACM Press.

Forlizzi, J. & Ford, S. (2000). The building blocks of experience: An early framework for interaction designers. *Proceedings of Conference on Designing Interactive Systems 2000*, 419-423.

Frijda, N. H. (1988). The Laws of Emotion. *American Psychologist*, *43,* 349-358.

Frijda, N. H. (1994). Varieties of affect: emotions and episodes, moods and sentiments. In P. Ekman & R. J. Davidson (Eds.), *The Nature of Emotion, fundamental questions* (pp. 59-67). Oxford: Oxford University Press.

Gaver, B. & Martin, H. (2000). Alternatives - Exploring information appliances through conceptual design proposals. In *CHI '00 Conference Proceedings* (pp. 209-216). New

York: ACM Press.

Gaver, B. et al. (2004). The drift table: Designing for ludic engagement. In *CHI'04 Extended Abstracts* (*pp.* 885-900). New York: ACM Press.

Green, W. S. & Jordan, P. W. (2002). *Pleasure with Products: Beyond Usability*. London: Taylor and Francis.

Grudin, J. (1990). The computer reaches out: the historical continuity of interface design. In *CHI '90 Conference Proceedings* (pp. 261-268). New York: ACM Press.

Grudin, J. (1992). Utility and usability: Research issues and development contexts. *Interacting with Computers*, *4* 209-217.

Gulliver, S. R. & Ghinea, G. (2006). Defining user perception of distributed multimedia quality. *ACM Transactions on Multimedia Computing, Communications, and Applications, 2*, 241-257.

Han, S. H., Kim, K. J., Yun, M. H., Hong, S. W. & Kim, J. (2004). Identifying mobile phone design features critical to user satisfaction. *Human Factors and Ergonomics in Manufacturing*, *14*, 15-29.

Hassenzahl, M. (2001). The effect of perceived hedonic quality on product appealingness. *International Journal of Human-Computer Interaction*, *13,* 481-499.

Hassenzahl, M. (2003). The thing and I: Understanding the relationship between user and product. In M. Blythe, C. Overbeeke, A. F. Monk, & P. C. Wright (Eds.), *Funology: From Usability to Enjoyment* (pp. 31-42): Kluwer Academic Publishers.

Hassenzahl, M. (2004b). Emotions can be quite ephemeral. We cannot design them. *Interactions*, *11(5)*46-48.

Hassenzahl, M. (2004a). The Interplay of Beauty, Goodness, and Usability in Interactive Products. *Human-Computer Interaction*, *19*, 319-349.

Hassenzahl, M. (2006). Hedonic, Emotional, and Experiental Perspectives on Product Quality. In C. Ghaoui (Ed.), *Encyclopedia of Human Computer Interaction* (pp. 266-272). London: Idea Group.

Hassenzahl, M. (2007). Aesthetics in interactive products: Correlates and consequences of beauty. In H. N. J. Schifferstein & P. Hekkert (Eds.), *Product experience.* Amsterdam: Elsevier.

Hassenzahl, M., Kekez, R. & Burmester, M. (2002). The importance of a software's pragmatic quality depends on usage modes. In H. Luczak, A. E. Cakir & G. Cakir (Eds.), *Proceedings of the 6th international conference on Work With Display Units (WWDU 2002)* (pp. 275-276). Berlin: ERGONOMIC.

Hassenzahl, M., Platz, A., Burmester, M. & Lehner, K. (2000). Hedonic and ergonomic quality aspects determine a software´s appeal. In *CHI '00 Conference Proceedings* (pp.

201-208). New York: ACM Press.

Hassenzahl, M. & Sandweg, N. (2004). From mental effort to perceived usability: Transforming experiences into summary assessments. In *CHI’04 Extended Abstracts* (*pp.* 1283-1286). New York: ACM Press.

Hassenzahl, M. & Tractinsky, N. (2006). User experience - a research agenda. *Behaviour & Information Technology, 25*, 91-97.

Hassenzahl, M. & Ullrich, D. (2007). To do or not to do: Differences in user experience and retrospective judgments depending on the presence or absence of instrumental goals. *Interacting with computers, 19,* 429-437.

Hatscher, M. (2002). Joy of Use - Determinants of joy. In H. Luczak, A. E. Cakir, & G. Cakir (Eds.), *Proceedings of the 6th international conference on Work With Display Units* (pp. 277-278). Berlin: ERGONOMIC.

Hekkert, P., Snelders, D. & van Wieringen, P. C. (2003). ‘Most advanced, yet acceptable’: typicality and novelty as joint predictors of aesthetic preference in industrial design. *British Journal of Psychology, 94,* 111-124.

Hendrickson, A. R., Massey, P. D. & Cronan, T. P. (1993). On the test-retest reliability of perceived usefulness and perceived ease of use scales. *MIS Quarterly, 17,* 227-230.

Herbon, A., Peter, Ch., Markert, L., van der Meer, E. & Voskamp, J. (2005). Emotion studies in HCI - a new approach. In *HCII’05 Conference Proceedings.* Las Vegas, NV: Mira Digital Publishing.

Hess, E. H. & Polt, J. M. (1960). Pupil Size in Relation to Interest Value of Visual Stimuli. *Science, 132,* 349-350.

Hofstede, G. (1980). *Culture's Consequences: International Differences in Work-Related Values*. Beverly Hills, CA: Sage.

Hornbæk, K. (2006). Current practice in measuring usability: Challenges to usability studies and research. *International Journal of Human-Computer Studies, 64,* 79-102.

Hornbæk, K. & Law, E. (2007). Meta-Analysis of Correlations Among Usability Measures. In *CHI '07 Conference Proceedings* (pp. 617-626). New York: ACM Press.

Igbaria, M., Schiffman, S. J. & Wieckowski, T. J. (1994). The respective roles of perceived usefulness and perceived fun in the acceptance of microcomputer technology. *Behaviour & Information Technology, 13,* 349-361.

International Organization for Standardization (1998). *ISO 9241 - Ergonomic requirements for office work with visual display terminals (VDTs) - Part 11: Guidance on usability*.

International Organization for Standardization (1999). *ISO 13407 - Human-centred design processes for interactive systems*.

International Organization for Standardization (2001). *ISO 9126 - Software engineering -*

Product quality.

International Telecommunications Union (2004). *Subjective quality evaluation of telephone services based on spoken dialogue systems*.

Izard, C. E. (1977). *Human Emotions.* New York: Plenum Press.

Jekosch, U. (2004). Basic Concepts and Terms of 'Quality', reconsidered in the Context of Product-Sound Quality. *Acta Acustica, 90*, 999-1006.

Jordan, P. W. (1998). Human factors for pleasure in product use. *Applied Ergonomics, 29*, 25-33.

Jordan, P. W. (2000). *Designing pleasurable products.* London: Taylor & Francis.

Kallio, T. (2003). Why We Choose the More Attractive Looking Objects - Somatic Markers and Somaesthetics in User Experience. In *DPPI'03 Conference Proceedings* (pp. 142-143). New York: ACM Press.

Kano, N. (1984). Attractive quality and must-be quality. *The Journal of the Japanese Society for Quality Control*, *14(2),* 39-48.

Katz-Haas, R. (1998). Ten Guidelines for User-Centered Web Design. *Usability Interface*, *5*.

Keinonen, T. (1998). *One-dimensional usability - Influence of usability on consumers' product preference*. Helsinki, Finland: University of Art and Design.

Kim, J., Lee, J. & Choi, D. (2003). Designing emotionally evocative homepages: an empirical study of the quantitative relations between design factors and emotional dimensions. *International Journal of Human-Computer-Studies*, *59*, 899-940.

Kirakowski, J. (1996). The software usability measurement inventory: Background and usage. In P. W. Jordan, B. Thomas, B. A. Weerdmeester & I. L. McClelland (Eds.), *Usability Evaluation in Industry* (pp. 169-178). London: Taylor & Francis.

Kirakowski, J. & Corbett, M. (1993). SUMI: The Software Usability Measurement Inventory. *British Journal of Educational Technology*, *24*, 210-212.

Kleiss, J. A. & Enke, G. (1999). Assessing Automotive Audio System Visual Appearance Attributes Using Empirical Methods. In *Human Factors in Audio Interior Systems, Driving, and Vehicle Seating*. Warrendale: Society of Automotive Engineers.

Kollmann, T. (2004). Attitude, adoption or acceptance? Measuring the market success of telecommunication and multimedia technology. *International Journal of Business Performance Management*, *6*, 133-152.

Kurosu, M. & Kashimura, K. (1995). Apparent usability vs. inherent usability - Experimental analysis on the determinants of the apparent usability. In *CHI´95 Conference Proceedings* (pp. 292-293). New York: ACM Press.

Lang, J. (1988). Symbolic aesthetics in architecture: toward a research agenda. In J. L. Nasar (Ed.), *Environmental aesthetics* (pp. 11-26). New York: Cambridge University Press.

Lang, P. J. (1980). Behavioral treatment and bio-behavioral asessment: Computer applications. In J. B. Sidowski, H. Johnson & T. A. Williams (Eds.), *Technology in Mental Health Care Delivery Systems* (pp. 119-137). Norwood, NJ: Ablex.

Lang, P. J., Greenwald, M. K., Bradley, M. M. & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology, 30,* 261-27.

Larsen, R. J. & Fredrickson, B. L. (1999). Measurement issues in emotion research. In D. Kahnemann, E. Diener & N. Schwarz (Eds.), *Well-Being: the foundations of hedonic psychology*. New York: Russel Sage Foundation.

Laugwitz, B. (2001). *Experimentelle Untersuchung von Regeln der Ästhetik von Farbkombinationen und von Effekten auf den Benutzer bei ihrer Anwendung im Benutzungsoberflächendesign [Experimental investigation of the aesthetics of color combinations and of its impact on users when applied to graphical user interface design]*. Berlin: dissertation.de.

Laurel, B. K. (1986). Interface as mimesis. In D. A. Norman & S. W. Draper (Eds.), *User centered system design - New Perspectives on Human-Computer Interaction*. Hillsdale, N.J.: Lawrence Erlbaum.

Laurel, B. K. (1991). *Computers as theatres.* Boston: Addison-Wesley.

Lauriault, T. & Lindgaard, G. (2006). New and promising territory? Exploring the use of olfaction in cybercartography. *Cartographica*, *41*, 73-91.

Lavie, T. & Tractinsky, N. (2004). Assessing dimensions of perceived visual aesthetics of web sites. *International Journal of Human-Computer Studies*, *60,* 269-298.

Lazarus, R. S. (1991). *Emotion and adaptation.* New York: Oxford University Press.

Leder, H., Belke, B., Oeberst, A. & Augustin, D. (2004). A model of aesthetics appreciation and aesthetic judgments. *British Journal of Psychology, 95,* 489-508.

Leder, H. & Carbon, C. C. (2005). Dimensions in appreciation of car interior design. *Applied Cognitive Psychology*, *19,* 603-618.

LeDoux, J. E. (1995). Emotion: Clues from the Brain. *Annual Review of Psychology*, *46,* 209-235.

Lewis, J. R. (1995). IBM computer usability satisfaction questionnaires: Psychometric evaluation and instructions for use. *International Journal of Human-Computer Interaction*, *7,* 57-78.

Lindgaard, G. & Dudek, C. (2003). What is the evasive beast we call user satisfaction? *Interacting with Computers*, *15,* 429-452.

Lindgaard, G. & Whitfield, T. W. A. (2004). Integrating aesthetics within an evolutionary and psychological framework. *Theoretical Issues in Ergonomics Science*, *2*, 73-90.

Liu, Y. (2003). Engineering aesthetics and aesthetic ergonomics: Theoretical foundations and a dual-process research methodology. *Ergonomics*, *46*, 1273-1292.

Logan, R. J. (1994). Behavioral and emotional usability: Thomson consumer electronics. In M. E. Wiklund (Ed.), *Usability in practice: How companies develop user friendly products* (pp. 59-82). Boston: Academic Press.

Lyon, R. H. (2003). Product Sound Quality - from Perception to Design. *Sound and vibration, 108*, 2471-2475.

Macdonald, A. S. (1997). Developing a qualitative sense. In N. A. Stanton (Ed.), *Human factors in consumer product design and evaluation* (pp. 175-191). London: Taylor & Francis.

Macdonald, A. S. (2001). Aesthetic intelligence: optimizing user-centred design. *Journal of Engineering Design*, *12*, 37-45.

Mahlke, S. (2002). Factors influencing the experience of website usage. In *CHI '02 Extended Abstracts* (pp. 846-847). New York: ACM Press.

Mahlke, S. (2005). An integrative model on web user experience. In P. Isaías & M. B. Nunes (Eds.), *Proceeding of ICWI2005* (pp. 91-95). Lisbon, Portugal: IADIS.

Mahlke, S. (2006a). Studying user epxernce with digital audio players. In R. Harper, M. Rauterberg & M. Combetto (Eds.), *Entertainment Computing – ICEC2006* (pp. 358-361). Berlin: Springer.

Mahlke, S. (2006b). Aesthetic and Symbolic Qualities as Antecedents of Overall Judgements of Interactive Products. In N. Bryan-Kinns, A. Blanford, P. Cruzon & L. Nigay (Eds.), *People and Computers XX - Engage* (pp. 57-64). London: Springer.

Mahlke, S. (2007a). *User experience of driver assistance systems*. Position paper for the Mensch & Computer 2007 workshop 'Automotive User Interfaces'.

Mahlke, S. (2007b). Interview with Gitte Lindgaard on visual appeal and aesthetics in human-technology interaction. *mmi interaktiv, 13*, 96-102.

Mahlke, S., Lemke, I. & Thüring, M. (2007). The diversity of non-instrumental qualities in human-technology interaction. *mmi interaktiv, 13,* 55-64.

Mahlke, S. & Lindgaard, G. (2007). Emotional Experiences and Quality Perceptions of Interactive Products. In J. Jacko (Ed.), *Human-Computer Interaction, Part I,* (pp. 164-173). Berlin: Springer.

Mahlke, S., Minge, M. & Thüring, M. (2006). Measuring multiple components of emotions in interactive contexts. In *CHI '06 Extended Abstracts* (pp. 1061-1066). New York: ACM Press.

Mahlke, S. & Thüring, M. (2007). Studying Antecedents of Emotional Experiences in Interactive Contexts. In *CHI '07 Conference Proceedings* (pp. 915-918). New York: ACM Press.

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive Science*, *4,* 333-369.

Martinho, C., Machado, I. & Paiva, A. (2000). A cognitive approach to affective user modeling. In A. Paiva (Ed.), *Affective interactions: towards a new generation of computer interfaces* (pp. 64-75). Berlin: Springer.

Matsumoto, D. (1993). Ethnic differences in affect intensity, emotion judgments, display rule attitudes, and self-reported emotional expression in an American sample. *Motivation and Emotion*, *17,* 107-123.

Mayhew, D. J. (1999). *The Usability Engineering Lifecycle.* London: Academic Press.

McCarthy, J. & Wright, P. (2004). *Technology as experience.* Cambridge: MIT Press.

Mentis, H. & Gay, G. (2003). User Recalled Occurrences of Usability Errors: Implications on the User Experience. In *CHI'03 Extended Abstract* (pp. 736-737): New York: ACM Press.

Millard, N., Hole, L. & Crowle, S. (1999). Smiling Through: Motivation at the User Interface. In Bullinger, H.-J. & Ziegler, J. (Eds.), *Human Computer Interaction: Ergonomics and User Interfaces* (pp. 824-828). Mahwah, NJ: Lawrence Erlbaum.

Möller, S. (2005). *Quality of Telephone-Based Spoken Dialogue Systems*. New York: Springer.

Monk, A., Hassenzahl, M., Blythe, M. & Reed, D. (2002). Funology: designing enjoyment. In *CHI’02 Extended Abstracts* (pp. 924-925). New York: ACM Press.

Morris, M. G. & Turner, J. M. (2001). Assessing users' subjective quality of experience with the world wide web: an exploratory examination of temporal changes in technology acceptance. *International Journal of human-Computer Studies*, *54,* 877-901.

Mundorf, N., Westin, S. & Dholakia, N. (1993). Effects of hedonic components and user’s gender on the acceptance of screen-based information services. *Behaviour & Information Technology*, *12*, 293-301.

Nielsen, J. (1993). *Usability Engineering*. San Diego: Academic Press.

Nielsen, J. & Levy, J. (1994). Measuring usability: preference vs. performance. *Communications of the ACM*, *37*, 66-75.

Norman, D. A. (1999). *The Invisible Computer.* MIT Press.

Norman, D. A. (2002). Emotion & design - attractive things work better. *Interactions, 9(4),* 36-42.

Norman, D. A. (2004). *Emotional design: why we love (or hate) everyday things.* New York: Basic Books.

Norman, D. A. & Draper, S. (1986). *User Centered System Design: New Perspectives on Human-Computer Interaction.* Hillsdale: Lawrence Erlbaum.

Novak, T. P., Hoffman, D. L. & Yung, Y. (1999). Measuring the customer experience in online environments: A structural modeling approach. *Marketing Science, 19*, 22-42.

Oatley, K. & Johnson-Laird, P. N. (1987). Towards a cognitive theory of emotions. *Cognition and Emotion, 1*, 29-50.

Oliver, R. L. (1993). Cognitive, affective, and attribute basis of the satisfaction response. *Journal of Consumer Research, 20*, 418-430.

Ortony, A., Clore, G. L. & Collins, A. (1988). *The cognitive structure of emotions.* Cambridge: Cambridge University Press.

Ortony, A., Norman, D. A. & Revelle, W. (2005). Affect and proto-affect in effective functioning. In J.-M. Fellous & M. A. Arbib (Eds.), *Who needs emotions? The brain meets the machine.* (pp. 173-202). New York: Oxford University Press.

Oulasvirta, A. & Saariluoma, P. (2004). Long-term working memory and interrupting messages in human-computer interaction. *Behaviour & Information Technology, 23*, 53-64.

Overbeeke, K., Djadjadiningrat, T., Hummels, C. & Wensveen, S. (2002). Beauty in usability: Forget about ease of use! In W. S. Green & P. W. Jordan (Eds.), *Pleasure with Products: Beyond Usability* (pp. 9-18). London: Taylor and Francis.

Paap, K. R. & Cooke, N. J. (1997). Design of menus. In M. G. Helander, T. K. Landauer & P. V. Prabhu (Eds.), *Handbook of Human-Computer Interaction* (pp. 533-572). North-Holland: Elsevier.

Pahl, G., Beitz, W., Feldhusen, J. & Grote, K. H. (2007). *Engineering Design*. London: Springer.

Park, S., Choi, D. & Kim, J. (2004). Critical factors for the aesthetic fidelity of web pages: empirical studies with professional web designers and users. *Interacting with Computers, 16*, 351-376.

Partala, T. & Surakka, V. (2004). The effects of affective interventions in human-computer interaction. *Interacting with Computers, 16*, 295-309.

Plocher, T. A., Garg, C. & Chestnut, J. (1999). Connecting culture, user characteristics and user interface design. In H.-J. Bullinger & J. Ziegler (Eds.), *Human Computer Interaction: Ergonomics and User Interfaces* (pp. 803-807). Mahwah, NJ: Lawrence Erlbaum.

Preece, J. (1994). *Human-computer interaction.* Reading, MA: Addison-Wesley.

Rafaeli, A. & Vilnai-Yavetz, I. (2004). Instrumentality, aesthetics and symbolism of physical artifacts as triggers of emotion. *Theoretical Issues in Ergonomics Science, 5*, 91-112.

Rauterberg, M. (1993). A product oriented approach to quantify usability attributes and the interactive quality of user interfaces. In H. Luczak, A. Cakir & G. Cakir (Eds.), *Pro-*

ceedings of the 3rd international conference on Work With Display Units. Berlin: ERGONOMIC.

Reber, R., Schwarz, N. & Winkielman, P. (2004). Processing fluency and aesthetic pleasure: is beauty in the perceiver's processing experience? *Personality and Social Psychology Review, 8,* 364-382.

Roseman, I. J. (2001). A model if appraisal in the emotions system: integrating theory, research, and application. In K. R. Scherer, A. Schorr & T. Johnstone (Eds.), *Appraisal Processes in Emotion: Theory, Methods, Research* (pp. 68-91). New York: Oxford University Press.

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology, 39,* 1281-1288.

Russell, J. A. (2003). Core Affect an Psychological Construction of Emotion. *Psychological Review, 110,* 145-172.

Russell, J. A. & Feldman Barrett, L. (1999). Core affect, prototypical emotional episodes, and other things called emotion. *Journal of Personality and Social Psychology, 76,* 805-819.

Russell, J. A., Weiss, A. & Mendelssohn, G. A. (1989). The Affect Grid: A single-item scale of pleasure and arousal. *Journal of Personality and Social Psychology, 57,* 493-502.

Ryan, R. M. & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation. *American Psychologist, 55,* 68-78.

Scherer, K. R. (1984). On the nature and function of emotion: A component process approach. In K. R. Scherer & P. Ekman (Eds.), *Approaches to emotion* (pp. 293-317). Hillsdale, NJ: Erlbaum.

Scherer, K. R. (2001). Appraisal considered as a process of multi-level sequential checking. In K. R. Scherer, A. Schorr & T. Johnstone (Eds.), *Appraisal Processes in Emotion: Theory, Methods, Research* (pp. 92-120). New York: Oxford University Press.

Schenkman, B. N. & Jönsson, F. U. (2000). Aesthetics and preferences of web pages. *Behaviour & Information Technology, 19,* 367-377.

Schifferstein, H. (2005). The perceived importance of sensory modalities in product usage: A study of self-reports. *Acta psychologica, 121,* 41-64.

Schorr, A. (2001). Subjective measurement in appraisal research: present state and future perspectives. In K. R. Scherer, A. Schorr & T. Johnstone (Eds.), *Appraisal Processes in Emotion: Theory, Methods, Research* (pp. 331-349). New York: Oxford University Press.

Schwarz, N. & Clore, G. L. (1983). Mood, misattribution, and judgments of well-being: Informative and directive functions of affective states. *Journal of Personality and Social Psychology, 45,* 513-523.

Segars, A. H., & Grover, V. (1993). Re-examining perceived ease of use and usefulness: A confirmatory factor analysis. *MIS Quarterly*, *17,* 517-525.

Sengers et al. (2004). Experience as Interpretation. Position paper for the *CHI 2004 workshop 'Cross-dressing and border-crossing'*.

Shackel, B. (1984). The concept of usability. In J. Bennett, D. Case, J. Sandelin & M. Smith (Eds.), *Visual display terminals: usability issues and health concerns* (pp. 45-88). Englewood Cliffs, NJ: Prentice Hall.

Shackel, B. (1991). Usability - context, framework, design and evaluation. In B. Shackel & S. Richardson (Eds.), *Human Factors for Informatics Usability* (pp. 21-38). Cambridge: Cambridge University Press.

Shneiderman, B. (1986). *Designing the User Interface: Strategies for Effective Human-computer Interaction*. Reading, MA: Addison-Wesley.

Smith, C. A., & Ellsworth, P. C. (1985). Patterns of cognitive appraisal in emotion. *Journal of Personality and Social Psychology*, *48,* 813-838.

Stephanidis, C. & Salvendy, G. (1998). Toward an Information Society for All: An International Research and Development Agenda. *International journal of human-computer interaction*, *10,* 107-134.

Subramanian, G. H. (1994). A replication of perceived usefulness and perceived ease of use measurement. *Decision Sciences, 25,* 863-873.

Sung, H. H., Kwang, J. K., Myung, H. Y. & Sang, W. H. (2004). Identifying mobile phone design features critical to user satisfaction. *Human Factors and Ergonomics in Manufacturing*, *14*, 15-29.

Suri, J. F. (2002). Designing experience: Whether to measure pleasure or just tune in? In W. S. Green & P. W. Jordan (Eds.), *Pleasure with Products: Beyond Usability* (pp. 161-174). London: Taylor and Francis.

Swallow, D., Blythe, M. & Wright, P. (2005). Grounding experience: relating theory and method to evaluate the user experience of smart phones. In N. Marmaras, T. Kontogiannis & D. Nathanael (Eds.), *Proceeding of EACE '05* (pp. 91-98). Athens, Greece: National Technical University.

Szajna, B. (1994). Software evaluation and choice: predictive evaluation of the Technology Acceptance Instrument. *MIS Quarterly, 18,* 319-324.

Taylor, S. & Todd, P. (1995). Assessing IT Usage: The Role of Prior Experience. *MIS Quarterly*, *19,* 561-570.

Tiger, L. (1992). *The pursuit of pleasure*. Boston: Little, Brown & Company.

Tractinsky, N. (1997). Aesthetics and apparent usability: Empirically assessing cultural and methodological issues. In *CHI'97 Conference Proceedings* (pp. 115-122). New York:

ACM.

Tractinsky, N. (2004). Towards the study of aesthetics in information technology. In *ICIS'04 Conference Proceedings*.

Tractinsky, N., Katz, A. S. & Ikar, D. (2000). What is beautiful is usable. *Interacting with Computers*, *13*, 127-145.

Tractinsky, N. & Zmiri, D. (2006). Exploring Attributes of Skins as Potential Antecedents of Emotion in HCI. In P. Fishwick (Eds.), *Aesthetic Computing* (pp. 405-422). Cambridge: MIT Press.

Venkatesh, V. & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46,* 186-204.

Verein Deutscher Ingenieure (1993). *VDI 2221: Methodik zum Entwickeln und Konstruieren technischer Systeme und Produkte [Systematic approach to the development and design of technical systems and products]*. Berlin: Beuth.

Ward, R. D. & Marsden, P. H. (2003). Physiological responses to different WEB page designs. *International Journal of Human-Computer Studies*, *59*, 199-212.

Watson, A. & Sasse, A. (1998). Measuring perceived quality of speech and video in multimedia conferencing applications. In *Proceedings of the sixth ACM international conference on Multimedia* (pp. 55-60). New York: ACM Press.

Whitfield, T. W. A. (1983). Predicting preferences for everyday objects. *Journal of Environmental Psychology, 3,* 221-237.

Whitfield, T. W. A. (2000). Beyond prototypicality: towards a categorial-motivation model of aeshtetics. *Empirical studies of the arts, 18,* 1-11.

Winer, B. J. (1971). *Statistical Principles in Experimental Design*. New York: McGraw-Hill.

Winograd, T. (1996). *Bringing design to software.* New York: ACM Press.

Zajicek, M. & Brewster, S. (2003). Design principles to support older adults. *Universal Access in the Information Society, 3*, 111-113.

Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist*, *35*, 151-175.

Zaman, B. & Shrimpton-Smith, T. (2006). The FaceReader: Measuring instant fun of use. In *NordiCHI'06 Conference Proceedings* (pp. 457-460).

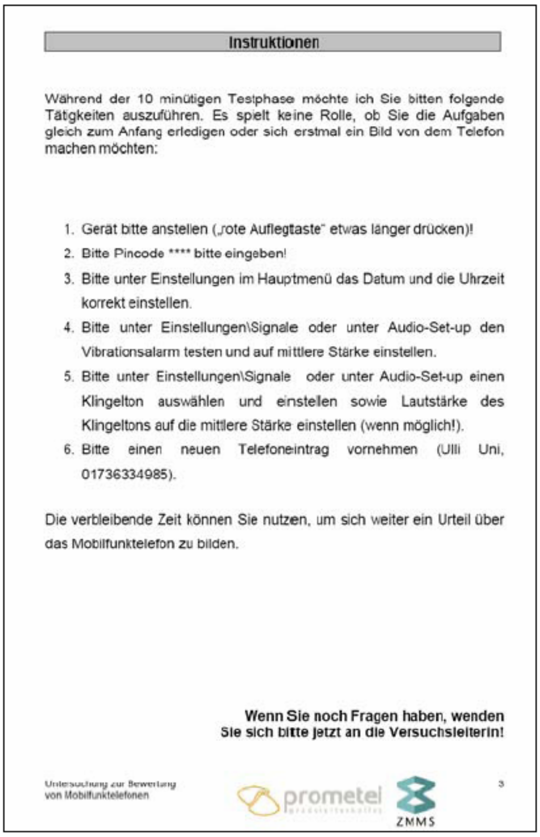
Zhang, P. & Li, N. (2004). Love at first sight or sustained effect? The role of perceived affective quality on users´ cognitive reactions to IT. In *ICIS'04 Conference Proceedings*.

Zhang, P. & Li, N. (2005). The importance of affective quality. *CACM*, *48(9),* 105-108.

Appendices

This section contains five appendices. Each appendix presents additional information regarding one of the five empirical studies reported in Chapters 4 to 7. Appendix A contains the questionnaires and instruction sheets used in the study on non-instrumental quality perceptions (Section 4.2.2) and Appendix B presents the materials used in the study on emotional user reactions (Section 4.3.2). Appendix C gives a description of the used systems, questionnaires, and detailed results of Study 1 (Chapter 5). In Appendix D, the pretest results, the used systems, the materials, and detailed results of Study 2 (Chapter 6) can be found, and Appendix E contains a description of the used systems, questionnaires, and detailed results of Study 3 (Chapter 7).

Appendix A Empirical study on non-instrumental qualities



Instruktionen

Während der 10 minütigen Testphase möchte ich Sie bitten folgende Tätigkeiten auszuführen. Es spielt keine Rolle, ob Sie die Aufgaben gleich zum Anfang erledigen oder sich erstmal ein Bild von dem Telefon machen möchten:

1. Gerät bitte anstellen („rote Auflegtaste" etwas länger drücken)!
2. Bitte Pincode **** bitte eingeben!
3. Bitte unter Einstellungen im Hauptmenü das Datum und die Uhrzeit korrekt einstellen.
4. Bitte unter Einstellungen\Signale oder unter Audio-Set-up den Vibrationsalarm testen und auf mittlere Stärke einstellen.
5. Bitte unter Einstellungen\Signale oder unter Audio-Set-up einen Klingelton auswählen und einstellen sowie Lautstärke des Klingeltons auf die mittlere Stärke einstellen (wenn möglich!).
6. Bitte einen neuen Telefoneintrag vornehmen (Ulli Uni, 01736334985).

Die verbleibende Zeit können Sie nutzen, um sich weiter ein Urteil über das Mobilfunktelefon zu bilden.

Wenn Sie noch Fragen haben, wenden Sie sich bitte jetzt an die Versuchsleiterin!

Untersuchung zur Bewertung von Mobilfunktelefonen 3

Fragebogen

Die Testphase ist jetzt abgeschlossen. Bitte geben Sie jetzt auf den folgenden Seiten Ihre Bewertung zu diesem Mobilfunktelefon ab.

Bitte umblättern!

Untersuchung zur Bewertung von Mobilfunktelefonen 4

ID:________________ Datum:_ _ . _ _ . _ _ _ _

Bewertung von verschiedenen Qualitäten und Eigenschaften von Mobilfunktelefonen.

Verantwortliche Ansprechpartner:

Cand. Dipl.-Psych. Iris Lemke; E-Mail: iris.lemke@zmms.tu-berlin.de
Dipl.-Psych. Sascha Mahlke; E-Mail: sascha.mahlke@zmms.tu-berlin.de

Untersuchung zur Bewertung von Mobilfunktelefonen — prometei — ZMMS — 1

Einleitung

Herzlich Willkommen am Zentrum für Mensch-Maschine-Systeme.

Vielen Dank, dass Sie sich bereit erklärt haben, an dieser Untersuchung teilzunehmen!

In dieser Untersuchung geht es um Ihre Bewertung verschiedener Qualitäten und Eigenschaften von Mobilfunktelefonen. Im Verlauf der Untersuchung wird Ihnen ein Testgerät präsentiert, welches Sie zurerst begutachten sollen. Sie werden ca. 10 Minuten Zeit haben das Gerät zu explorieren. In dieser Zeit werden Sie ausserdem gebeten, ein paar einfache Tätigkeiten mit dem Gerät auszuführen. Sie werden genügend Zeit haben, um diese zu erledigen und um einen Gesamteindruck von dem Gerät zu gewinnen. Anschließend werde ich Sie bitte, das Telefon anhand eines Fragebogens zu bewerten.

Bei Ihrer Bewertung interessieren uns alle Aspekte, die für Sie bei der Anschaffung und Nutzung eines solchen Gerätes von Bedeutung sind. Falls Ihnen noch weitere Punkte auffallen, haben Sie ganz zum Schluss noch einmal Gelegenheit, diese zu nennen.

Wenn Sie noch Fragen haben, wenden Sie sich bitte jetzt an die Versuchsleiterin!

Bitte umblättern!

Untersuchung zur Bewertung von Mobilfunktelefonen — prometei — ZMMS — 2

Fragebogen

Das Design / die Gestaltung des Produkts ist ...

	Stimme überhaupt nicht zu						Stimme voll zu
... kreativ	O	O	O	O	O	O	O
... ästhetisch	O	O	O	O	O	O	O
... originell	O	O	O	O	O	O	O
... angenehm	O	O	O	O	O	O	O
... speziell	O	O	O	O	O	O	O
... klar	O	O	O	O	O	O	O
... symmetrisch	O	O	O	O	O	O	O
... faszinierend	O	O	O	O	O	O	O
... rein	O	O	O	O	O	O	O
... raffiniert	O	O	O	O	O	O	O

Bitte umblättern!

Untersuchung zur Bewertung von Mobilfunktelefonen — prometei — ZMMS — 5

Fragebogen

Inwiefern treffen die folgenden Aussagen zu?

	Stimme überhaupt nicht zu						Stimme voll zu
Das Telefon liegt gut in der Hand.	O	O	O	O	O	O	O
Das Telefon vermittelt positive Botschaften über den Benutzer.	O	O	O	O	O	O	O
Das Telefon ist handlich.	O	O	O	O	O	O	O
Die Oberfläche fühlt sich gut an.	O	O	O	O	O	O	O
Die Tasten fühlen sich spannend an.	O	O	O	O	O	O	O
Das Telefon symbolisiert Dinge, die mir wichtig sind.	O	O	O	O	O	O	O
Es macht Spaß das Telefon in der Hand zu halten.	O	O	O	O	O	O	O
Das Telefon hat eine angenehme Oberfläche.	O	O	O	O	O	O	O
Ich denke, das Telefon ist ein gutes Produkt.	O	O	O	O	O	O	O
Das Telefon passt gut zu einer sympathischen Persönlichkeit.	O	O	O	O	O	O	O
Die Oberfläche des Telefons zu befühlen nervt.	O	O	O	O	O	O	O
Das Telefon hat ein angenehmes Gewicht.	O	O	O	O	O	O	O
Die Tasten fühlen sich interessant an.	O	O	O	O	O	O	O
Ich kann mir vorstellen, das Produkt zu kaufen.	O	O	O	O	O	O	O
Es ist unangenehm über die Tasten zu streichen.	O	O	O	O	O	O	O
Die Tasten können eindeutig erfühlt werden.	O	O	O	O	O	O	O
Das Telefon erzeugt eindeutige Assoziationen.	O	O	O	O	O	O	O
Die Druckpunkte der Tasten sind gut erfühlbar	O	O	O	O	O	O	O
Wenn ich das Produkt zur Verfügung hätte, würde ich es nutzen.	O	O	O	O	O	O	O
Das Telefon repräsentiert sympathische Dinge	O	O	O	O	O	O	O
Die Oberfläche fühlt sich spannend an.	O	O	O	O	O	O	O

Untersuchung zur Bewertung von Mobilfunktelefonen — prometei — ZMMS — 6

	Stimme überhaupt nicht zu						Stimme voll zu
Das Telefon erzeugt positive Assoziationen.	O	O	O	O	O	O	O
Die Tasten fühlen sich gut an.	O	O	O	O	O	O	O
Das Telefon kommuniziert begehrenswertes Image	O	O	O	O	O	O	O
Die Oberflächestruktur des Telefons ist schmeichelnd.	O	O	O	O	O	O	O
Das Gewicht des Telefons ist gut ausbalanciert.	O	O	O	O	O	O	O
Das Telefon erzeugt negative Assoziationen.	O	O	O	O	O	O	O
Das Telefon ist ein Handschmeichler.	O	O	O	O	O	O	O
Das Telefon kann Bedürfnisse über die reine Funktionalität hinaus erfüllen.	O	O	O	O	O	O	O
Das Telefon steht für lebenswerte Dinge.	O	O	O	O	O	O	O
Die Oberfläche fühlt sich interessant an.	O	O	O	O	O	O	O
Das Telefon vermittelt Werte, die mir wichtig sind.	O	O	O	O	O	O	O

Bitte umblättern!

Untersuchung zur Bewertung von Mobilfunktelefonen

prometei ZMMS 7

Fragebogen

Ich finde das Produkt ...

Harmlos	O	O	O	O	O	O	O	Herausfordernd
Ausgrenzend	O	O	O	O	O	O	O	Einbeziehend
Praktisch	O	O	O	O	O	O	O	Unpraktisch
Lahm	O	O	O	O	O	O	O	Fesselnd
Bringt mich Leuten näher	O	O	O	O	O	O	O	Trennt mich von Leuten
Widerspenstig	O	O	O	O	O	O	O	Handhabbar
Phantasielos	O	O	O	O	O	O	O	Kreativ
Isolierend	O	O	O	O	O	O	O	Verbindend
Voraussagbar	O	O	O	O	O	O	O	Unberechenbar
Originell	O	O	O	O	O	O	O	Konventionell
Nicht Vorzeigbar	O	O	O	O	O	O	O	Vorzeigbar
Verwirrend	O	O	O	O	O	O	O	Übersichtlich
Neuartig	O	O	O	O	O	O	O	Herkömmlich
Minderwertig	O	O	O	O	O	O	O	Wertvoll
Umständlich	O	O	O	O	O	O	O	Direkt
Innovativ	O	O	O	O	O	O	O	Konservativ
Stilvoll	O	O	O	O	O	O	O	Stillos
Menschlich	O	O	O	O	O	O	O	Technisch
Mutig	O	O	O	O	O	O	O	Vorsichtig
Fachmännisch	O	O	O	O	O	O	O	Laienhaft
Einfach	O	O	O	O	O	O	O	Kompliziert
Gut	O	O	O	O	O	O	O	Schlecht
Schön	O	O	O	O	O	O	O	Häßlich

Untersuchung zur Bewertung von Mobilfunktelefonen

prometei ZMMS 8

Der Klang des Telefons ist ... / Das Telefon klingt ...

Angenehm	O	O	O	O	O	O	O	Unangenehm
Kräftig	O	O	O	O	O	O	O	Gedämpft
Undeutlich	O	O	O	O	O	O	O	Deutlich
Zurückhaltend	O	O	O	O	O	O	O	Aufdringlich
Natürlich	O	O	O	O	O	O	O	Mechanisch
Harmonisch	O	O	O	O	O	O	O	Unharmonisch
Minderwertig	O	O	O	O	O	O	O	Hochklassig
Passend	O	O	O	O	O	O	O	Unpassend

Bitte umblättern!

Untersuchung zur Bewertung von Mobilfunktelefonen

prometei ZMMS 9

Abschlussfragebogen

Abschließend folgen noch einige Fragen zu Ihrer Person und Ihren Bewertungen:

Alter: ______________

männlich ☐ weiblich ☐

Steht Ihnen aktuell ein Mobiltelefon zur Verfügung (eigenes oder sonstiges)?

Ja ☐ Nein ☐

Wenn ja, welche Handymarke nutzen Sie zurzeit?

Bitte frei eintragen: ____________________________

Wie viele Jahre insgesamt benutzen Sie schon Mobilfunktelefone?

Bitte frei eintragen ____________________________

Haben Sie schon einmal in der Vergangenheit ein *Motorola* Mobilfunktelefon in Gebrauch?

Ja ☐ Nein ☐

Wenn ja, welches Modell?

Bitte frei eintragen: ____________________________

Könnten Sie sich vorstellen, dieses Mobilfunktelefon für den eigenen Gebrauch zu erwerben?

Ja ☐ Nein ☐

Mir gefällt das Telefon:

sehr gut **ganz gut** **gar nicht**

Untersuchung zur Bewertung von Mobilfunktelefonen

prometei ZMMS 10

Appendix B Empirical study on emotional user reactions

Herzlich Willkommen im Zentrum für Mensch-Maschine-Systeme.

Vielen Dank, dass Sie sich bereit erklärt haben, an der heutigen Untersuchung teilzunehmen!

Auf den folgenden Seiten finden Sie 10 Aufgaben, die Sie insgesamt an zwei verschiedenen Handysimulationen bearbeiten werden. Falls zur Bearbeitung interaktive Eingaben notwendig sind, so achten Sie bitte auf den hervorgehobenen Text und benutzen genau diesen für Ihre Eingaben.

Sie haben für die Bearbeitung jeder Aufgabe maximal zwei Minuten Zeit. Sollten Sie eine Aufgabe nicht bis zum Ende bearbeiten können, wird die Aufgabenbearbeitung abgebrochen.

Haben Sie eine Aufgabe fertig bearbeitet oder ist die Bearbeitungszeit abgelaufen, bekommen Sie dies rückgemeldet. Nach der Rückmeldung beantworten Sie bitte umgehend die zwei kurzen Fragen, die unterhalb jeder Aufgabe gestellt werden. Worum es sich bei den Fragen genau handelt, wird Ihnen auf der folgenden Seite ausführlich erläutert.

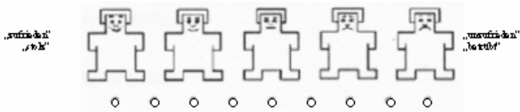
Im Laufe dieser Untersuchung werden Sie SAM begegnen. Das ist SAM:

SAM bedeutet *Self Assessment Manikin*. SAM stellt Sie und Ihre Gefühle dar. Sie werden SAM heute benutzen, um Ihre emotionale Reaktion auf die Erledigung bestimmter Aufgaben zu ermitteln. Sie können über SAM mitteilen, welches Gefühl eine Interaktion in Ihnen aus-löst. Geben Sie dabei bitte nicht eine Bewertung für das Produkt ab, sondern **teilen Sie IHR Gefühl mit, welches die Interaktion mit dem Produkt in Ihnen hervorruft.**

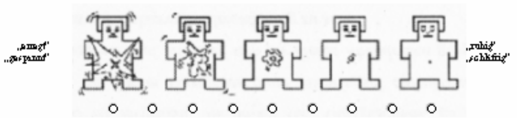
Ein Gefühl kann man aus zwei Blickwinkeln betrachten, nämlich:

→ die Stimmung eines Gefühls (positiv oder negativ)
→ die innere Erregung, die damit einhergeht

Stimmung
Die erste Zeile geht von einem breiten Lachen bis zu einem großen Stirnrunzeln. Diese Zeile versinnbildlicht Stimmungen wie „völlig zufrieden oder stolz" bis „völlig unzufrieden oder betrübt".

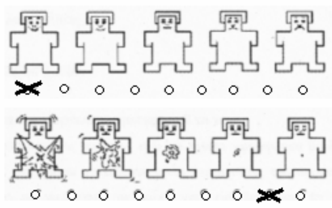


Erregung
Die zweite Zeile stellt Ihre Erregung dar, die von sehr „erregt" oder „gespannt" bis sehr „ruhig" oder „schläfrig" geht.

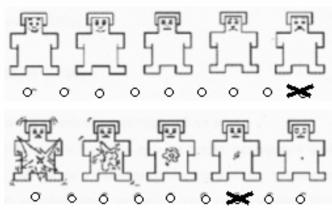


Sie geben an wie Sie sich fühlen, indem Sie in **jeder der beiden Zeilen eine Markierung** setzen. Versuchen Sie bitte, immer Ihr erstes spontanen Gefühl darzustellen. Bewerten Sie dabei nicht das Produkt, sondern geben Sie Ihre Gefühl wieder.

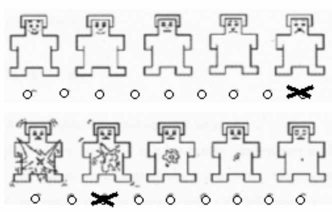
Beispiele:
Entspannung



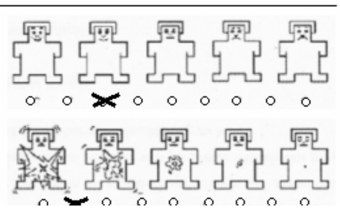
Langeweile



Angst



Begeisterung



Hier nochmal die wichtigsten Instruktionen auf einen Blick:

- Lesen Sie sich die Aufgaben vor Bearbeitung sorgfältig durch!
- Bitte vermeiden Sie es, während der Aufgabenbearbeitung zu sprechen!
- Beachten Sie, dass die Aufgabenbearbeitung nach der Rückmeldung beendet ist.
- Beantworten Sie *umgehend* nach Rückmeldung der Beendigung einer Aufgabe die beiden SAM-Skalen!

Haben Sie noch Fragen?

Aufgabe 1: Sie sitzen gerade in der letzten Reihe einer Veranstaltung und erwarten einen wichtigen Anruf. Das Handy sollten Sie auf keinen Fall ausstellen! Trotzdem, wenn der Anruf kommt, möchten Sie nicht, dass es unbedingt ganz laut klingelt.

Also stellen Sie bitte den Klingelton in Ihrem Handy auf „leise".

Aufgabe 2: Die Datumsanzeige in Ihrem Mobiltelefon muss offensichtlich neu eingestellt werden!
Suchen Sie doch gleich mal die entsprechende Funktion und geben den

02.09.2005 **ein.**

Aufgabe 3: Beim Bäcker haben Sie gerade einen alten Freund getroffen. Mensch, wie lange Sie sich schon nicht gesehen haben! Und doch hat man sich sofort wiedererkannt... Sie tauschen Ihre Handynummern aus. Sie möchten seine Nummer gleich in Ihrem Handy speichern. Er diktiert Ihnen:

02698673250

Erstellen Sie einen neuen Eintrag in Ihrem Telefonbuch und speichern seine Handynummer.

Aufgabe 4: Sie sind gerade an der Theaterkasse und wollen für sich und Ihren Bekannten *Anton* zwei Karten für die heutige Vorstellung um 18 Uhr kaufen. Die Dame an der Kasse sagt, 18 Uhr ist schon komplett weg, aber es gibt noch wenige Karten für die Spätvorstellung.

Rufen Sie Ihren Bekannten Anton per Handy an, um ihn zu fragen, ob er auch zur Spätvorstellung mitkommen würde. Seine Mobilfunknummer haben Sie ja in Ihrem Handy gespeichert.

Aufgabe 5: Sie sind später mit einem Bekannten im Café verabredet. Erinnern Sie ihn mit einer Kurznachricht noch einmal an das Treffen. Übrigens ist Ihr Mobiltelefon auf automatische Worterkennung eingestellt (T9).

Schreiben Sie ihr mal eine kurze SMS mit dem Inhalt:

Bis um 3!

Die Mobilfunknummer Ihres Bekannten ist:

0254332890

in Ihrem Mobiltelefon die Freisprecheinrichtung anschalten wollten, damit Sie ankommende Anrufe gleich annehmen können.

Schalten Sie also gleich die Funktion „Freisprecheinrichtung" ein!

Aufgabe 7: Von einer Feier kommen Sie müde nach Hause und wollen eigentlich nur noch ins Bett. Morgen möchten Sie erst mal ausschlafen. Aber um halb zwölf haben Sie einen wichtigen Termin... Verschlafen wäre da total schlecht. Gut, dass Ihr Handy eine Weckerfunktion hat.

Also stellen Sie bitte den Wecker in Ihrem Handy ein.

Auf *09:00* **Uhr**

dürfte reichen!

Aufgabe 8: Ihre Bekannte fragt Sie, ob Ihr neues Mobiltelefon auch eine Rufumleitung hat. Sie erklärt Ihnen, damit könne man eingehende Anrufe an ein anderes Mobiltelefon weiterleiten. Sie wollen das gleich mal ausprobieren und die Rufumleitung mit der Funknummer Ihrer Bekannten einstellen.

Stellen Sie also die Rufumleitung in Ihrem Mobiltelefon ein:

02705434860

Aufgabe 9: Ihre Bekannte Andrea hat eine neue Handynummer.

Sie können also ihren alten Telefonbucheintrag löschen.

Suchen Sie bitte den *Eintrag von Andrea* und löschen ihn.

Aufgabe 10: Von einer Arbeitskollegin haben Sie eine ganze Weile schon nichts mehr gehört. Melden Sie sich doch einfach mal wieder mit einer Kurtnachricht. Auch dieses Mobiltelefon ist wieder auf automatische Worterkennung (T9) eingestellt.

02543328905

Schreiben Sie ihr einfach eine kurze SMS mit dem Inhalt:

Hallo du!

An dieser Stelle bitten wir Sie zunächst um einige Angaben zu Ihrer Person.

Alter: ________________

Geschlecht: ☐ weiblich ☐ männlich

Beruf: (mehrfach möglich)
☐ Schüler/ Student/ in Ausbildung (Vollzeit)
☐ abgeschlossene Berufsausbildung
☐ abgeschlossenes Hochschulstudium
☐ nichts trifft zu

Steht Ihnen aktuell ein Mobiltelefon zur Verfügung (eigenes oder sonstiges)?
☐ Ja ☐ Nein

Wenn ja, welche Handymarke nutzen Sie zur Zeit?
Bitte frei eintragen: ______________________________

Wenn ja, wie oft nutzen Sie folgendes Dienste mit dem Mobiltelefon?

	überhaupt nicht	so gut wie nie	1-2 mal die Woche	fast täglich	täglich
(a) Sie rufen jemanden an	☐	☐	☐	☐	☐
(b) Sie schreiben eine SMS	☐	☐	☐	☐	☐
(c) Sie laden kostenpflichtig einen neuen Klingelton	☐	☐	☐	☐	☐
(d) Sie versenden Bilder	☐	☐	☐	☐	☐
(e) Sie surfen im Internet	☐	☐	☐	☐	☐

Wie oft nutzen Sie diese Funktionen an einem Computer (privat und dienstlich)?

	überhaupt nicht	so gut wie nie	1-2 mal die Woche	fast täglich	täglich
(a) (Lern-/Text-)Programme	☐	☐	☐	☐	☐
(b) Internet	☐	☐	☐	☐	☐
(c) Online-Spiele	☐	☐	☐	☐	☐
(d) Programmierung	☐	☐	☐	☐	☐

In diesem Fragebogen bitten wir Sie, sich an die Bearbeitung der einzelnen Aufgaben sowie die dabei ausgelösten positiven und negativen Emotionen zu erinnern.

Nachdem Sie die Videoaufzeichnung einer Aufgabe angeschaut haben, beantworten Sie bitte die folgenden Fragen, indem Sie ankreuzen, wie sehr Sie einer Aussage inhaltlich zustimmen. Ist eine Aussage als Gedanke nicht relevant gewesen, so kreuzen Sie bitte „irrelevant" an. Bei der ersten Frage machen Sie bitte eine freie Angabe in Stichpunkten.

Versuchen Sie, sich so viele Einzelheiten wie möglich in das Bewusstsein zurückzurufen, die während der jeweiligen Aufgabenphase für Sie bedeutsam waren.

Es ist wichtig, dass Sie alle Fragen beantworten und bei jeder Aufgabe *nur ein* Kreuz setzen.

1. Wie würden Sie die Emotionen **mit Ihren eigenen Worten** benennen, die während der Aufgabenbearbeitung relevant waren?

____

Wie würden Sie die Phase der Aufgabenbearbeitung **ganz allgemein** einschätzen?

	ganz und gar nicht		ziemlich		in höchstem Maße	irrelevant
2. **angenehm**	☐	☐	☐	☐	☐	☐
3. **unangenehm**	☐	☐	☐	☐	☐	☐

Als Sie die oben genannten Emotionen erlebten, dachten Sie, dass...

	ganz und gar nicht		ziemlich		in höchstem Maße	irrelevant
4. ... Sie die Bearbeitung der Aufgabe an diesem System vor **ganz neue** Anforderungen stellt?	☐	☐	☐	☐	☐	☐
5. ... das System Sie dabei unterstützt, **Ihre Ziele** zu erreichen?	☐	☐	☐	☐	☐	☐
6. ... dass Sie das System **unter Kontrolle** haben?	☐	☐	☐	☐	☐	☐
7. ... dass Sie mit Ihrer tatsächlichen Leistung **zufrieden** sein werden?	☐	☐	☐	☐	☐	☐

Appendix C Study 1

Appendix C gives a description of the used systems, questionnaires, and detailed results of Study 1 (Chapter 5).

Appendix C.1 Description of systems used in Study 1

The following table contains some detailed information about the used portable audio players.

Description	*Player*
66,5 x 67 x 20 mm *Display*: 132 x 32 pixel Controls: 1 joystick button (4-directions/ confirm) and one button on the front *Menu design*: icon and text based menu, right/left	
51 x 84 x 19 mm, 108 g *Display*: 160x104 pixel *Controls*: 5 touch buttons and 1 slider (up/down/enter) on the front; 1 button and 1 button on the top *Menu design*: text menu, up/down, context menu, extra back button	
68,6 x 105 x 22,1 mm, 203 g *Display*: 160 x 104 pixel *Controls*: 6 button and 1 slider (up/down) plus extra confirm button on the front; 3 button on the left side; 1 slider on the top *Menu design*: text menu, up/down, extra back button	
75,9 x 112,5 x 24,1 mm, 226 g *Display*: 160 x 104 pixel *Controls*: 4 Buttons on the left side, one jog-dial (up/down/enter) and 3 buttons on the right side *Menu design*: text menu, up/down, extra back button	

Appendix C.2 Questionnaires used in Study 1

Explorationsstudie Digitale Audio Player: Fragebogen 1 Mai/Juni 2005

Es geht nun um Ihren ersten Eindruck von dem Produkt!
Unten ist eine Liste von Worten aufgeführt, mit der die Interaktion mit einem technischen System beschrieben werden kann. Bitte geben sie jeweils an wie treffend jedes Wort die Interaktion mit von Ihnen gerade benutztem Produkt beschreibt.
Bitte gebe Sie zu jedem Begriff eine Antwort!

Die Interaktion mit dem Produkt ist ...

	Stimme voll zu						Stimme überhaupt nicht zu
... angenehm.	O	O	O	O	O	O	O
... inaktiv.	O	O	O	O	O	O	O
... unangenehm.	O	O	O	O	O	O	O
... intensiv.	O	O	O	O	O	O	O
... unbefriedigend	O	O	O	O	O	O	O
... träge.	O	O	O	O	O	O	O
... ansprechend.	O	O	O	O	O	O	O
... erregend.	O	O	O	O	O	O	O
... wohltuend.	O	O	O	O	O	O	O
... lebendig.	O	O	O	O	O	O	O
... abstoßend.	O	O	O	O	O	O	O
... bedächtig.	O	O	O	O	O	O	O
... unerfreulich.	O	O	O	O	O	O	O
... kräftig.	O	O	O	O	O	O	O
... stillstehend.	O	O	O	O	O	O	O
... fein.	O	O	O	O	O	O	O
... schläfrig.	O	O	O	O	O	O	O
... unbequem.	O	O	O	O	O	O	O
... aktiv.	O	O	O	O	O	O	O
... schön.	O	O	O	O	O	O	O

VP:______ Bedingung:______ Sascha Mahlke - prometei/fsp6

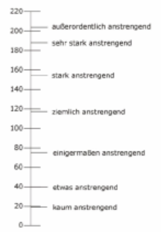
Explorationsstudie Digitale Audio Player: Fragebogen 2 mit Aufgaben Mai/Juni 2005

Es wird Ihnen im Folgenden eine Situation beschrieben, in der Sie vier sehr kurze Aufgaben mit dem vorliegenden Produkt bearbeiten sollen. Zuerst wird Ihnen dazu die Situation beschrieben – denken Sie sich bitte in diese hinein. Darauf folgen die Aufgaben, für deren Lösung Sie je max. eine Minute Zeit haben. Geben Sie dem Versuchsleiter bitte kurz bescheid, wenn Sie mit der Aufgabe beginnen und diese abgeschlossen haben. Geben Sie bitte außerdem nach jeder Aufgabe kurz eine Gesamtbewertung für die absolvierte Aufgabe an!

Situationsbeschreibung
Sie sind gerade in die U-Bahn eingestiegen, um sich zu einem Termin aufzumachen und haben sich hingesetzt. Bevor Sie los sind, haben Sie noch schnell Ihren Digitalen Audio Player eingesteckt, den Sie gerade aus Ihrer Tasche geholt haben und jetzt in der Hand halten.

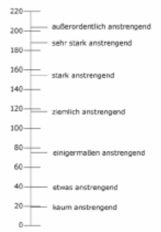
Aufgabe 1
Sie möchten jetzt das Album von *Rodney Hunter* mit dem Namen *Hunter Files* hören. Wählen Sie dieses aus!

Bitte kreuzen Sie auf der nebenstehenden Skala Ihre Gesamtbewertung für die gerade absolvierte Aufgabe an!



Aufgabe 2
Sie möchten in der U-Bahn ein Gespräch neben Ihnen mithören, während Sie Musik hören. Wählen Sie eine niedrige Lautstärke!

Bitte kreuzen Sie auf der nebenstehenden Skala Ihre Gesamtbewertung für die gerade absolvierte Aufgabe an!



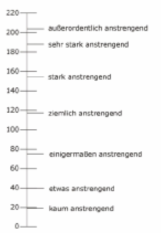
bitte umblättern →

VP:______ Bedingung:______ Sascha Mahlke - prometei/fsp6

Explorationsstudie Digitale Audio Player: Fragebogen 2 mit Aufgaben Mai/Juni 2005

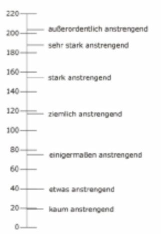
Aufgabe 3
Sie haben Ihre Uhr heute vergessen und wollen nachschauen, ob Sie ihren Termin noch rechtzeitig einhalten können. Schauen Sie nach der Uhrzeit in dem Player!

Bitte kreuzen Sie auf der nebenstehenden Skala Ihre Gesamtbewertung für die gerade absolvierte Aufgabe an!



Aufgabe 4
Sie denken bei dem Gesprächsthema an Ihren Freund Peter und Ihnen fällt ein, dass dieser am 10. Juni Geburtstag hat und Sie den Geburtstag die letzten Jahre meist vergessen haben. Prüfen Sie im Kalender Ihres Players, ob Peters Geburtstag vermerkt ist.

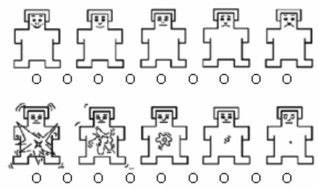
Bitte kreuzen Sie auf der nebenstehenden Skala Ihre Gesamtbewertung für die gerade absolvierte Aufgabe an!



VP:______ Bedingung:______ Sascha Mahlke - prometei/fsp6

Explorationsstudie Digitale Audio Player: Fragebogen 3 Mai/Juni 2005

Wie fühlen Sie sich nach der Nutzung des Produkts?



In wiefern treffen die folgenden Aussagen zu?

	Stimme voll zu						Stimme überhaupt nicht zu
Das System ermöglicht es mir, die Aufgaben zu bewältigen.	O	O	O	O	O	O	O
Ich finde es leicht vom Produkt, zu bekommen was ich will.	O	O	O	O	O	O	O
Ich denke, das System ist ein gutes Produkt.	O	O	O	O	O	O	O
Das Produkt liegt gut in der Hand.	O	O	O	O	O	O	O
Die Bedienung des Produkts strengt mich an.	O	O	O	O	O	O	O
Insgesamt denke ich, das Produkt ist nützlich.	O	O	O	O	O	O	O
Ich kann mir vorstellen, das Produkt zu kaufen.	O	O	O	O	O	O	O
Das Produkt fühlt sich gut an.	O	O	O	O	O	O	O
Die Funktionen des Produkts sind für die Aufgaben bedeutsam.	O	O	O	O	O	O	O
Die Bedienung des Produkts ist klar und verständlich.	O	O	O	O	O	O	O
Das Produkt ist komfortabel zu tragen.	O	O	O	O	O	O	O
Das Produkt ist hilfreich bei der Lösung der Aufgabe.	O	O	O	O	O	O	O
Das Produkt ist leicht zu bedienen.	O	O	O	O	O	O	O
Wenn ich das Produkt zur Verfügung hätte, würde ich es nutzen.	O	O	O	O	O	O	O
Das Produkt macht einen zerbrechlichen Eindruck.	O	O	O	O	O	O	O

bitte umblättern →

Explorationsstudie Digitale Audio Player: Fragebogen 3 Mai/Juni 2005

Das Produkt, dass ich gerade benutzt habe, ist ...

... isolierend	O	O	O	O	O	O	O	... verbindend
... laienhaft	O	O	O	O	O	O	O	... fachmännisch
... stillos	O	O	O	O	O	O	O	... stilvoll
... minderwertig	O	O	O	O	O	O	O	... wertvoll
... ausgrenzend	O	O	O	O	O	O	O	... einbeziehend
... nicht vorzeigbar	O	O	O	O	O	O	O	... vorzeigbar
... konventionell	O	O	O	O	O	O	O	... originell
... phantasielos	O	O	O	O	O	O	O	... kreativ
... vorsichtig	O	O	O	O	O	O	O	... mutig
... konservativ	O	O	O	O	O	O	O	... innovativ
... lahm	O	O	O	O	O	O	O	... fesselnd
... harmlos	O	O	O	O	O	O	O	... herausfordernd
... herkömmlich	O	O	O	O	O	O	O	... neuartig
... schlecht	O	O	O	O	O	O	O	... gut
... hässlich	O	O	O	O	O	O	O	... schön
... trennt mich von Leuten	O	O	O	O	O	O	O	... bringt mich Leuten näher

Die Gestaltung des Produkts ist ...

	Stimme voll zu						Stimme überhaupt nicht zu
... kreativ	O	O	O	O	O	O	O
... ästhetisch	O	O	O	O	O	O	O
... originell	O	O	O	O	O	O	O
... angenehm	O	O	O	O	O	O	O
... speziell	O	O	O	O	O	O	O
... klar	O	O	O	O	O	O	O
... symmetrisch	O	O	O	O	O	O	O
... faszinierend	O	O	O	O	O	O	O
... rein	O	O	O	O	O	O	O
... raffiniert	O	O	O	O	O	O	O

VP:______ Bedingung:______ Sascha Mahlke - prometei/fsp6

Explorationsstudie Digitale Audio Player: Fragebogen 4 Mai/Juni 2005

Kurz einige Fragen zu Ihrer Person:

Alter: ______

Geschlecht: O männlich O weiblich

Beruf/Studienfach: ______________

Besitzen Sie einen Digitalen Audio Player? O ja O nein

Wenn ja, welchen? ______________

Wie oft nutzen Sie diesen?
O täglich O mehrmals die Woche O mehrmals im Monat O seltener

Nutzen Sie Digitale Audio Dateien an einem Computer? O ja O nein

Wenn ja, welches Programm nutzen Sie dazu? ______________

Wie oft nutzen Sie einen Computer?
O täglich O mehrmals die Woche O mehrmals im Monat O seltener

bitte umblättern →

VP:______ Sascha Mahlke - prometei/fsp6

Explorationsstudie Digitale Audio Player: Fragebogen 4 Mai/Juni 2005

Welche der vier Produkte würden sie bevorzugen?
Bitte bringen Sie die Produkte in eine Reihenfolge:

1. ______________
2. ______________
3. ______________
4. ______________

A B C D

Wie begründen Sie ihre Entscheidung?

VP:______ Sascha Mahlke - prometei/fsp6

Appendix C.3 Detailed results of Study 1

The following table contains the results of all analyses of variance for the factor PRODUCT in Study 1.

Dependent Variable	*df*	*F*	*η*	*P*
Number of completed tasks	3, 87	8.2***	0.22	<0.001
Time on task	3, 87	3.0*	0.09	0.036
Usefulness	3, 87	8.2***	0.22	<0.001
Ease of use	3, 87	10.5***	0.27	<0.001
Visual aesthetics	3, 87	8.4***	0.24	<0.001
Haptic quality	3, 87	10.9***	0.27	<0.001
Symbolic quality	3, 87	8.4***	0.23	<0.001
Subjective feeling (valence)	3, 75	4.4**	0.15	0.006
Subjective feeling (arousal)	3, 75	1.5	0.06	0.210
Overall ratings	3, 87	3.9*	0.12	0.011
Ranking	3, 87	3.7*	0.11	0.015

* p < .05; ** p < .01; *** p < .001

The following table presents al within-subject contrasts (F-values and significances) for all conditions of PRODUCT (A, B, C & D) in Study 1.

Dependent Variable	*A - B*	*A - C*	*A - D*	*B - C*	*B - D*	*C – D*
Number of completed tasks	1.1	24.4***	24.9***	5.1**	5.5**	0.005
Time on task	0.6	9.3**	5.0*	2.4	1.6	0.5
Usefulness	2.6	30.1***	13.9**	6.5*	2.1	2.0
Ease of use	1.1	28.8***	16.8***	12.1**	5.2*	2.1
Visual aesthetics	14.7**	22.7***	2.7	0.003	6.4*	8.9**
Haptic quality	8.6**	0.5	7.3*	5.6*	24.7***	12.6**
Symbolic quality	20.6***	11.2**	1.8	1.8	9.9**	4.2
Subjective feeling (valence)	2.3	14.3**	13.9**	1.8	1.2	0.9
Subjective feeling (arousal)	0.1	2.7	3.5	2.8	1.1	0.009
Overall ratings	2.4	16.1***	3.2	2.1	0.2	0.009
Ranking	1.3	11.5**	0.1	2.8	0.7	9.7**

* p < .05; ** p < .01; *** p < .001

Appendix D Study 2

Appendix D contains the pretest results, the used systems, the materials, and detailed results of Study 2 (Chapter 6).

Appendix D.1 Pretest of usability variations

A pretest with ten participants was conducted to test whether the variation of presentation properties led to differences in interaction characteristics and perceived usability. Five participants tested the high usable version, and five participants used the low usable system. A set of five tasks was given for each version, and participants had two minutes two solve each task. The number of completed tasks within two minutes, and the time for completion of all tasks were measured as performance data. At the end of the pretest, they rated each of the versions regarding their usability with the System Usability Scale (SUS) by Brooke (1996). The SUS questionnaire consisted of ten items. An overall score was computed that ranged form 0 to 20.

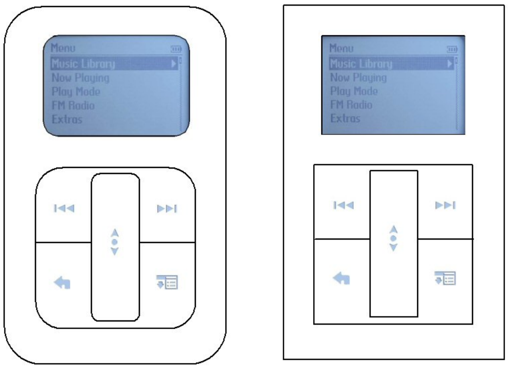
The two usability versions differed with respect to central interaction characteristics. Compared to the version of lower usability, the highly usable system led to a greater percentage of correct solutions, $F_{1,8}$=14.4, $p<.01$, and to faster completion, $F_{1,8}$=11.3, $p<.05$. Participants with the usable version completed 4.8 tasks and needed 199 seconds on average. The other participants finished 3.2 tasks and interacted with the system for 334 seconds on average. Usability ratings differed for the two systems, $F_{1,8}$=11.1, $p<.05$. The average rating was 14 for the high usable version and 6.6 for the low usable version.

In summary, the high usable version got better perceived usability rating and led to better performance with respect to the number of completed task and the average time for completion.

Appendix D.2 Pretest of visual aesthetics variations

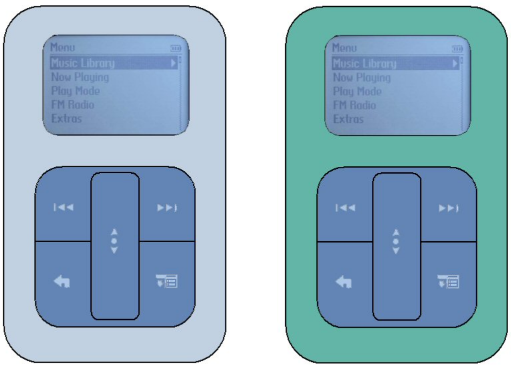
In a series of pretests, effective variations of shape, color combination, and symmetry were identified. The pretests were conducted as online experiments. Participants were shown pairs of versions at a time and had to indicate the more aesthetic one.

In the first pretest, nine versions that were combination of three variations of roundedness and three variations of unity were evaluated. Sixteen Participants did 36 comparisons between all versions each. Overall 576 comparisons were down and 128 data points for each version available. The version with a medium level of roundedness and a high level of unity was preferred in 92 % of the comparisons and was chosen most often as more aesthetic. The version with a low level of roundedness and a high level of unity was preferred in 34 % of the comparisons and was assessed as least aesthetic.



Medium level of roundedness and high level of unity on the right and low level of roundedness and a high level of unity on the left.

In a second pretest, seven different color combinations that differed with respect to differences in hue and brightness were tested using the best rated shape from the first pretest. Twelve participants did 21 comparisons between all versions each. Overall 576 comparisons were down and 128 data points for each version available. A version with high differences in brightness and no variation in hue was preferred in 72 % of the comparisons and was chosen most often as more aesthetic. A version with no variation in brightness and high difference in hue was preferred in 32 % of the comparisons and was assessed as least aesthetic.



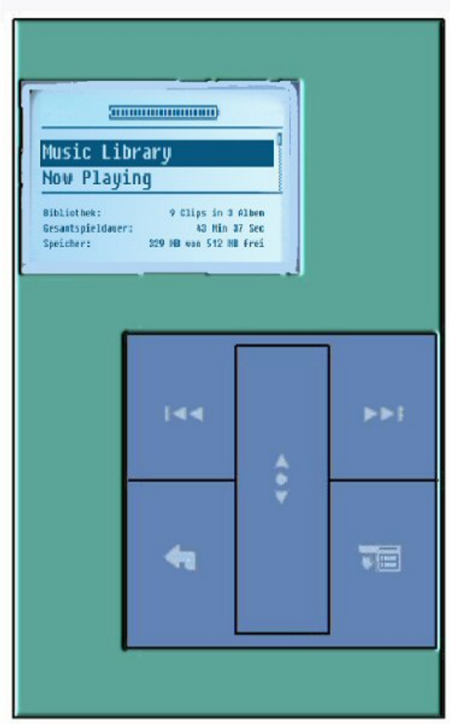
High differences in brightness and no variation in hue on the right and no variation in brightness and high difference in hue on the left.

For a last pretest, the design combined of the best shape and best color combination and the version with worst shape and color combination were combined with different levels of symmetry. Nine different versions were tested. Ten participants did 36 comparisons between all versions each. Overall 360 comparisons were down and 80 data points for each version available.

The version with a medium level roundedness and a high level of unity, high differences in brightness and no variation in hue and high symmetry was preferred in 95 % of the comparisons and was chosen most often as more aesthetic. It can be seen as high aesthetics version on the next page.

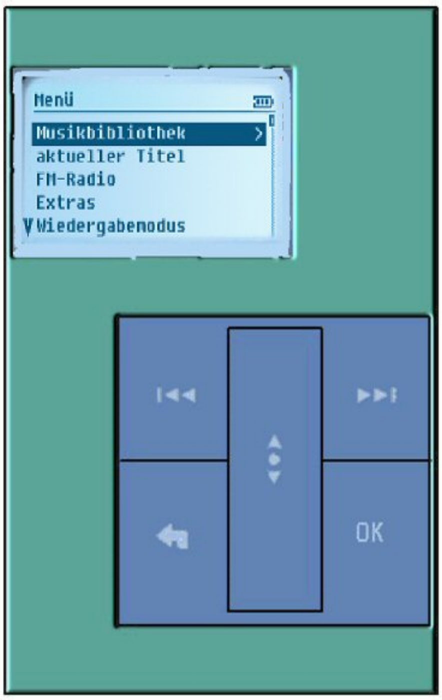
The version with a low level roundedness and a high level of unity, no variation in brightness and high difference in hue and a shift of the display to the left and the controls to the right of the product body was preferred in 25 % of the comparisons and was assessed as least aesthetic. It can be seen as low aesthetics version on the next page.

Appendix D.3 Screenshots of systems used in Study 2



Low usability / low aesthetics

Low usability / high aesthetics



High usability / low aesthetics

High usability / high aesthetics

Appendix D.4 Questionnaires used in Study 2

ID:_______________ Datum:_ _ . _ _ . _ _ _ _

Wie bewerten Sie verschiedene Gestaltungsvarianten tragbarer Audio-Player?

Verantwortlicher Ansprechpartner:

Dipl.-Psych. Sascha Mahlke; E-Mail: sascha.mahlke@zmms.tu-berlin.de

Einleitung

Herzlich Willkommen am Zentrum für Mensch-Maschine-Systeme.

Vielen Dank, dass Sie sich bereit erklärt haben, an dieser Untersuchung teilzunehmen!

In dieser Untersuchung geht es um Ihre Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player. Im Verlauf der Untersuchung werden Ihnen zwei Varianten präsentiert, die wir aus einer größeren Menge ausgewählt haben. Sie können diese Varianten im Verlauf der Untersuchung anhand verschiedener Fragebogen bewerten. Wir geben Ihnen außerdem zu jeder Variante fünf typische Aufgaben, anhand derer Sie die Benutzung der Variante ausprobieren können. Während der Bearbeitung der Aufgaben erheben wir zusätzlich physiologische Daten. Dazu wurden bereits die benötigten Elektroden angebracht und getestet.

Die Audio-Player werden als Simulation auf dem kleinen Bildschirm vor Ihnen dargestellt. Bei der Präsentation handelt es sich also noch um erste Prototypen für spätere Produkte. Sie können die Player jedoch schon direkt über den Bildschirm, der als Touch-Screen funktioniert, bedienen.

Bevor Sie jeden Player anhand von fünf Aufgaben ausprobieren können, erhalten Sie eine kurze Beschreibung zur Bedienung der jeweiligen Variante. Nach der Bearbeitung jeder Aufgabe, sind Sie aufgefordert zwei Fragen zu beantworten, die unterhalb jeder Aufgabe gestellt werden. Worum es sich bei diesen Fragen genau handelt, wird Ihnen auf der folgenden Seite erklärt. Im Anschluss an die Bearbeitung der Aufgaben, erhalten Sie dann die Möglichkeit, die Variante auf einem umfangreichen Fragebogen zu bewerten. Bei Ihrer Bewertung interessieren uns alle Aspekte, die für Sie bei der Anschaffung und Nutzung eines solchen Gerätes von Bedeutung sind. Falls Ihnen noch weitere Punkte auffallen, haben Sie ganz zum Schluß noch einmal Gelegenheit, diese zu nennen.

Bitte umblättern!

Das ist SAM!

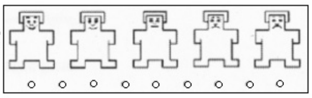
Im Laufe dieser Untersuchung werden Sie SAM begegnen. Das ist SAM:

SAM stellt Sie und Ihre Gefühle dar. Sie werden SAM heute benutzen, um Ihre emotionale Reaktion auf die Erledigung bestimmter Aufgaben zu ermitteln. Sie können über SAM mitteilen, welches Gefühl eine Interaktion in Ihnen auslöst. Geben Sie dabei bitte nicht eine Bewertung für das Produkt ab, sondern **teilen Sie IHR Gefühl mit, welches die Interaktion mit dem Produkt in Ihnen hervorruft.** Ein Gefühl kann man aus zwei Blickwinkeln betrachten, nämlich:

→ die Stimmung eines Gefühls (positiv oder negativ)
→ die innere Erregung, die damit einhergeht

SAM beschreibt Ihre **Stimmungen** von einem breiten Lachen bis zu einem großen Stirnrunzeln. Diese Zeile versinnbildlicht Stimmungen wie „völlig zufrieden" oder „stolz" bis „völlig unzufrieden" oder „betrübt":

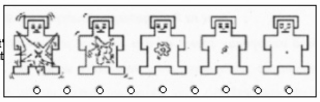
„zufrieden" „stolz"



„unzufrieden" „betrübt"

Eine zweite Zeile stellt Ihre **Erregung** dar, die von sehr „erregt" oder „gespannt" bis sehr „ruhig" oder „schläfrig" geht.

„erregt" „gespannt"



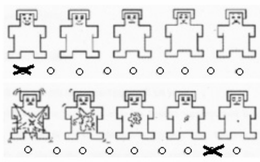
„ruhig" „schläfrig"

Sie geben an wie Sie sich fühlen, indem Sie in **jeder der beiden Zeilen eine Markierung** setzen. Versuchen Sie bitte, immer Ihr erstes spontanes Gefühl darzustellen. Bewerten Sie dabei nicht das Produkt, sondern geben Sie Ihr Gefühl wieder. Einige Beispiele folgen auf der folgenden Seite.

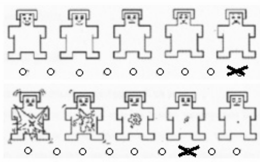
Bitte umblättern!

Beispiele

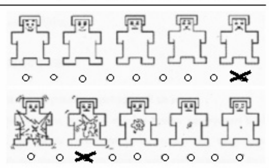
Entspannung



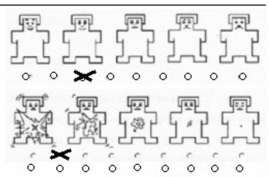
Langeweile



Angst



Begeisterung



Bitte umblättern!

Instruktionen

Hier nochmal die wichtigsten Dinge, die für Sie zu beachten sind, auf einen Blick:

- Uns interessieren *alle* Aspekte, die für Sie bei der Anschaffung und Nutzung tragbarer Audio-Player relevant sind.
- Lesen Sie sich die Beschreibung zur Bedienung der einzelnen Audio-Player und die Aufgaben vor der Bearbeitung sorgfältig durch!
- Bitte vermeiden Sie es, während der Aufgabenbearbeitung zu sprechen! Stellen Sie Fragen an den Versuchsleiter bitte nur zwischen den Aufgaben.
- Beantworten Sie *umgehend* nach der Bearbeitung einer Aufgabe die beiden SAM-Skalen!
- Achten Sie darauf, möglichst keine der Fragen auszulassen.

Haben Sie noch Fragen? Bitte wenden Sie sich an den Versuchsleiter, wenn Sie hier angekommen sind!

Erste Variante

Die erste Gestaltungsvariante wurde soeben für Sie auf dem Display dargestellt. Bevor Sie die Benutzung der Variante anhand einiger Aufgaben ausprobieren, beantworten Sie bitte kurz die folgenden Fragen. Beziehen Sie dabei Ihren Gesamteindruck ein:

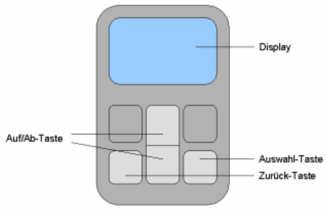
Das Design / die Gestaltung des Produkts ist ...

	Stimme überhaupt nicht zu						Stimme voll zu
... kreativ	O	O	O	O	O	O	O
... ästhetisch	O	O	O	O	O	O	O
... originell	O	O	O	O	O	O	O
... angenehm	O	O	O	O	O	O	O
... speziell	O	O	O	O	O	O	O
... klar	O	O	O	O	O	O	O
... symmetrisch	O	O	O	O	O	O	O
... faszinierend	O	O	O	O	O	O	O
... rein	O	O	O	O	O	O	O
... raffiniert	O	O	O	O	O	O	O

Bitte umblättern!

Beschreibung der Variante D (U1)

Der tragbare Audio-Player kann mit der Hand über das Touchscreen bedient werden. Für die Bearbeitung der folgenden Aufgaben werden lediglich vier Bedienelemente benötigt.



Auf dem Display werden Informationen dargestellt. Die Auf/Ab-Taste dient zum Wechsel zwischen verschiedenen Menüpunkten. Klicken Sie die obere Hälfte der Taste, bewegen Sie sich in einem Menü auf; klicken Sie die untere Hälfte, bewegen Sie sich ab. Die Auswahl-Taste wählt den aktuellen Menüpunkt aus. Mit der Zurück-Taste gelangen Sie aus einem Untermenü zurück auf die nächst höhere Menüebene.

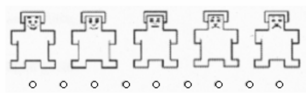
Sie haben im Folgenden für die Bearbeitung jeder Aufgabe maximal zwei Minuten Zeit. Bitte geben Sie dem Versuchsleiter kurz Bescheid, wenn Sie sich die Aufgabenstellung durchgelesen haben und mit der Aufgabe beginnen möchten. Haben Sie eine Aufgabe fertig bearbeitet oder ist die Bearbeitungszeit abgelaufen, bekommen Sie dies durch den Versuchsleiter rückgemeldet. Falls Sie noch Fragen zur Bedienung haben oder mit der Aufgabenbearbeitung beginnen möchten, wenden Sie sich bitte jetzt an den Versuchsleiter!

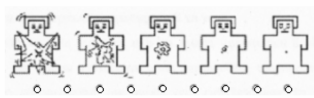
Aufgabe A

Denken Sie daran, während der Bearbeitung möglichst nicht zu sprechen!

Ihr Audio-Player verfügt über ein Radio. Stellen Sie bitte fest, welcher Sender gerade eingestellt ist!

Nach der Bearbeitung teilen Sie bitte IHR momentanes Gefühl mit:





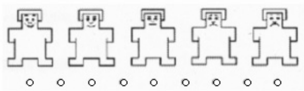
Bitte umblättern!

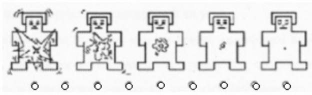
Aufgabe B

Denken Sie daran, während der Bearbeitung möglichst nicht zu sprechen!

Stellen Sie bitte fest, welche Lieder sie unter der Kategorie „deutscher Punk“ auf ihrem Audio-Player gespeichert haben!

Nach der Bearbeitung teilen Sie bitte IHR momentanes Gefühl mit:





Bitte umblättern!

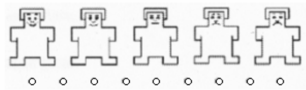
Untersuchung zur Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player

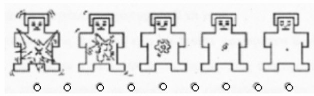
Aufgabe C

Denken Sie daran, während der Bearbeitung möglichst nicht zu sprechen!

Sie können mit Ihrem Audio-Player auch ihre Kontakte (Telefonnummern etc.) verwalten. Überprüfen Sie bitte, ob Sie schon Kontakte gespeichert haben!

Nach der Bearbeitung teilen Sie bitte IHR momentanes Gefühl mit:





Bitte umblättern!

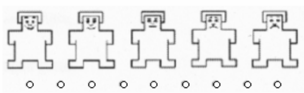
Untersuchung zur Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player

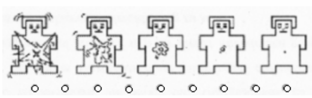
Aufgabe D

Denken Sie daran, während der Bearbeitung möglichst nicht zu sprechen!

Stellen Sie den Wiedergabemodus Ihres Audio-Players bitte auf „Random einmal“!

Nach der Bearbeitung teilen Sie bitte IHR momentanes Gefühl mit:





Bitte umblättern!

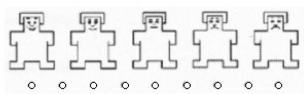
Untersuchung zur Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player

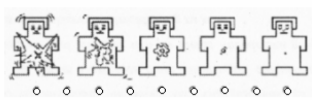
Aufgabe E

Denken Sie daran, während der Bearbeitung möglichst nicht zu sprechen!

Sie wollen nach Italien in den Urlaub fahren. Um sich darauf einzustellen, haben Sie Lust, die Menüsprache Ihres Audio-Players in Italienisch zu ändern.

Nach der Bearbeitung teilen Sie bitte IHR momentanes Gefühl mit:





Bitte umblättern!

Untersuchung zur Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player

Fragebogen

Sie haben nun die Möglichkeit diese Gestaltungsvariante anhand des folgenden Fragebogens zu bewerten. Bitte achten Sie bei den nachfolgenden Bewertungen darauf, dass Sie keine Zeile vergessen!

Bitte umblättern!

Ich finde das Produkt ...

Harmlos	O	O	O	O	O	O	O	Herausfordernd
Ausgrenzend	O	O	O	O	O	O	O	Einbeziehend
Praktisch	O	O	O	O	O	O	O	Unpraktisch
Lahm	O	O	O	O	O	O	O	Fesselnd
Bringt mich Leuten näher	O	O	O	O	O	O	O	Trennt mich von Leuten
Widerspenstig	O	O	O	O	O	O	O	Handhabbar
Phantasielos	O	O	O	O	O	O	O	Kreativ
Isolierend	O	O	O	O	O	O	O	Verbindend
Voraussagbar	O	O	O	O	O	O	O	Unberechenbar
Originell	O	O	O	O	O	O	O	Konventionell
Nicht Vorzeigbar	O	O	O	O	O	O	O	Vorzeigbar
Verwirrend	O	O	O	O	O	O	O	Übersichtlich
Neuartig	O	O	O	O	O	O	O	Herkömmlich
Minderwertig	O	O	O	O	O	O	O	Wertvoll
Umständlich	O	O	O	O	O	O	O	Direkt
Innovativ	O	O	O	O	O	O	O	Konservativ
Stilvoll	O	O	O	O	O	O	O	Stillos
Menschlich	O	O	O	O	O	O	O	Technisch
Mutig	O	O	O	O	O	O	O	Vorsichtig
Fachmännisch	O	O	O	O	O	O	O	Laienhaft
Einfach	O	O	O	O	O	O	O	Kompliziert

Bitte umblättern!

Inwiefern treffen die folgenden Aussagen zu?

	Stimme überhaupt nicht zu						Stimme voll zu
Das System ermöglicht es mir, die Aufgaben zu bewältigen.	O	O	O	O	O	O	O
Ich finde es leicht vom Produkt, zu bekommen, was ich will.	O	O	O	O	O	O	O
Ich denke, das System ist ein gutes Produkt.	O	O	O	O	O	O	O
Die Bedienung des Produkts strengt mich an.	O	O	O	O	O	O	O
Insgesamt denke ich, das Produkt ist nützlich.	O	O	O	O	O	O	O
Ich kann mir vorstellen, das Produkt zu kaufen.	O	O	O	O	O	O	O
Die Funktionen des Produkts sind für die Aufgaben relevant.	O	O	O	O	O	O	O
Die Bedienung des Produkts ist klar und verständlich.	O	O	O	O	O	O	O
Das Produkt ist hilfreich bei der Lösung der Aufgabe.	O	O	O	O	O	O	O
Das Produkt ist leicht zu bedienen.	O	O	O	O	O	O	O
Wenn ich das Produkt zur Verfügung hätte, würde ich es nutzen.	O	O	O	O	O	O	O

Das Design / die Gestaltung des Produkts ist ...

	Stimme überhaupt nicht zu						Stimme voll zu
... kreativ	O	O	O	O	O	O	O
... ästhetisch	O	O	O	O	O	O	O
... originell	O	O	O	O	O	O	O
... angenehm	O	O	O	O	O	O	O
... speziell	O	O	O	O	O	O	O
... klar	O	O	O	O	O	O	O
... symmetrisch	O	O	O	O	O	O	O
... faszinierend	O	O	O	O	O	O	O
... rein	O	O	O	O	O	O	O
... raffiniert	O	O	O	O	O	O	O

Bitte umblättern!

	Ich stimme nicht zu	Ich bin unentschieden	Ich stimme zu
Ich würde das System meinen Bekannten empfehlen.	O	O	O
Die Benutzung des Systems zu erlernen war anfangs schwierig.	O	O	O
Ich wusste bei der Benutzung manchmal nicht, was ich als nächstes machen sollte.	O	O	O
Ich bin manchmal unsicher, ob ich die richtige Eingabe gemacht habe.	O	O	O
Der Umgang mit dem System ist zufriedenstellend.	O	O	O
Die Art der Informationsdarstellung ist bei diesem System klar und verständlich.	O	O	O
Es werden nicht genug Informationen auf dem Display dargestellt.	O	O	O
Ich habe das Gefühl, die Kontrolle über das System zu haben, wenn ich es nutze.	O	O	O
Ich würde das System nicht täglich benutzen wollen.	O	O	O
Die Informationen, die das System mir gibt, sind verständlich und ausreichend.	O	O	O
Die Aufgaben können mit dem System auf unkomplizierte Weise bearbeitet werden.	O	O	O
Das System hilft mir, die Probleme, die ich bei der Benutzung habe, zu lösen.	O	O	O
Es wird deutlich, dass die Bedürfnisse der Nutzer bei der Gestaltung des Systems berücksichtigt wurden.	O	O	O
Die Anordnung der Menüs und Menüpunkte des Systems erscheint logisch.	O	O	O
Den Gebrauch neuer Funktionen zu erlernen ist schwierig.	O	O	O
Es sind zu viele Arbeitsschritte nötig um eine Aufgabe zu bearbeiten.	O	O	O
Es ist leicht, das System die Dinge tun zu lassen, die man will.	O	O	O
Ich werde nie die Benutzung aller Funktion des Systems erlernen.	O	O	O
Das System verhält sich gelegentlich auf eine Weise, die ich nicht verstehe.	O	O	O
Man kann auf den Blick alle Optionen erfassen, die das System zu diesem Zeitpunkt bietet.	O	O	O

Bitte umblättern!

Kurze Pause

Bevor wir Ihnen den nächsten Audio-Player demonstrieren, folgt eine kurze Pause, in der wir noch einmal die Aufzeichnung der physiologischen Daten testen müssen.

Wenden Sie sich bitte an den Versuchsleiter!

Zweite Variante

Die zweite Gestaltungsvariante wurde soeben für Sie auf dem Display dargestellt. Bevor Sie die Benutzung der Variante anhand einiger Aufgaben ausprobieren, beantworten Sie bitte kurz die folgenden Fragen:

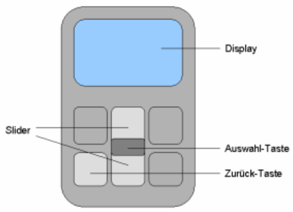
Das Design / die Gestaltung des Produkts ist ...

	Stimme überhaupt nicht zu						Stimme voll zu
... kreativ	O	O	O	O	O	O	O
... ästhetisch	O	O	O	O	O	O	O
... originell	O	O	O	O	O	O	O
... angenehm	O	O	O	O	O	O	O
... speziell	O	O	O	O	O	O	O
... klar	O	O	O	O	O	O	O
... symmetrisch	O	O	O	O	O	O	O
... faszinierend	O	O	O	O	O	O	O
... rein	O	O	O	O	O	O	O
... raffiniert	O	O	O	O	O	O	O

Bitte umblättern!

Beschreibung der Variante G (U0)

Der tragbare Audio-Player kann mit der Hand über das Touchscreen bedient werden. Für die Bearbeitung der folgenden Aufgaben werden lediglich vier Bedienelemente benötigt.



Auf dem Display werden Informationen dargestellt. Der „Slider" dient zum Wechsel zwischen verschiedenen Menüpunkten. Indem Sie mit dem Finger von oben nach unter bzw. unten nach oben über das Eingabefeld „ziehen", bewegen Sie sich in einem Menü auf bzw. ab. Die Auswahl-Taste, welche sich in der Mitte des „Sliders" befindet, wählt den aktuellen Menüpunkt aus. Mit der Zurück-Taste gelangen Sie aus einem Untermenü zurück auf die nächst höhere Menüebene.

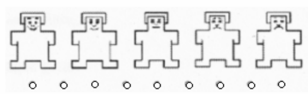
Sie haben im Folgenden für die Bearbeitung jeder Aufgabe maximal zwei Minuten Zeit. Bitte geben Sie dem Versuchsleiter jeweils kurz Bescheid, wenn Sie sich die Aufgabenstellung durchgelesen haben und mit der Aufgabe beginnen möchten. Haben Sie eine Aufgabe fertig bearbeitet oder ist die Bearbeitungszeit abgelaufen, bekommen Sie dies durch den Versuchsleiter rückgemeldet. Falls Sie noch Fragen zur Bedienung haben oder mit der Aufgabenbearbeitung beginnen möchten, wenden Sie sich bitte jetzt an den Versuchsleiter!

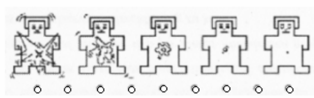
Aufgabe F

Denken Sie daran, während der Bearbeitung möglichst nicht zu sprechen!

Überprüfen Sie bitte, welcher Titel im Moment gespielt wird!

Nach der Bearbeitung teilen Sie bitte IHR momentanes Gefühl mit:





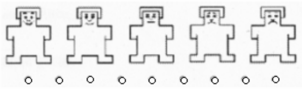
Bitte umblättern!

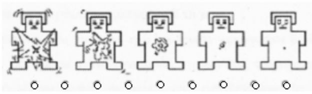
Aufgabe G

Denken Sie daran, während der Bearbeitung möglichst nicht zu sprechen!

Bitte lassen Sie sich von Ihrem Audio-Player die Uhrzeit anzeigen!

Nach der Bearbeitung teilen Sie bitte IHR momentanes Gefühl mit:





Bitte umblättern!

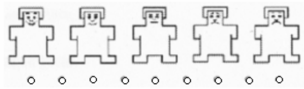
Untersuchung zur Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player

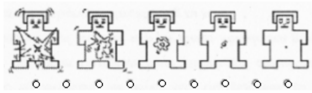
Aufgabe H

Denken Sie daran, während der Bearbeitung möglichst nicht zu sprechen!

Ihr Audio-Player kann auch als Wechselmedium für Computerdaten dienen. Sie wollen für die Wechselmediumsfunktion mehr Speicherplatz reservieren. Erhöhen Sie bitte den Speicherplatz auf 256 MB!

Nach der Bearbeitung teilen Sie bitte IHR momentanes Gefühl mit:





Bitte umblättern!

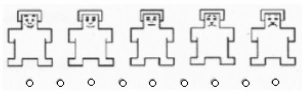
Untersuchung zur Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player

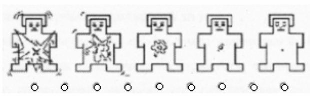
Aufgabe K

Denken Sie daran, während der Bearbeitung möglichst nicht zu sprechen!

Überprüfen Sie bitte, welche Titel Sie in Ihren Bookmarks gespeichert haben!

Nach der Bearbeitung teilen Sie bitte IHR momentanes Gefühl mit:





Bitte umblättern!

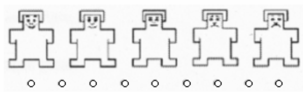
Untersuchung zur Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player

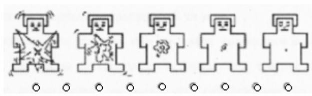
Aufgabe L

Denken Sie daran, während der Bearbeitung möglichst nicht zu sprechen!

Sie wollen unterschiedliche Klangeigenschaften Ihres Audio-Players testen. Ändern Sie bitte die Audioeinstellungen nach „Classic“!

Nach der Bearbeitung teilen Sie bitte IHR momentanes Gefühl mit:





Bitte umblättern!

Untersuchung zur Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player

Fragebogen

Sie haben nun die Möglichkeit diese Gestaltungsvariante anhand des folgenden Fragebogens zu bewerten. Bitte achten Sie bei den nachfolgenden Bewertungen darauf, dass Sie keine Zeile vergessen!

Bitte umblättern!

Ich finde das Produkt ...

Harmlos	O	O	O	O	O	O	O	Herausfordernd
Ausgrenzend	O	O	O	O	O	O	O	Einbeziehend
Praktisch	O	O	O	O	O	O	O	Unpraktisch
Lahm	O	O	O	O	O	O	O	Fesselnd
Bringt mich Leuten näher	O	O	O	O	O	O	O	Trennt mich von Leuten
Widerspenstig	O	O	O	O	O	O	O	Handhabbar
Phantasielos	O	O	O	O	O	O	O	Kreativ
Isolierend	O	O	O	O	O	O	O	Verbindend
Voraussagbar	O	O	O	O	O	O	O	Unberechenbar
Originell	O	O	O	O	O	O	O	Konventionell
Nicht Vorzeigbar	O	O	O	O	O	O	O	Vorzeigbar
Verwirrend	O	O	O	O	O	O	O	Übersichtlich
Neuartig	O	O	O	O	O	O	O	Herkömmlich
Minderwertig	O	O	O	O	O	O	O	Wertvoll
Umständlich	O	O	O	O	O	O	O	Direkt
Innovativ	O	O	O	O	O	O	O	Konservativ
Stilvoll	O	O	O	O	O	O	O	Stillos
Menschlich	O	O	O	O	O	O	O	Technisch
Mutig	O	O	O	O	O	O	O	Vorsichtig
Fachmännisch	O	O	O	O	O	O	O	Laienhaft
Einfach	O	O	O	O	O	O	O	Kompliziert

Bitte umblättern!

Inwiefern treffen die folgenden Aussagen zu?

	Stimme überhaupt nicht zu						Stimme voll zu
Das System ermöglicht es mir, die Aufgaben zu bewältigen.	O	O	O	O	O	O	O
Ich finde es leicht vom Produkt, zu bekommen, was ich will.	O	O	O	O	O	O	O
Ich denke, das System ist ein gutes Produkt.	O	O	O	O	O	O	O
Die Bedienung des Produkts strengt mich an.	O	O	O	O	O	O	O
Insgesamt denke ich, das Produkt ist nützlich.	O	O	O	O	O	O	O
Ich kann mir vorstellen, das Produkt zu kaufen.	O	O	O	O	O	O	O
Die Funktionen des Produkts sind für die Aufgaben relevant.	O	O	O	O	O	O	O
Die Bedienung des Produkts ist klar und verständlich.	O	O	O	O	O	O	O
Das Produkt ist hilfreich bei der Lösung der Aufgabe.	O	O	O	O	O	O	O
Das Produkt ist leicht zu bedienen.	O	O	O	O	O	O	O
Wenn ich das Produkt zur Verfügung hätte, würde ich es nutzen.	O	O	O	O	O	O	O

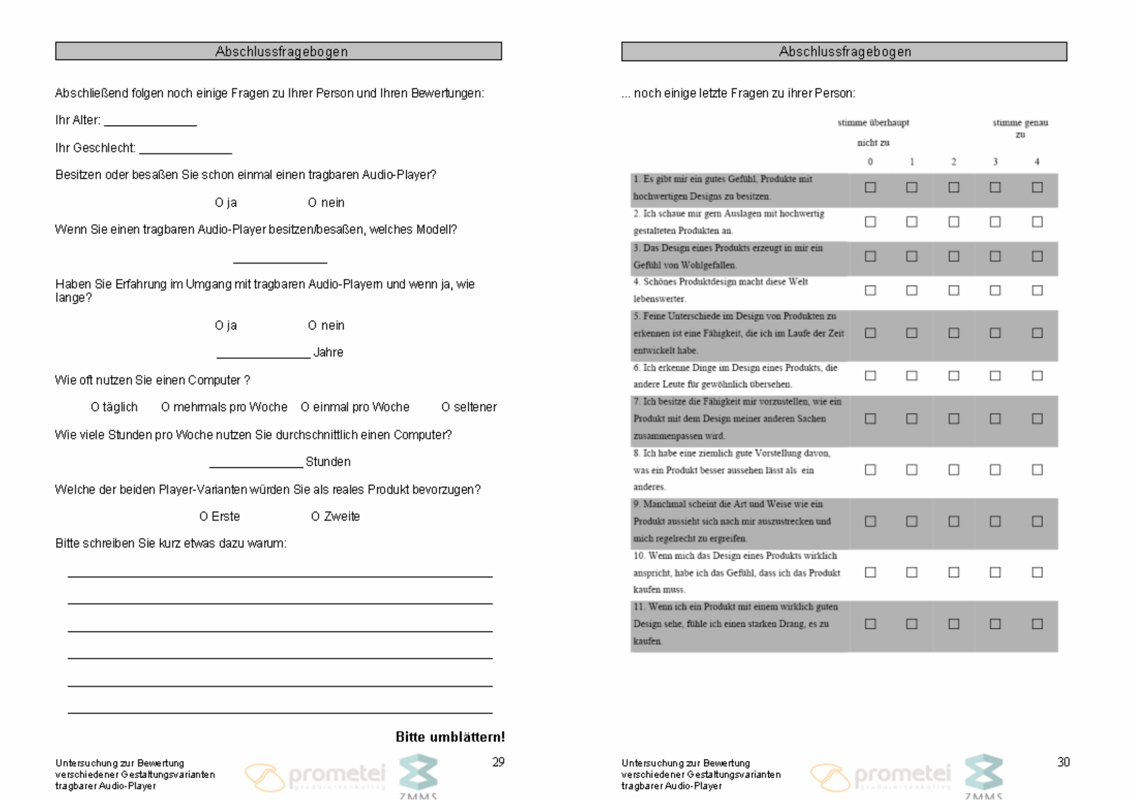
Das Design / die Gestaltung des Produkts ist ...

	Stimme überhaupt nicht zu						Stimme voll zu
... kreativ	O	O	O	O	O	O	O
... ästhetisch	O	O	O	O	O	O	O
... originell	O	O	O	O	O	O	O
... angenehm	O	O	O	O	O	O	O
... speziell	O	O	O	O	O	O	O
... klar	O	O	O	O	O	O	O
... symmetrisch	O	O	O	O	O	O	O
... faszinierend	O	O	O	O	O	O	O
... rein	O	O	O	O	O	O	O
... raffiniert	O	O	O	O	O	O	O

Bitte umblättern!

	Ich stimme nicht zu	Ich bin unentschieden	Ich stimme zu
Ich würde das System meinen Bekannten empfehlen.	O	O	O
Die Benutzung des Systems zu erlernen war anfangs schwierig.	O	O	O
Ich wusste bei der Benutzung manchmal nicht, was ich als nächstes machen sollte.	O	O	O
Ich bin manchmal unsicher, ob ich die richtige Eingabe gemacht habe.	O	O	O
Der Umgang mit dem System ist zufriedenstellend.	O	O	O
Die Art der Informationsdarstellung ist bei diesem System klar und verständlich.	O	O	O
Es werden nicht genug Informationen auf dem Display dargestellt.	O	O	O
Ich habe das Gefühl, die Kontrolle über das System zu haben, wenn ich es nutze.	O	O	O
Ich würde das System nicht täglich benutzen wollen.	O	O	O
Die Informationen, die das System mir gibt, sind verständlich und ausreichend.	O	O	O
Die Aufgaben können mit dem System auf unkomplizierte Weise bearbeitet werden.	O	O	O
Das System hilft mir, die Probleme, die ich bei der Benutzung habe, zu lösen.	O	O	O
Es wird deutlich, dass die Bedürfnisse der Nutzer bei der Gestaltung des Systems berücksichtigt wurden.	O	O	O
Die Anordnung der Menüs und Menüpunkte des Systems erscheint logisch.	O	O	O
Den Gebrauch neuer Funktionen zu erlernen ist schwierig.	O	O	O
Es sind zu viele Arbeitsschritte nötig um eine Aufgabe zu bearbeiten.	O	O	O
Es ist leicht, das System die Dinge tun zu lassen, die man will.	O	O	O
Ich werde nie die Benutzung aller Funktion des Systems erlernen.	O	O	O
Das System verhält sich gelegentlich auf eine Weise, die ich nicht verstehe.	O	O	O
Man kann auf den Blick alle Optionen erfassen, die das System zu diesem Zeitpunkt bietet.	O	O	O

Bitte umblättern!



Abschlussfragebogen

Abschließend folgen noch einige Fragen zu Ihrer Person und Ihren Bewertungen:

Ihr Alter: ____________

Ihr Geschlecht: ____________

Besitzen oder besaßen Sie schon einmal einen tragbaren Audio-Player?

O ja O nein

Wenn Sie einen tragbaren Audio-Player besitzen/besaßen, welches Modell?

____

Haben Sie Erfahrung im Umgang mit tragbaren Audio-Playern und wenn ja, wie lange?

O ja O nein

____________ Jahre

Wie oft nutzen Sie einen Computer ?

O täglich O mehrmals pro Woche O einmal pro Woche O seltener

Wie viele Stunden pro Woche nutzen Sie durchschnittlich einen Computer?

____________ Stunden

Welche der beiden Player-Varianten würden Sie als reales Produkt bevorzugen?

O Erste O Zweite

Bitte schreiben Sie kurz etwas dazu warum:

Bitte umblättern!

Untersuchung zur Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player 29

Abschlussfragebogen

... noch einige letzte Fragen zu ihrer Person:

	stimme überhaupt nicht zu 0	1	2	3	stimme genau zu 4
1. Es gibt mir ein gutes Gefühl, Produkte mit hochwertigen Designs zu besitzen.	☐	☐	☐	☐	☐
2. Ich schaue mir gern Auslagen mit hochwertig gestalteten Produkten an.	☐	☐	☐	☐	☐
3. Das Design eines Produkts erzeugt in mir ein Gefühl von Wohlgefallen.	☐	☐	☐	☐	☐
4. Schönes Produktdesign macht diese Welt lebenswerter.	☐	☐	☐	☐	☐
5. Feine Unterschiede im Design von Produkten zu erkennen ist eine Fähigkeit, die ich im Laufe der Zeit entwickelt habe.	☐	☐	☐	☐	☐
6. Ich erkenne Dinge im Design eines Produkts, die andere Leute für gewöhnlich übersehen.	☐	☐	☐	☐	☐
7. Ich besitze die Fähigkeit mir vorzustellen, wie ein Produkt mit dem Design meiner anderen Sachen zusammenpassen wird.	☐	☐	☐	☐	☐
8. Ich habe eine ziemlich gute Vorstellung davon, was ein Produkt besser aussehen lässt als ein anderes.	☐	☐	☐	☐	☐
9. Manchmal scheint die Art und Weise wie ein Produkt aussieht sich nach mir auszustrecken und mich regelrecht zu ergreifen.	☐	☐	☐	☐	☐
10. Wenn mich das Design eines Produkts wirklich anspricht, habe ich das Gefühl, dass ich das Produkt kaufen muss.	☐	☐	☐	☐	☐
11. Wenn ich ein Produkt mit einem wirklich guten Design sehe, fühle ich einen starken Drang, es zu kaufen.	☐	☐	☐	☐	☐

Untersuchung zur Bewertung verschiedener Gestaltungsvarianten tragbarer Audio-Player 30

Appendix D.5 Detailed results of Study 2

The following tables contain the results of all mixed linear model analyses of the two factors USABILITY and VISUAL AESTHETICS for all dependent variables (interaction characteristics, quality perceptions, emotional user reactions, and overall judgments) in Study 2.

Mixed linear models test for number of completed tasks:

	df	*F*	*p*
USABILITY (U)	1	52.875	<.001***
VISUAL AESTHETICS (A)	1	0.470	.332
U x A	1	0.421	.431

* p < .05; ** p < .01; *** p < .001

Mixed linear models test for time on task:

	df	*F*	*p*
USABILITY (U)	1	44.455	<.001***
VISUAL AESTHETICS (A)	1	0.772	.382
U x A	1	0.457	.501

* p < .05; ** p < .01; *** p < .001

Mixed linear models test for perceived usability:

	df	*F*	*p*
USABILITY (U)	1	70.403	<.001***
VISUAL AESTHETICS (A)	1	1.447	.232
U x A	1	1.443	.233

* p < .05; ** p < .01; *** p < .001

Mixed linear models test for perceived visual aesthetics:

	df	*F*	*p*
USABILITY (U)	1	0.647	.423
VISUAL AESTHETICS (A)	1	55.188	<.001***
U x A	1	3.131	.080

* p < .05; ** p < .01; *** p < .001

Mixed linear models test for subjective feelings (valence):

	df	*F*	*p*
USABILITY (U)	1	38.711	<.001***
VISUAL AESTHETICS (A)	1	4.658	.034*
U x A	1	0.229	.634

* p < .05; ** p < .01; *** p < .001

Mixed linear models test for subjective feelings (arousal):

	df	*F*	*p*
USABILITY (U)	1	19.215	<.001***
VISUAL AESTHETICS (A)	1	5.563	.021*
U x A	1	2.287	.135

* p < .05; ** p < .01; *** p < .001

Mixed linear models test for EMG (c.s.):

	df	*F*	*p*
USABILITY (U)	1	2.754	.094
VISUAL AESTHETICS (A)	1	0.066	.798
U x A	1	0.007	.935

* p < .05; ** p < .01; *** p < .001

Mixed linear models test for EMG (z.m.):

	df	*F*	*p*
USABILITY (U)	1	1.154	.286
VISUAL AESTHETICS (A)	1	0.109	.742
U x A	1	0.057	.811

* p < .05; ** p < .01; *** p < .001

Mixed linear models test for EDA:

	df	*F*	*p*
USABILITY (U)	1	17.594	<.001***
VISUAL AESTHETICS (A)	1	1.555	.216
U x A	1	1.817	.181

* p < .05; ** p < .01; *** p < .001

Mixed linear models test for heart rate:

	df	*F*	*p*
USABILITY (U)	1	1.650	.203
VISUAL AESTHETICS (A)	1	0.306	.582
U x A	1	4.030	.058

* p < .05; ** p < .01; *** p < .001

Mixed linear models test for the overall rating:

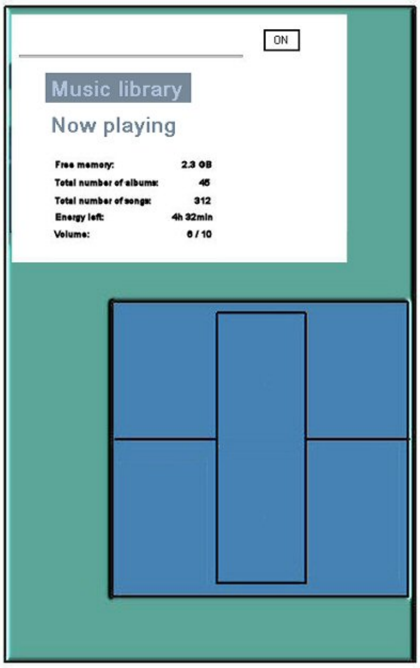
	df	*F*	*p*
USABILITY (U)	1	69.451	<.001***
VISUAL AESTHETICS (A)	1	3.203	.077
U x A	1	0.370	.544

* p < .05; ** p < .01; *** p < .001

Appendix E Study 3

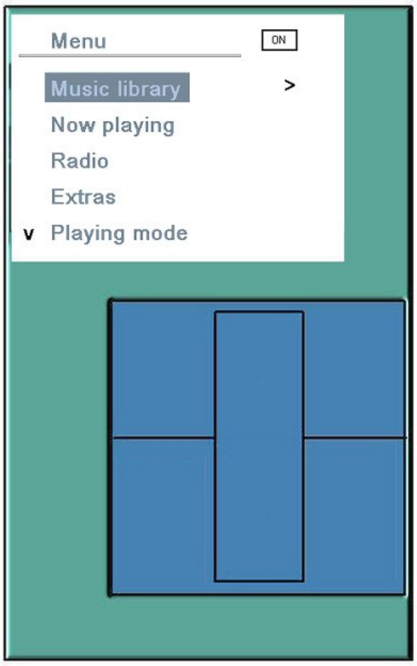
Appendix E contains a description of the used systems, questionnaires, and detailed results of Study 3 (Chapter 7).

Appendix E.1 Screenshots of systems used in Study 3

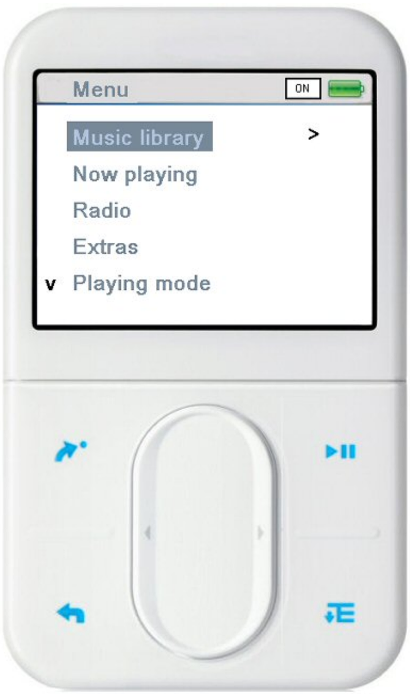


Low usability / low aesthetics

Low usability / high aesthetics



High usability / low aesthetics



High usability / high aesthetics

Appendix E.2 Questionnaires used in Study 3

ID:_______________ Date: _ _ / _ _ / _ _

Digital Audio Player Study

Sascha Mahlke (sascha.mahlke@zmms.tu-berlin.de)

Dr. Gitte Lindgaard (gitte_lindgaard@carleton.ca)

Introduction

Welcome to the Human-Oriented Technology Lab and thank you for taking part in this study.

In this study we want to know your opinion on a portable audio player design. During the experiment you will be interacting with one audio player that we chose from a larger set. The design is displayed on a small screen. It is a very early prototype for future products, but you can already use it via a touchscreen. You have about ten minutes time to test it.

Before testing the player you have to fill in a short questionnaire on the next page and get some more instruction on the following pages. Then I will present the player on the small display. You have to fill in a short questionnaire to describe your first impression of what you see. Than you will be given a short description about how to use the player. During usage you will be asked how you feel about the player you are using. After usage I will ask you to fill in a few short questionnaires asking your opinion of the player you have just tested. We are interested in all aspects that might be important for you for purchase and use the products. At the end of the experiment you will also be asked to indicate any important aspects that may not have been addressed in the questionnaires.

→

Questionnaire

Before we start:

How do you feel at the moment? How would you rate your mood?

	Disagree				Agree
contented	O	O	O	O	O
rested	O	O	O	O	O
uneasy	O	O	O	O	O
bad	O	O	O	O	O
lethargic	O	O	O	O	O
calm	O	O	O	O	O
good	O	O	O	O	O
tired	O	O	O	O	O
restless	O	O	O	O	O
unwell	O	O	O	O	O
alert	O	O	O	O	O
relaxed	O	O	O	O	O

→

Introduction

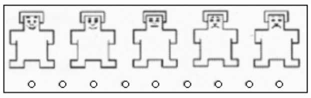
This is SAM:

SAM is another way you can use to describe you feelings. You will use SAM later to describe what you feel while you are using the interactive products presented in this study. This description is to explain how it works.
Feelings can be seen from two perspectives:

→ the sentiment of a feeling (positive or negative),
→ the intensity of a feeling (high or low).

SAM describes your **sentiment** from a bright smile to raised eyebrows. This row characterizes your sentiment from very "satisfied" or "happy" to very "unsatisfied" or "sad".

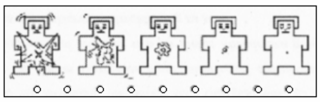
"satisfied" "happy"



"unsatisfied" "sad"

The second row illustrates your **arousal**, that can reach from very "aroused" or "tense" to very "calm" or "drowsy".

"aroused" "tense"



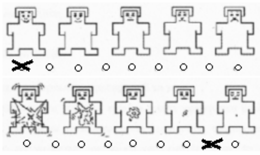
"calm" "drowsy"

It is important that you do not use SAM to rate the product, but to describe your feelings while you interact with the product. You should do it spontaneously and immediately. You describe your feeling by marking the dot that most closely describes your feeling in each row as shown in the examples on the next page.

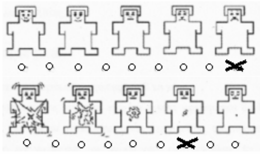
→

Introduction

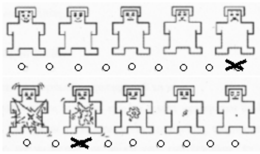
Relaxed



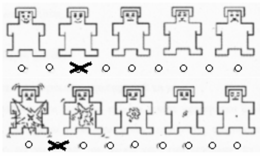
Bored



Frightened



Excited



Digital Audio Player Study

Introduction

Before you start testing the portable audio player, let me remind you of the things that are important during the study:

- We are interested in all aspects of the products that are important for you when thinking of purchasing and using it.
- When you are asked to describe your present feeling with SAM, please do this immediately.

Do you have any further questions before we start?

Digital Audio Player Study

Questionnaire before usage

You can see the first design on the display now. Please answer the following questions concerning your first impression of the prototype before using it.

The design of the product is ...

	Disagree						Agree
... creative	O	O	O	O	O	O	O
... aesthetic	O	O	O	O	O	O	O
... original	O	O	O	O	O	O	O
... pleasant	O	O	O	O	O	O	O
... special	O	O	O	O	O	O	O
... clear	O	O	O	O	O	O	O
... symmetric	O	O	O	O	O	O	O
... fascinating	O	O	O	O	O	O	O
... clean	O	O	O	O	O	O	O
... sophisticated	O	O	O	O	O	O	O

→

Digital Audio Player Study

Questionnaire

We want to know more about your emotional experience during the interaction with the prototype. Please respond to the questions below by placing a check mark in the appropriate space for the respective scale. If a particular question does not make sense, please mark the circle "does not apply".

How would you evaluate your usage of the product in general?
(Note: To allow assessing ambivalent situations, we ask you to respond to both scales.)

	not at all		moderately		extremely	does not apply
pleasant						O
unpleasant						O

While using the product, did you think that...

	not at all		moderately		extremely	does not apply
you were **familiar** with this type of interaction?						O
It met your **expectations**?						O

While using the product, to what extent did you think that one or more of the following factors influenced your interactive experience with the system?

	not at all		moderately		extremely	does not apply
the behavior of **the product**?						O
chance or **special circumstances**?						O
your own behaviour?						O
Was your own behavior **consistent with what you have expected**?						O

At the time of using the product, did you think the interaction...

	not at all		moderately		extremely	does not apply
would bring about **positive, desirable outcomes** for you (e.g., helping you to reach a goal, giving pleasure, or terminating an unpleasant situation)?						O
would bring about **negative, undesirable outcomes** for you (e.g., preventing you from reaching a goal or satisfying a need, or producing unpleasant feelings)?						O
could have been **modified** by **appropriate action**?						O

→

Digital Audio Player Study

Questionnaire

Please rate the product now!

	Disagree						Agree
The product enables me to accomplish relevant tasks.	O	O	O	O	O	O	O
I find it easy to get the product to do what I want it to do.	O	O	O	O	O	O	O
I think the product is a good product.	O	O	O	O	O	O	O
Interacting with the product requires a lot of effort.	O	O	O	O	O	O	O
Overall, I find the product useful.	O	O	O	O	O	O	O
I can imagine buying the product.	O	O	O	O	O	O	O
The product's functionality is relevant for important tasks.	O	O	O	O	O	O	O
The interaction with the product is easy for me to understand.	O	O	O	O	O	O	O
The product allows me to accomplish important tasks.	O	O	O	O	O	O	O
Overall, I find the product easy to use,	O	O	O	O	O	O	O
I would use the product, if I had it.	O	O	O	O	O	O	O

The design of the product is ...

	Disagree						Agree
... creative	O	O	O	O	O	O	O
... aesthetic	O	O	O	O	O	O	O
... original	O	O	O	O	O	O	O
... pleasant	O	O	O	O	O	O	O
... special	O	O	O	O	O	O	O
... clear	O	O	O	O	O	O	O
... symmetric	O	O	O	O	O	O	O
... fascinating	O	O	O	O	O	O	O
... clean	O	O	O	O	O	O	O
... sophisticated	O	O	O	O	O	O	O

Digital Audio Player Study

Questionnaire

I think the product is ...

easy	O	O	O	O	O	O	O	challenging
non-inclusive	O	O	O	O	O	O	O	inclusive
practical	O	O	O	O	O	O	O	Impractical
unexciting	O	O	O	O	O	O	O	exciting
uncontrollable	O	O	O	O	O	O	O	manageable
standard	O	O	O	O	O	O	O	creative
isolating	O	O	O	O	O	O	O	connecting
predictable	O	O	O	O	O	O	O	unpredictable
original	O	O	O	O	O	O	O	typical
presentable	O	O	O	O	O	O	O	unpresentable
confusing	O	O	O	O	O	O	O	clear
novel	O	O	O	O	O	O	O	commonplace
cheap	O	O	O	O	O	O	O	expensive
cumbersome	O	O	O	O	O	O	O	efficient
innovative	O	O	O	O	O	O	O	conservative
classy	O	O	O	O	O	O	O	common
human	O	O	O	O	O	O	O	technical
courageous	O	O	O	O	O	O	O	cautious
professional	O	O	O	O	O	O	O	amateurish
simple	O	O	O	O	O	O	O	complex
ugly	O	O	O	O	O	O	O	beautiful
good	O	O	O	O	O	O	O	bad

→

Digital Audio Player Study

Questionnaire

	Disagree	Undecided	Agree
I would recommend the product to my friends.	O	O	O
Learning to use this product initially is difficult.	O	O	O
I sometimes don't know what to do next with this product.	O	O	O
I sometimes wonder if I'm using the right command.	O	O	O
Working with this product is satisfying.	O	O	O
The way product information is presented is clear and understandable.	O	O	O
There is never enough information on the display.	O	O	O
I feel in charge of this product when I am using it.	O	O	O
I would not like to use this product every day.	O	O	O
I can understand and act on the information provided by this product.	O	O	O
Tasks can be performed in a straightforward manner using this product.	O	O	O
The product has helped me overcome any problems I had using it.	O	O	O
It is obvious that user needs have fully been taken into consideration.	O	O	O
The organization of the menus or information lists seems logical.	O	O	O
Learning how to use new functions is difficult.	O	O	O
There are too many steps required to get something to work.	O	O	O
It is easy to make the product do exactly what you want.	O	O	O
I will never learn to use all that is offered in this product.	O	O	O
This product occasionally behaves in a way that can't be understood.	O	O	O
It is easy to see at a glance what the options are at each stage.	O	O	O

→

Digital Audio Player Study

Questionnaire

Concluding, some questions regarding your overall judgment, the situation and some questions regarding your person follow:

Why did you rate the product the way you did?

____

____

____

____

While using the product ...

... I felt serious.	O	O	O	O	O	O	O	... I felt playful.
... I focused on the product.	O	O	O	O	O	O	O	... I focused on attaining my goals.

Your age: __________

O female O male

Have you lived in Canada for more than ten years?

O yes O no

If not, which country did you live in most of the time before?

____

Do you own a portable audio player?

O yes O no

Which one?

____

→

Digital Audio Player Study

Questionnaire

Do you have experience using mobile digital audio players and for how long?

O yes O no

____________ years

How often do you use a computer?

O daily O several times a week O one a week O infrequently

How many hours do you use a computer per week?

____________ hours

What do you think about yourself?

	Disagree				Agree
Owning products with superior design makes me feel good about myself.	O	O	O	O	O
I enjoy seeing displays of products that have superior design.	O	O	O	O	O
A product's design is a source of pleasure for me.	O	O	O	O	O
Beautiful product designs make our world a better place to live.	O	O	O	O	O
Being able to see subtle differences in product designs is one skill I have developed over time.	O	O	O	O	O
I see things in a product's design that other people tend to miss	O	O	O	O	O
I have the ability to imagine how a product will fit in with designs of other things I already know.	O	O	O	O	O
I have a pretty good idea about what makes one product look better than its competitors.	O	O	O	O	O
Sometimes the way a product looks seems to reach out and grab me.	O	O	O	O	O
If a product's design really "speaks" to me, I feel that I must buy it.	O	O	O	O	O
When I see a product with a really great design, I feel a strong urge to buy it.	O	O	O	O	O

Digital Audio Player Study

Informed Consent: Digital Audio Player Study

This study is part of a project in Human-Computer Interaction, sponsored by the HOTLab at Carleton University. The Principal Investigators is Sascha Mahlke, Berlin University of Technology, Germany, and the project is sponsored by Dr. Gitte Lindgaard, Department of Psychology, Carleton University.

In this study we are interested in your opinion about portable audio player designs. The study takes about 40 minutes and takes place in one of our labs. During the experiment you will be interacting with one audio player version that we chose from a larger set. The design is displayed on a small screen. It is a very early prototype of future products, but you can already use it via a touchscreen. You will be asked to test the audio player in the session. During the interaction with the audio players you will be asked how you feel. Thereafter you will be given a set of questionnaires asking your opinion about them. We are interested in all aspects that might be important for you for when considering purchasing and/or using the products. At the end of the experiemnt you will also be given an opportunity to indicate any important aspects that were not addressed in the questionnaires.

You will receive 1% grade raising credit for your participation in this study. During the study you have the right to withdraw at any point without penalty and can skip any questions you do not wish to answer. If you withdraw before completion of the study, you are still entitled to receive credit for your participation.

The data collected from this study will be used for research purposes only; your identity will be kept strictly anonymous. We will store all the data using a coding system rather than using your name. Data files will be destroyed as soon as we finish analyzing the data and no later than by the end of July 2007. No one except the above mentioned research team will have access to the data. Presentations resulting from this study will not disclose the identity of individual participants.

If you have any questions about the study or about your role and rights within the context of this study, please contact the Principal Investigator or the Faculty Sponsor.

Sascha Mahlke
PhD student
Phone: 613 520 2600 ex 6629
Email: sascha.mahlke@zmms.tu-berlin.de

Dr. Gitte Lindgaard
Professor and Chair, HOTLab
Phone: 613 520 2600 ex 2555
Email: gitte_lindgaard@carleton.ca

If you have ethical concerns regarding our study you can contact the departmental chair and the chair of the Carleton University Ethics Committee for Psychological Research.

Dr. Mary Gick
Chair, Department of Psychology
Phone: 613 520 2600 ex 2264
Email: mary_gick@carleton.ca

Dr. Janet Mantler
Chair Ethics Committee for Psychological Research
Phone: 613 520 2600 ex 4173
Email: janet_mantler@carleton.ca

Please confirm that you have read the above description of this project and have received a personal copy of this form. Please acknowledge that you agree to participate in this study and understand that you may withdraw at any time.

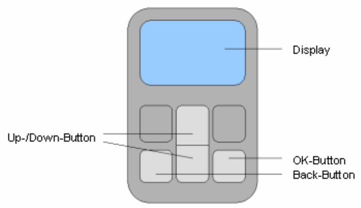
Participant's Signature: ______________________ Date: ___________

Investigator's Signature: ______________________ Date: ___________

In the exploration condition the following two pages were presented after Page 7:

Description of the design

You can use the prototype of a portable audio player with your fingers via the touch screen. Only the following controls can be used:



Information will be presented on the display. The Up-/Down Button can be used to change the menu options. Using the OK Button you can choose an option. The Back-Button can be used to get from a submenu to a higher-level menu.

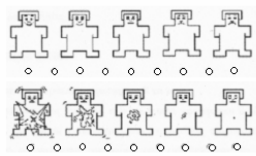
If you have further questions regarding usage, please ask the investigator. Overall you now have five minutes to explore the prototype. During that time you will be asked three times – a message will pop up on the display – to fill in the SAM scales on the next page.

→

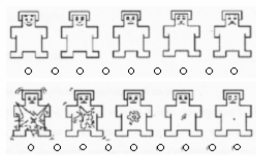
Digital Audio Player Study

Questionnaire during usage

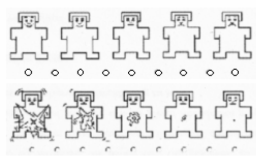
Please fill in these SAM scales when the first message poped up on the display.



Please fill in these SAM scales when the next message poped up on the display.



Please fill in these SAM scale when your exploration time is over.

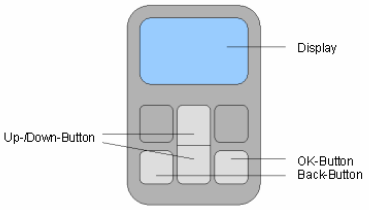


Digital Audio Player Study

In the task condition the following four pages were presented after Page 7:

Description of the design

You can use the prototype of a portable audio player with your fingers via the touch screen. Only the following controls can be used:



Information will be presented on the display. The Up-/Down Button can be used to change the menu options. Using the OK Button you can choose an option. The Back-Button can be used to get from a submenu to a higher-level menu.

If you have further questions regarding usage, please ask the investigator. Overall you are now given five tasks to explore the prototype. You have two minutes to complete each task. The tasks are given on the next pages. After each task you are asked to fill in the SAM scales.

→

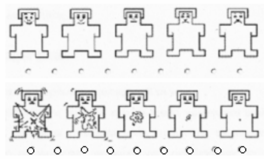
Digital Audio Player Study

Tasks

First task

Please set the playback mode to RANDOM ENDLESS.

Please fill in the SAM scale after you completed the task or the time is over.



Second task

The audio player is able to manage your contacts. Please find out if any contacts are saved so far.

→

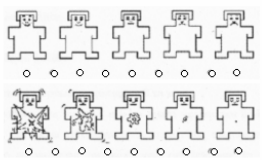
Digital Audio Player Study

Tasks

Third task

Please have a look which songs you find on the player in the Genre Pop.

Please fill in the SAM scale after you completed the task or the time is over.



Fourth task

Please change the sound setting of the player to CLASSIC.

→

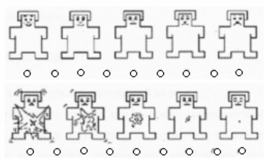
Digital Audio Player Study

Tasks

Fifth task

The audio player can be also used to store data. You have to reserve storage for the data. Please set the data storage to 1GB.

Please fill in the SAM scale after you completed the task or the time is over.



→

Digital Audio Player Study

Appendix E.3 Overview of the data for all dependent variables in Study 3

Component *&* *Dependent variable*	*Canadian*								*German*							
	Goal Mode				*Action Mode*				*Goal Mode*				*Action Mode*			
	Low Usability		*High Usability*		*Low Usability*		*High Usability*		*Low Usability*		*High Usability*		*Low Usability*		*High Usability*	
	Low Aes.	*High Aes.*	*Low Aes.*	*High Aes.*	*Low Aes.*	*High Aes.*	*Low Aes.*	*High Aes.*	*Low Aes.*	*High Aes.*	*Low Aes.*	*High Aes.*	*Low Aes.*	*High Aes.*	*Low Aes.*	*High Aes.*
Interaction characteristics																
No. of accomplished tasks (0-5)	3.4	3.3	4.5	4.4	-	-	-	-	3.3	4.0	4.5	4.4	-	-	-	-
Average time on task [s]	50.9	52.3	23.7	29.0	-	-	-	-	48.6	45.2	26.6	30.0	-	-	-	-
Quality perceptions																
Perceived usability (0-8)	4,4	4.9	6.2	5.6	4.4	4.8	6.2	5.6	3.5	4.4	5.0	6.5	4.0	3.7	5.7	6.1
Perceived visual aesthetics (0-6)	3.5	4.9	3.7	4.8	3.0	4.2	3.5	4.7	3.2	4.7	3.2	4.6	3.0	4.0	3.2	4.6
Subjective feelings																
SAM – valence (1-9)	4.3	4.7	5.8	5.3	4.2	4.6	5.6	5.4	4.9	5.0	5.0	5.7	2.7	3.3	4.5	5.2
SAM – arousal (1-9)	4.2	3.7	3.5	2.9	3.0	3.5	3.5	3.1	3.2	2.8	3.2	3.0	2.8	3.3	1.7	2.8
Cognitive appraisals																
Pleasantness (1-5)	3.0	3.6	3.7	4.0	3.1	2.8	3.1	3.6	2.4	3.2	3.6	3.6	2.5	2.8	3.5	3.8
Novelty (1-5)	2.8	2.4	1.9	1.8	2.7	2.8	2.5	2.5	3.5	2.8	2.6	2.4	3.5	3.3	2.4	2.2
Goal relevance (1-5)	3.5	3.3	4.3	3.9	3.6	3.1	3.4	3.8	2.9	3.3	3.3	3.2	3.2	2.4	3.0	2.8
Coping potential (1-5)	3.4	3.7	3.9	3.6	4.1	4.1	3.7	3.7	2.9	3.5	3.5	3.0	4.1	3.6	4.0	4.0
Norm/self compatibility (1-5)	3.0	2.9	2.8	2.1	2.0	2.5	2.6	2.6	3.0	3.3	2.7	2.9	2.4	2.4	3.1	3.0
Overall judgments																
Global rating (0-2)	0.9	1.3	1.6	1.4	0.8	0.8	1.1	1.4	0.8	1.2	1.1	1.4	0.4	0.8	1.1	1.4

Appendix E.4 Detailed results of Study 3

The following tables present the results of all analyses of variance of the four factors USABILITY, VISUAL AESTHETICS, MODE, and CULTURE for all dependent variables (interaction characteristics, quality perceptions, emotional user reactions, and overall judgments) in Study 3.

Analysis of variance for number of completed tasks (80 participants in goal-mode):

	df	*F*	*p*	*η*
CULTURE (C)	1	0.384	.537	.005
USABILITY (U)	1	**15.398**	**<.001*** **	**.176**
VISUAL AESTHETICS (A)	1	0.171	.681	.002
C x U	1	0.384	.537	.005
C x A	1	0.682	.411	.009
U x A	1	0.682	.411	.009
C x U x A	1	0.682	.411	.009
ERROR	72	(1.172)		

Note. Values enclosed in parentheses represent mean square errors. * p < .05; ** p < .01; *** p < .001

Analysis of variance for time on task (80 participants in goal-mode):

	df	*F*	*p*	*η*
CULTURE (C)	1	0.120	.730	.002
USABILITY (U)	1	25.415	<.001***	.261
VISUAL AESTHETICS (A)	1	0.001	.981	.000
C x U	1	0.049	.826	.001
C x A	1	0.069	.794	.001
U x A	1	2.163	.146	.029
C x U x A	1	0.016	.899	.000
ERROR	72	(6335.279)		

Note. Values enclosed in parentheses represent mean square errors. * p < .05; ** p < .01; *** p < .001

Analysis of variance for perceived usability:

	df	F	p	η
CULTURE (C)	1	1.546	.216	.011
MODE (M)	1	0.007	.935	.000
USABILITY (U)	1	28.101	<.001***	.169
VISUAL AESTHETICS (A)	1	1.101	.296	.008
C x M	1	0.037	.848	.000
C x U	1	1.005	.318	.007
M x U	1	0.033	.856	.000
C x M x U	1	0.004	.950	.000
C x A	1	1.443	.232	.010
M x A	1	0.932	.336	.007
C x M x A	1	0.677	.412	.005
U x A	1	0.284	.595	.002
C x U x A	1	1.986	.161	.014
M x U x A	1	0.002	.967	.000
C x M x U x A	1	0.008	.928	.000
ERROR	138	(3.390)		

Note. Values enclosed in parentheses represent mean square errors. * p < .05; ** p < .01; *** p < .001

Analysis of variance for perceived visual aesthetics:

	df	F	p	η
CULTURE (C)	1	4.739	.031*	.032
MODE (M)	1	0.956	.330	.007
USABILITY (U)	1	0.900	.344	.006
VISUAL AESTHETICS (A)	1	63.991	<.001***	.309
C x M	1	0.516	.474	.004
C x U	1	0.207	.650	.001
M x U	1	2.629	.107	.018
C x M x U	1	0.025	.874	.000
C x A	1	0.078	.780	.001
M x A	1	0.644	.424	.004
C x M x A	1	0.025	.874	.000
U x A	1	0.178	.673	.001
C x U x A	1	1.015	.316	.007
M x U x A	1	0.323	.571	.002
C x M x U x A	1	0.155	.695	.001
ERROR	143	(1.161)		

Note. Values enclosed in parentheses represent mean square errors. * p < .05; ** p < .01; *** p < .001

Analysis of variance for the overall rating:

	df	F	p	η
CULTURE (C)	1	3.098	.081	.021
MODE (M)	1	8.052	.005**	.054
USABILITY (U)	1	25.166	<.001***	.151
VISUAL AESTHETICS (A)	1	8.052	.005**	.054
C x M	1	0.290	.591	.002
C x U	1	0.090	.765	.001
M x U	1	2.312	.131	.016
C x M x U	1	0.850	.358	.006
C x A	1	1.085	.299	.008
M x A	1	0.063	.802	.000
C x M x A	1	0.156	.693	.001
U x A	1	0.988	.322	.007
C x U x A	1	0.024	.877	.000
M x U x A	1	1.830	.178	.013
C x M x U x A	1	1.830	.178	.013
ERROR	138	(0.299)		

Note. Values enclosed in parentheses represent mean square errors. * p < .05; ** p < .01; *** p < .001

Analysis of variance for subjective feelings (valence) / absolute values:

	df	F	p	η
CULTURE (C)	1	3.815	.049*	.026
MODE (M)	1	8.226	.005**	.054
USABILITY (U)	1	22.072	<.001***	.133
VISUAL AESTHETICS (A)	1	1.390	.240	.010
C x M	1	5.643	.019**	.038
C x U	1	0.003	.958	.000
M x U	1	2.343	.128	.016
C x M x U	1	2.133	.146	.015
C x A	1	0.937	.335	.006
M x A	1	0.226	.635	.002
C x M x A	1	0.003	.958	.000
U x A	1	0.226	.635	.002
C x U x A	1	1.308	.255	.009
M x U x A	1	0.003	.958	.000
C x M x U x A	1	0.112	.739	.001
ERROR	144	(2.243)		

Note. Values enclosed in parentheses represent mean square errors. * p < .05; ** p < .01; *** p < .001

Analysis of variance for subjective feelings (arousal) / absolute values:

	df	F	p	η
CULTURE (C)	1	7.516	.007**	.050
MODE (M)	1	2.145	.145	.015
USABILITY (U)	1	2.371	.126	.016
VISUAL AESTHETICS (A)	1	0.013	.910	.000
C x M	1	0.114	.736	.001
C x U	1	0.001	.970	.000
M x U	1	0.013	.910	.000
C x M x U	1	3.386	.068	.023
C x A	1	1.355	.246	.009
M x A	1	3.386	.068	.023
C x M x A	1	0.238	.626	.002
U x A	1	0.013	.910	.000
C x U x A	1	1.028	.312	.007
M x U x A	1	0.069	.793	.000
C x M x U x A	1	0.408	.524	.003
ERROR	138	(1.969)		

Note. Values enclosed in parentheses represent mean square errors. * $p < .05$; ** $p < .01$; *** $p < .001$

Analysis of variance for subjective feelings (valence) / relative values:

	df	F	p	η
CULTURE (C)	1	0.719	.398	.005
MODE (M)	1	1.667	.199	.011
USABILITY (U)	1	14.469	<.001***	.091
VISUAL AESTHETICS (A)	1	5.156	.025*	.035
C x M	1	5.783	.017*	.039
C x U	1	0.661	.417	.005
M x U	1	0.184	.669	.001
C x M x U	1	2.271	.134	.016
C x A	1	0.854	.357	.006
M x A	1	0.266	607	.002
C x M x A	1	0.364	.547	.003
U x A	1	0.908	.342	.006
C x U x A	1	0.931	.336	.006
M x U x A	1	0.000	.993	.000
C x M x U x A	1	1.246	.266	.009
ERROR	144	(3.270)		

Note. Values enclosed in parentheses represent mean square errors. * $p < .05$; ** $p < .01$; *** $p < .001$

Analysis of variance for subjective feelings (arousal) / relative values:

	df	F	p	η
CULTURE (C)	1	1.730	.190	.012
MODE (M)	1	0.003	.960	.000
USABILITY (U)	1	1.543	.216	.011
VISUAL AESTHETICS (A)	1	1.366	.244	.009
C x M	1	0.459	.499	.003
C x U	1	0.514	.475	.004
M x U	1	0.806	.371	.006
C x M x U	1	1.200	.275	.008
C x A	1	0.987	.322	.007
M x A	1	2.255	.135	.015
C x M x A	1	0.826	.365	.006
U x A	1	0.393	.532	.003
C x U x A	1	0.607	.437	.004
M x U x A	1	0.022	.884	.000
C x M x U x A	1	0.111	.740	.001
ERROR	138	(3.486)		

Note. Values enclosed in parentheses represent mean square errors. * $p < .05$; ** $p < .01$; *** $p < .001$

Analysis of variance for intrinsic pleasantness (cognitive appraisals):

	df	F	p	η
CULTURE (C)	1	1.384	.241	.010
MODE (M)	1	2.571	.111	.018
USABILITY (U)	1	21.426	<.001***	.130
VISUAL AESTHETICS (A)	1	4.049	.046*	.028
C x M	1	1.796	.182	.012
C x U	1	2.316	.130	.016
M x U	1	0.013	.910	.000
C x M x U	1	0.194	.660	.001
C x A	1	0.046	.831	.000
M x A	1	0.496	.483	.003
C x M x A	1	0.077	.782	.001
U x A	1	0.038	.845	.000
C x U x A	1	1.026	.313	.007
M x U x A	1	2.779	.098	.019
C x M x U x A	1	0.087	.768	.001
ERROR	144	(3.714)		

Note. Values enclosed in parentheses represent mean square errors. * $p < .05$; ** $p < .01$; *** $p < .001$

Analysis of variance for novelty (cognitive appraisals):

	df	F	p	η
CULTURE (C)	1	7.533	.007**	.050
MODE (M)	1	1.623	.205	.011
USABILITY (U)	1	21.004	<.001***	.128
VISUAL AESTHETICS (A)	1	1.428	.234	.010
C x M	1	1.366	.244	.009
C x U	1	1.829	.178	.013
M x U	1	0.029	.865	.000
C x M x U	1	1.759	.187	.012
C x A	1	0.414	.521	.003
M x A	1	0.774	.380	.005
C x M x A	1	0.021	.885	.000
U x A	1	0.145	.704	.001
C x U x A	1	0.091	.763	.001
M x U x A	1	0.290	.591	.002
C x M x U x A	1	0.001	.990	.000
ERROR	138	(3.999)		

Note. Values enclosed in parentheses represent mean square errors. * p < .05; ** p < .01; *** p < .001

Analysis of variance for self/norm compatibility (cognitive appraisals):

	df	F	p	η
CULTURE (C)	1	13.059	<.001***	.084
MODE (M)	1	3.356	.069	.023
USABILITY (U)	1	3.356	.069	.023
VISUAL AESTHETICS (A)	1	1.086	.299	.008
C x M	1	0.028	.867	.000
C x U	1	1.086	.299	.008
M x U	1	0.598	.441	.004
C x M x U	1	0.346	.557	.002
C x A	1	0.000	.987	.000
M x A	1	0.387	.535	.003
C x M x A	1	1.900	.170	.013
U x A	1	0.387	.535	.003
C x U x A	1	0.191	.663	.001
M x U x A	1	2.713	.102	.019
C x M x U x A	1	0.001	.987	.000
ERROR	144	(1.085)		

Note. Values enclosed in parentheses represent mean square errors. * p < .05; ** p < .01; *** p < .001

Analysis of variance for goal conduciveness (cognitive appraisals):

	df	F	p	η
CULTURE (C)	1	0.868	.353	.006
MODE (M)	1	7.864	.006**	.053
USABILITY (U)	1	0.249	.619	.002
VISUAL AESTHETICS (A)	1	0.007	.933	.000
C x M	1	1.233	.269	.009
C x U	1	1.014	.316	.007
M x U	1	1.836	.178	.013
C x M x U	1	1.033	.311	.007
C x A	1	0.007	.933	.000
M x A	1	1.192	.277	.008
C x M x A	1	0.567	.453	.004
U x A	1	0.268	.606	.002
C x U x A	1	0.108	.742	.001
M x U x A	1	1.836	.178	.013
C x M x U x A	1	0.459	.499	.003
ERROR	138	(3.414)		

Note. Values enclosed in parentheses represent mean square errors. * p < .05; ** p < .01; *** p < .001

Analysis of variance for coping potential (cognitive appraisals):

	df	F	p	η
CULTURE (C)	1	1.664	.199	.012
MODE (M)	1	1.386	.241	.010
USABILITY (U)	1	0.027	.871	.000
VISUAL AESTHETICS (A)	1	0.003	.960	.000
C x M	1	0.004	.950	.000
C x U	1	0.251	.617	.002
M x U	1	4.374	.038	.030
C x M x U	1	0.031	.861	.000
C x A	1	0.151	.698	.001
M x A	1	0.161	.689	.001
C x M x A	1	1.133	.289	.008
U x A	1	0.546	.461	.004
C x U x A	1	0.251	.617	.002
M x U x A	1	0.004	.950	.000
C x M x U x A	1	0.003	.960	.000
ERROR	144	(1.954)		

Note. Values enclosed in parentheses represent mean square errors. * p < .05; ** p < .01; *** p < .001