



## Value in experience

Design and evaluation framework based on case studies of novel mobile services

Mari Ervasti



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## **Value in experience**

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## **Abstract**

The concept of 'value' has received extensive interest in research in the fields of psychology, marketing and, more recently, human-computer interaction (HCI). Gaining insights into users' personal values can lead to a better understanding of user behaviour. However, the concept of value is not clearly defined, and researchers have produced differing views on the conceptualization of the construct. In the past decade, user experience has received considerable attention in HCI research. Yet the relationship between user experience and value has not gained much attention. The goal of this dissertation is to better understand and articulate the value in user experience. The focus is on novel mobile service solutions, taking into account the viewpoint of different user groups. Achieving an understanding of different user groups will greatly help design successful mobile services for target user populations.

The empirical foundation for this dissertation is findings concerning user experience from seven individual case studies conducted in the field with the end-users. Interpretive case studies of novel mobile services in varying usage contexts involved different user groups: children, teenagers, college students and vision and memory -impaired older people. An initial value framework is developed as a synthesis from the literature. By utilizing this framework, the user experience findings obtained are re-examined from the point of view of value through a cross-case analysis and synthesis. Based on this analysis, value parameters from individual mobile service case studies are interpreted and categorized. The initial value framework is complemented by relying on the value parameters identified from the case studies.

This work contributes to the field of HCI by showing that user experience and value are closely intertwined. The thesis proposes the concept of "value in experience (ViE)", which refers to the user's iterative (subconscious and conscious) interpretation and evaluation of user experience with a service. A value design and evaluation framework is presented and demonstrated by evaluating value in experience from the case studies. Also the designer values are analysed and compared with the value in experience. The framework presents a rich description of value dimensions relevant to specific user groups and mobile service domains in varying usage contexts. Furthermore, value in experience design and evaluation guidelines related to different user groups are proposed.

The proposed conceptualization of value in experience offers insights to help understand the dimensions of value, and serves as a lens to guide interpretive analysis of value in experience. The complemented value design and evaluation

framework is a tool for identifying and describing the key value dimensions for value in experience evaluation. Furthermore, the framework can support service design processes. The cross-case study findings provide insights into the special characteristics of different user groups and their value priorities in specific service domains. Even though the framework is based on mobile services, its main constructs are expected also to be applicable to other types of digital services.

**Keywords** mobile service, user experience, case study, user values, designer value, value in experience, value design and evaluation framework, different user groups

## Preface

I came to work for VTT Technical Research Centre of Finland in 2007, and my interest in human-computer interaction (HCI), especially from the user perspective, was first awakened when I was given the chance of studying users' adoption of mobile services as the subject of my master's thesis. After receiving my Master's degree, this captivating research subject was placed in my hands as I participated in doing user research on many interesting mobile service research projects, thus re-focusing and anchoring the scope of my research into user experience. It is certainly not always straightforward to conduct a coherent piece of multi-year research. I have been fortunate to be able to continue the research on user experience over five years and to publish the results openly at international academic conferences.

The starting point for this dissertation was the finding that the empirical user experience research data provided new insights with regard to user's subjective, individually experienced value; the value appeared to be closely tied to user experience. When users described and interpreted their subjective experience with the service, they also revealed their relevant value priorities in the context of the given service. In addition, I noticed that the anticipated designer value and the actual experienced value were not congruent; users do not passively accept the pre-determined and controlled value propositions presented by the service provider, but instead experience value uniquely within their own personal contexts. These enlightening findings gave me the motivation and desire to gain a deeper understanding of value in user experience, and more specifically from the viewpoint of different user groups. During this process of working for a D.Sc. (Tech.) degree, I have received support from numerous people who deserve to be acknowledged here.

First and foremost, I am very grateful for the support, patience and the valuable and constructive comments I always received during this dissertation process from my supervisor, Professor Kaisa Väänänen-Vainio-Mattila from Tampere University of Technology.

I was honoured to have Associate Dean, Professor Gilbert Cockton from Northumbria University and Dr Virpi Roto from Aalto University as the pre-examiners of my dissertation. I respectfully thank them for providing very insightful and valuable reviews that greatly helped me finalize my dissertation. Their thorough comments

caused a large amount of rewriting and improving, but this was definitely necessary and helped me to clarify and express my ideas more clearly.

I owe my gratitude to Professor Gilbert Cockton and Dr Marianna Obrist from Newcastle University for accepting the invitation to act as opponents in my public examination.

I want to thank Professor Minna Isomursu for providing me with her valuable knowledge and expert advice; she has helped me to understand the fields of HCI and user experience research more deeply. I want to thank Minna for the great opportunities of carrying out interesting user experience research during these years and for co-authoring most of my publications.

The research work that this dissertation is built on was carried out in five separate research projects during the years 2007–2011 while I have been working at the VTT. Many individuals contributed in carrying out the research work.

I want to thank my Master's thesis instructor Dr Heli Helaakoski for offering me a chance to work on the Fummas project, and first introducing the user-centred HCI research field to me. I also want to thank the SmartTouch project team for making it possible for me to conduct user experience research in so many interesting and innovative application domains in field settings. I am especially grateful to Master's thesis worker Sari Saikkonen who was actively involved in planning and participating user experience data acquisition in the Amazing NFC user study and Ph.D. Marianne Kinnula for making her valuable contribution in collecting and analyzing user data within the School Attendance Supervision study. I also want to thank personnel on the HearMeFeelMe research project, and especially my colleague Juha Häikiö with whom I conducted the Finnish BlindNFC user tests and analysed the congruent empirical data, and the Spanish partners for implementing the Spanish user tests.

This dissertation was produced as a part of Value Creation in Smart Living Environments for Senior Citizens (VESC) project, and I would like to thank those in charge of this project. I am grateful to our "crew" on the VESC project, who persistently and with such good and enthusiastic team spirit carried out all the field tests in Karpalokoti whatever the weather or time, and especially Laura Sorri and Eeva Leinonen. In 2010 I had the pleasure to work on the iShake project at the University of California during a one-year visiting scholar period hosted by Professor Alexandre Bayen. I want to thank my colleagues at UC Berkeley for their support during this educative year. The VESC project, funded by the Academy of Finland, made this visit to Berkeley possible. I also want to gratefully acknowledge the Nokia Foundation and Emil Aaltonen Foundation for their financial support.

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I also want to address my thanks to people with whom I have had the privilege to author the scientific publications that form part of this thesis: Minna Isomursu, Heli Helaakoski, Igone Leibar, Marianne Kinnula, Laura Sorri, Eeva Leinonen,



Shideh Dashti, Jack Reilly, Jonathan Bray, Alexandre Bayen and Steven Glaser. Working with you has been interesting and educative.

Finally, I want to warmly thank all my friends, relatives, and colleagues who have shown that there is also a life outside this dissertation, and who have provided mental refreshment in one form or another during the years.

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Special thanks to my two older sisters, Kirsi and Kati, who gave me a love of books and an interest in maths and physics, and showed me with their example that studies and career in this somewhat "male-dominated" field could be worthwhile.

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Oulu, October 2012

Mari Ervasti

## **Academic dissertation**

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## List of publications

This dissertation includes the following original publications:

- I Ervasti, M. and Helaakoski, H. (2010) Case study of application-based mobile service acceptance and development in Finland. *International Journal of Information Technology and Management (IJITM)*, Special Issue on Mobile Commuting and Commerce, 9(3), pp. 243–259.
- II Ervasti, M. and Isomursu, M. (2009) Learning through NFC-enabled urban adventure – User experience findings. In: *Proceedings of the First International Conference on Computer Supported Education (CSEDU 2009)*. March 23–26, Lisboa, Portugal. Inspec. Pp. 55–64.
- III Isomursu, M. and Ervasti, M. (2009) Touch-based access to Mobile Internet: User experience findings. *International Journal of Mobile Human Computer Interaction (IJMHCI)*, Special Issue on Mobile Internet User eXperience, 1(4), pp. 58–79.
- IV Ervasti, M., Kinnula, M. and Isomursu, M. (2010) User experiences with mobile supervision of school attendance. *International Journal on Advances in Life Sciences*, 2(1–2), pp. 29–41.
- V Ervasti, M., Isomursu, M. and Leibar, I.I. (2011) Touch- and audio-based medication management service concept for vision impaired older people. In: *Proceedings of the IEEE International Conference on RFID-Technologies and Applications (RFID-TA 2011)*. September 15–16, Barcelona, Spain. IEEE. Pp. 244–251.
- VI Ervasti, M., Dashti, S., Reilly, J., Bray, J.D., Bayen, A. and Glaser, S. (2011) iShake: Mobile phones as seismic sensors – User study findings. In: *Proceedings of the 10<sup>th</sup> International Conference on Mobile and Ubiquitous Multimedia (MUM'11)*. December 7–9, Beijing, China. ACM Press. Pp. 43–52.
- VII Sorri, L., Leinonen, E. and Ervasti, M. (2011) Wayfinding aid for the elderly with memory disturbances. In: *Proceedings of the 19<sup>th</sup> European Conference on Information Systems (ECIS 2011)*. (Ed. by Tuunainen, V.K., Rossi, M. and Nandhakumar, J.) June 9–11, Helsinki, Finland. Pp. 1704–1715.

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Publications I–VII

## List of abbreviations

AAL	Ambient Assisted Living
CUE	Components of User Experience
CV	Consumer Value
FUMMAS	Future Mobile Marketing Solutions
HCI	Human-Computer Interaction
HMFM	HearMeFeelMe
ICT	Information and Communication Technologies
ISO	International Organization for Standardization
MMSE	Mini-Mental State Examination
NFC	Near Field Communication
PDA	Personal Digital Assistant
PERVAL	Customer-Perceived Value Measurement Scale
PPA	Perceived Product Attributes
SERVPAL	Service Personal Values
SMS	Short Message Service
SV	Service Values
TAM	Technology Acceptance Model
UV	User Values
UX	User Experience
U2E-Frame	Usability & User Experience Frame
VALS	Values and Lifestyles
VESC	Value Creation in Smart Living Environments for Senior Citizens
ViE	Value in Experience



# 1. Introduction

*“You cannot NOT have a user experience.”* (Lou Carbone)

As McCarthy and Wright (2004) put it, we do not just use technology, we live with it. Human-Computer Interaction (HCI) to an increasing extent is occupying different domains of our everyday lives. In particular, mobile devices that we carry with us all the time and related multifaceted mobile services have increasingly occupied our life from work to leisure and from private to public. The move from fixed desktop environments to dynamic and ever-changing mobile environments has brought with it unforeseen aspects and challenges in capturing and understanding people’s interaction with technology and the resulting user experience. In consequence, the study of the relationship between humans and technology has evolved as one of the most dynamic and significant fields of technology research. Until quite recently, the scope of HCI research was more focused on traditional usability and utilitarian aspects of the system, and the HCI community has more or less neglected the social and emotional phenomena of interaction. But now the user is being regarded as an individual who has dreams and emotional experiences, and voluntarily takes a decision to use a system for personal and social purposes, instead of merely considering the user as a cognitive decision-maker or an expert obligated to use a system for work-related motives.

## 1.1 Background and motivation

Companies seem to have put a great deal of effort into the development of mobile technologies and new service features, whereas developing services based on providing value to the end-users has not been the primary guide for the evolution of novel mobile services. Mobile phone visionaries have assumed that technological development with a suitable business model will boost mobile service usage to new heights (Robins, 2003). However, the high expectations set for mobile services (Kalakota and Robinson, 2002) have not yet been fully realized. Despite the ever increasing variety and availability of services, straightforward mobile applications intended for simply passing the time have already been adopted by consumers, but more advanced and life-encompassing mobile service concepts are still waiting for

a larger uptake. Through the growing popularity of smart phones such as Apple iPhones, consumers are constantly being introduced to and familiarized with the world of inventive and diverse mobile services that are easy to access even for “beginners”, and thus are becoming increasingly mundane. However, introducing a successful novel mobile service that answers to users’ preferences and desires needs to take into account complex experimental and emotional aspects instead of merely aiming to prevent usability problems or provide just another way of “passing the time”.

Hence, today the HCI field emphasizes an approach to research and design for enjoyable and engaging experiences: “*Now it is no longer adequate just to avoid bad experiences; we have to find methods for designing good ones*” (Blythe et al., 2003). We need to take into account aspects that go beyond the obvious. Today user experience research highlights the non-utilitarian aspects of human-technology interactions, shifting the focus to user affect and sensation. User experience is seen as *something* desirable, though what exactly something means remains open and debatable (Law et al., 2008). Scholtz and Consolvo (2004) state that user a experience evaluation framework must be developed specifically for mobile computing to respond in the best way possible to the challenges of mobile service environments. Since mobile computing environments provide entirely new paradigms in information and service delivery, we need to gain an insight into what makes users appreciate different mobile services and to differentiate between what is seen as added value and what is considered nice-to-have or even an annoyance.

However, it is difficult to capture user experience in user-service interaction, because it is such a multi-faceted phenomenon. Battarbee (2004) has stated that perhaps due to this all-inclusiveness the term “experience” has become an umbrella concept that encompasses all aspects of the product, including usability as well as more fleeting feelings of positive or negative quality. User experience consists of smaller experiences (Forlizzi and Battarbee, 2004), and the user experience in each use case is unique. Therefore, defining experience is difficult to do because of its dynamic nature. User experience cannot be evaluated in a vacuum (Buchenau and Suri, 2000), and we cannot control users’ internal states or use contexts. Yet we need to understand why the user likes or dislikes a product. Understanding the user experience building blocks helps us both in defining, designing, and evaluating user experience. Furthermore, user experiences are the basis for user value perceptions, which have a cognitive-affective multi-dimensional nature (Helkkula and Kelleher, 2010). Thus, it is important to evaluate the user-perceived value from the perspective of the individual’s user experience (Helkkula et al., 2012).

A fairly recent development in HCI can be seen in a growing interest and concentration on value-centred design. One reason for this is that gaining an understanding and acting on users’ personal values is seen as a powerful tool for better comprehending user behaviour and reaching potential users (Durgee, 1996). Furthermore, understanding of user values could be seen to offer a stable basis for designing for “enjoyable experiences”, as values are relatively general and enduring tendencies, and valuations of objects that guide humans also in other

fields in life (e.g. Schwartz, 1992). Thus, according to Cockton (2005), system-, user- and context-centred view in HCI is necessary but not sufficient for effective interactive systems design, which requires a 'fourth' *value-centred* focus. Cockton (2005) states that an adequate basis for designing *worthwhile* systems needs a value-centred focus in order to create a stable structure for HCI, with the system, the user, the context and intended value as 'legs' at each corner.

Previously the assumption was that people make a rational evaluation and calculation of what is received and what is given, but simply conceptualizing the 'value' as a cognitive ratio and comparison between perceived benefit and sacrifice (e.g. Zeithaml, 1988) is a very narrow view of the concept, and does not reflect the complexity of consumers' perceptions of value. Value was seen as embedded in the object and recognized by the user. This kind of uni-dimensional view overlooks the various intangible, intrinsic, and emotional aspects of phenomena. Thus, user motives for service usage should be measured with a broader framework in a mobile service context. In the new perspective, value is realized when service is used, and thus service users act as both co-creators and judges of value (e.g. Sandström et al., 2008). User value is now considered a phenomenon related to user experience.

But even though the concept of 'value' has attracted extensive interest in the research, there is still complexity and a lack of consensus within this research subject (e.g. Sánchez-Fernández and Iñiesta-Bonillo, 2007). The field is troubled by vaguely defined terminological concepts of value and user experience, and confusion and inconsistency in using the terms. Furthermore, what is the source of value remains a major disagreement among researchers (Boztepe, 2007). Can value be understood as subjectively determined by the user and independent of the object's physical qualities, or can value be seen to be embedded in the object and recognized by the user? Moreover, the relationship between the user experience and value has not been explicitly defined in the literature. Helkkula and Kelleher (2010) state that an investigation into the relationship between the user experience and value is vitally important, as customer-perceived value and the meanings of service experiences are no longer seen as fixed and linked to service attributes and characteristics. In contrast, each individual customer is now acknowledged to form their personally perceived meanings based on their own personal and subjective experiences (Helkkula and Kelleher, 2010).

To further increase this challenge, very heterogeneous user groups make different demands on designing new mobile services to suit the needs and especially the wishes of end-users. In addition, the differing physical and cognitive abilities set one side of design criteria and user preferences set the other. It is much easier to design successful services if there is some understanding of the people who are likely to use them. Also, it is critical to the success of a service that appropriate and representative users are involved in the development work (Kujala and Kauppinen, 2004). Design work should not be based on generic models of the users, but it is necessary to think carefully about who is a user and how to involve users in the design process (Abrás et al., 2004). However, target user definitions are often at the level of very basic user characteristics, such as age, gender, and educational background. Such an approach does not help designers develop

insights or identify the linkage of users' in-depth service needs, motivations and values to technology features (Kujala and Väänänen-Vainio-Mattila, 2009), and as a consequence, the detailed and crucial design decisions are made without an explicit understanding of the relevant values the users place on the service.

The focus in this dissertation is on user-perceived value rather than economic value or the business value (of a customer) to the organization. To investigate and clarify the inseparable interrelationship between value and user experience (cf. Helkkula and Kelleher, 2010), the focus here is on "value in experience (ViE)" which refers to the user's iterative (subconscious and conscious) interpretation and evaluation of user experience. A perspective of individual service users who experience value is adopted here, and the focus is on individual values, also called personal user values. It is proposed that our long-term goal should be to develop an approach for design for and evaluation of value in experience. This dissertation examines value in experience through user experiences evoked by novel mobile services when the end-users encompass different user groups.

The specific context for undertaking this research was the case studies conducted within technology research projects between the years 2007–2011 (findings from these case studies are presented in Publications I–VII). Through individual real-life case studies of novel mobile services we gain practical insights into user's value in experience. This work is pursued to understand and articulate the concept of value in experience, as well as the interrelationship between value and user experience. In addition, the case studies provide interesting information on and understanding of the varying needs and requirements of different user groups, as well as their special characteristics and relevant value dimensions in a specific service usage context.

### 1.2 Research goals and questions

Several researchers have already suggested how the concept of user experience may be defined and evaluated in a way that facilitates the design of enjoyable services (see e.g. Forlizzi and Ford, 2000; Kankainen, 2003; Hassenzahl and Tractinsky, 2006; Roto, 2006). But one obvious outcome of all these different views is an immense number of diverse definitions and viewpoints on user experience. They are disintegrated and scattered in different forms and contexts. What is more, value perceived by the user is an important aspect of user experience (Helkkula and Kelleher, 2010), and one of the greatest challenges is to incorporate the "voice of the customer" into the design of new products and services (van der Haar et al., 2001).

Despite the extensive literature and research on value, it is still argued that the construct of value requires further refinement and development (e.g. Sánchez-Fernández and Iniesta-Bonillo, 2007). In addition, the relationship between user experience and user-perceived value has not much gained attention and remains scarcely researched and defined. A view is adopted here by Cockton (2005) who states that system-, user- and context-centred view in HCI requires a 'fourth' value-

centred focus. However, the existing user experience frameworks have no construct which would represent the perceived value object.

To understand the user's perspective of value, it is important to understand and identify what is important to them, and what motivates them to use the system or product, i.e. what kind of purpose, functions and characteristics are important to users in a certain usage context (Kujala and Väänänen-Vainio-Mattila, 2009). Furthermore, Cockton (2006) argues that the value of enduring outcomes of interactions is more important than qualities experienced during interactions, and describes the goal as a "happy ending" in terms of system impact. As a consequence, it is essential to find the key (often context-specific) value priorities behind different user groups and service contexts, and help researchers select and act upon the value components most appropriate for the particular service.

### **1.2.1 Characterizing value in experience**

In this dissertation a new way is proposed for understanding the role of value in user experience by emphasizing the close interrelationship between value and experience. It was discovered that it is difficult to talk about the user experience or value separately, since, in practice, these seem to be closely tied together. The starting point for this work was the belief that the original research material collected on user experience and analysed in the case studies provides insights with regard to the question of value in experience. Thus, the value priorities of the users were seen to become evident from their subjective user experiences of a service.

Because value is an abstract concept, designers and evaluators need to select a set of aspects that they can focus on. However, the task of identifying and conceptualizing all the values that play a role in value formation for all types of users and contexts seems very challenging, if not impossible. Still, a comprehensive set of the most relevant value dimensions in a specific service context is required in order to better understand and evaluate value in experience. Complementing the often quite general set of value dimensions suggested by other researchers would increase the applicability and usefulness of value constructs' across different service contexts. A broader framework for evaluation is, therefore, needed to better comprehend user-perceived value in mobile service contexts. Therefore, the first research question is:

#### **RQ1: What is value in experience and what are the relevant value dimensions?**

Here the focus is on "value in experience (ViE)", which is understood to be the user's iterative (both conscious and subconscious) interpretation and evaluation of subjective user experience with a service. Thus, users evaluate their user experiences based on their internal values (e.g. Forlizzi and Ford, 2000). Here is pursued to understand and illustrate the concept of value in experience, as well as the interrelationship between value and user experience. In addition, an initial value framework is developed for identifying the key value dimensions contributing

to value in experience. The framework is constructed by relying on the review and synthesis of existing value definitions, perspectives and models.

### **1.2.2 Evaluating value in experience**

Here the objective is to understand and identify the source of value, i.e. the dimensions that constitute value in experience. As in this dissertation value is seen to be closely tied to user experience, the assumption was that the value priorities of the users would become evident from their subjective descriptions of the user experience. By utilizing the initial value framework developed and introduced in RQ1, value parameters from individual mobile service case studies are interpreted and categorized. In this research work, the aim is to provide an understanding and present a rich description of value dimensions that are relevant to specific user groups and service domains in given usage contexts. In addition to capturing value in experience, the value framework is used for identifying the anticipated designer values to further examine the interesting congruencies and discrepancies between designer value and value in experience.

The next step is to complement the collection of value dimensions presented in the initial framework with values that emerged from mobile service case studies through a value in experience analysis. The complemented value framework provides a foundation for understanding and examining the value priorities of different user groups with regard to novel mobile services. Thus, the second research question is as follows:

#### **RQ2: Based on case studies of novel mobile services, how is value in experience manifested?**

Here the value in experience of different end-user groups is examined with various mobile services in varying contexts of use. The goal is to help researchers and designers to better understand and articulate the value in experience of a novel mobile technological solution, especially from the viewpoint of different user groups. This research question is evaluated and reflected from the findings of the individual case studies introduced in Publications I–VII. The initial value framework constructed in RQ1 is complemented with the identified values from case studies.

### **1.2.3 Applying value in experience knowledge to mobile service design and evaluation**

One needs also to be aware of the important user limitations and characteristics, and how these might affect value in experience. Achieving an understanding of different user groups will greatly help to design and successfully direct mobile services for specific user populations. The value framework and valuable insights gained from the relevant value dimensions of different user groups will provide essential guidelines for design and evaluation processes of novel mobile services. Therefore, the third research question in the dissertation is the following:

**RQ3: What are the design and evaluation implications for different user groups?**

When it is possible to identify the relevant value priorities, it is also possible to develop and improve mobile services that provide more value for the users. Identified values can, furthermore, be used as a basis for defining which user experience issues and value dimensions are under evaluation.

**1.3 Research approach and methods**

This dissertation describes and analyses user experience findings gained from seven individual case studies conducted in the field of technology research projects. The user experience findings obtained are examined through a cross-case analysis and synthesis in order to form in-depth understanding of value in experience of the end-users. This understanding provides the basis for the conclusions drawn from the case studies. The focus in this work is on actual users as primary sources of information about the phenomenon. The author has adopted the role of the 'outside observer' (Walsham, 1995) here, and is seen as not having a direct personal stake in various interpretations and outcomes.

The case study research can be positivist (Yin, 2003), interpretive (Walsham, 1993) or critical (Myers and Klein, 2011). The work carried out here in the case studies was by nature exploratory and interpretive. *Interpretive* studies attempt to understand phenomena through the subjective meanings that people create and associate to them (Walsham, 1993). Interpretive studies assume that social reality can only be interpreted (Orlikowski and Baroudi, 1991) and help researchers to understand human thought and action in social and organizational contexts (Klein and Myers, 1999). In interpretive studies, one attempt to derive constructs from the field by in-depth examination of and exposure to the phenomenon of interest. In this dissertation, the user experience data analysis process recognizes and follows the general principles of interpretive phenomenology (Reid et al., 2005; Willig and Stainton-Rogers, 2008) to emphasize the role of interpretation at different levels, which means that analysis was an inductive 'bottom-up' process. Firstly, the study participants provided detailed descriptions and interpretations of their subjective experiences in the form of stories and dialogues that could be shared and observed by the researchers. Secondly, the author interpreted the captured data and explored their meanings.

**1.3.1 Case study approach**

*Case study* is one of the most common qualitative research methods used in information systems research (Orlikowski and Baroudi, 1991). Here user research was realized in the form of case studies which were chosen as a research method because the goal was to obtain a rich set of data surrounding the specific research issue, as well as capturing its contextual complexity (Benbasat et al., 1987). The

distinctive need for case studies arises out of the desire to understand complex social phenomenon within its real-life contexts, especially when the boundaries between the phenomenon and context are not clearly evident (Yin, 2003). According to Benbasat et al. (1987), “a case study examines a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities (people, groups, or organizations)”.

Thus, case studies focus on activities as they occur in the real world, outside the sterile confines of the usability lab, allowing researchers to develop a detailed understanding of interaction techniques and coping strategies – an understanding that might be difficult (if not impossible) to develop through plain usability (Lazar et al., 2010). Case studies always contain a substantial qualitative component, focusing on questions that help describe or explain behaviour (Yin, 2003), and quantitative data may be used as a triangulation tool for corroborating results (Lazar, 2010). A fundamental difference between case studies and alternative research methods, such as laboratory or field experiments, is that the case study researcher may have less *a priori* knowledge of what the variables of interest will be, and how they will be measured (Benbasat et al., 1987). However, there are types of case studies in which the investigators have a prior notion of certain critical variables and research questions are specified prior to the study by the researchers, who are observers/investigators rather than participants (ibid). Bonoma (1985) also suggests that the case strategy could play a role in both hypothesis generation and testing.

The case studies part of this dissertation could be characterized as *exploratory* in nature (e.g. Lazar et al., 2010). In the case studies data were collected from the field and from empirical evidence acquired from these real-life case studies could be drawn theoretical and also practical conclusions. Thus, in this work, interpretive case studies provide exploratory descriptions of value in experience and propose implications for design and evaluation. In all the individual cases (Publications I–VII) user research has been conducted as close to realistic real-life contexts as possible, and has aimed to remain sufficiently open and flexible to permit exploration of whatever the phenomenon under study offers for inquiry (Patton, 2002). Thus, the purpose of case study research was to gather as rich and objective user experience data as possible without strict prejudices that would affect the objectivity of the research.

Case data in the research was qualitative. This included (often semi-structured) questions for interviews, plans for on-site observation and a list of two or more sources of evidence (e.g. Yin, 2003) to be used in that particular case research. As the project unfolded, the data collection plan was revised according to the researchers' judgments, unexpected observations, or limitations and opportunities. Research work was pursued to achieve *triangulation* (e.g. Patton, 2002) in order to strengthen a study and establish its reliability and validity by combining different kinds of methods and data. For example, case study research followed (1) *data triangulation*, through the use of a variety of data sources; (2) *investigator triangulation*, through the use of several different researchers and evaluators; and (3) *methodological triangulation*, through the use of multiple methods to study a single



problem and/or technological system. Using multiple methods and sources of data collection across all the cases offered the opportunity not only for triangulation but also for greater support to the researcher's conclusions by providing a consistent interpretation of certain aspects of the case under investigation, providing a strong argument in favour of the validity of the interpretation (Lazar et al., 2010). Through the aim of achieving triangulation an attempt was made to obtain both an objective view of events and the subjective interpretations of the participants. A clear description of data sources and the way they contributed to the findings of the research was an important aspect of the reliability and validity of those findings.

The data collection methods utilized in different case studies are described in more detail in Section 3.2.

### **1.3.2 Cross-case analysis and synthesis**

In this dissertation, the approach used for evaluating the value provided to the user was based on the information already collected and analysed on subjective user experiences presented in Publications I–VII. The starting point for this work was the belief that the original research material collected on user experience and analysed in the case studies provides insights with regard to the question of value in experience. Thus, the analysis of the value in experience of novel mobile services was carried out post hoc, and the analysis and evaluation results presented in this dissertation reveals many additional details. Consisting of distinct case studies with different user groups and application domains, the original field work material was gained from a variety of viewpoints and service approaches. Thus, the data provided a rich and broad view of value in experience as a phenomenon and offered a rich basis for building an overall understanding of how value in experience manifests itself in different cases, and also for extracting different aspects from the phenomenon.

A similar type of re-coding of existing user experience data had already been conducted in relation to the case study presented in Publication IV, where the case material was examined and analysed again using Schwartz's (1992) value model as an analytical tool (Isomursu et al., 2011). The new analysis results obtained of user's perceived value proved very interesting and provided new insights. However, the author felt that, even though Schwartz's value model was useful in describing human values, its dimensions might be especially focused on analysing societal values (Agle and Caldwell, 1999), and thus it still needed some complementation to existing value dimensions to better reveal and articulate value in experience in the context of novel mobile services. At the end of Section 4.2.4 there is a discussion of how the results of this thesis research compared to findings presented in Isomursu et al. (2011).

According to Yin (2009), *cross-case synthesis* applies to the analysis of multiple cases, and this analytic technique can be performed also when the individual case studies have been conducted as independent research studies. The technique treats each individual case study as a separate study, and combines findings

across a series of individual studies (*ibid*). Synthesis of different qualitative studies on the same subject is a form of *cross-case analysis* (Patton, 2002), where the challenge is to “retain the uniqueness and holism of accounts even as we synthesize them in the translations” (Noblit and Hare, 1988). Lessons can be synthesized from a number of case studies in order to generate generic factors that contribute to certain phenomenon. However, as stated by Yin (2009), the cross-case patterns identified will rely strongly on argumentative interpretation that is supported by the case study data, not on numeric properties. Interpretation, by definition, involves going beyond the descriptive data, and is appropriate as long as the researcher owns the interpretation and makes clear the difference between description and interpretation (Patton, 2002).

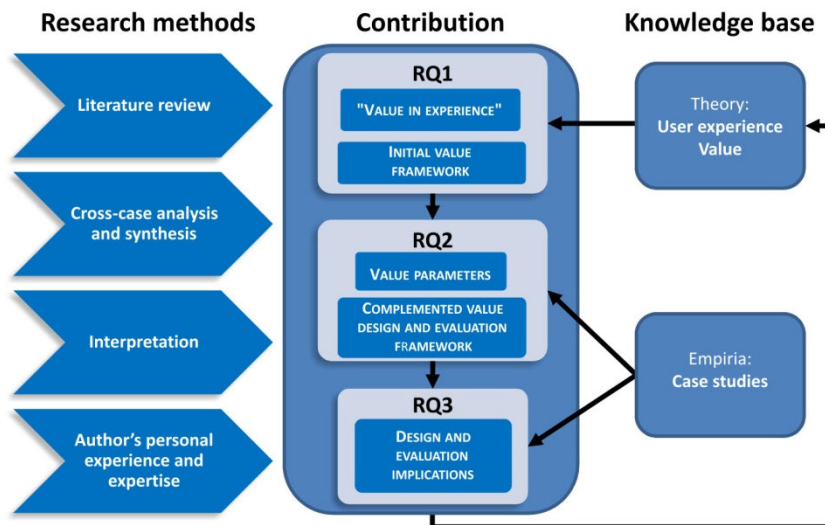
The theory from existing literature contributed to the dissertation work by accumulating the author’s knowledge on the research area. Adapting Eisenhardt’s (1989) identification of three distinct uses of theory in the research, the author has utilized other researchers’ work as an initial guide to better understanding and gaining insights into the concepts of user experience and value; as part of an iterative process of cross-case data analysis and synthesis; and as a basis for final contribution of this research. The motivation for the use of theory in the initial stage of interpretive cross-case study analysis was to create an initial theoretical framework for value evaluation, i.e. value dimensions for identifying value parameters, by taking into account other researchers’ previous knowledge and work. Thus, the re-analysis began with a formation of an initial value framework based on literature review, which was used as a guideline and analytical tool for interpreting the existing empirical user experience data from the point of view of value in experience on a case-by-case basis.

However, there was a desire here to avoid limiting the generation of in-depth understanding of value in experience blindly to any pre-set framework. Even though theory can provide a valuable initial guide, a danger of seeing only what the theory suggests was acknowledged, and thus here the aim was not to limit the insights and get trapped into a rigid theory which suppresses potential new emerging issues from the data. The assumption was that the value priorities of the users would become evident from their subjective descriptions of the user experience (already collected and analysed) and the following re-analysis of value in experience. Since the scope of many existing value models (such as Schwartz, 1992) is very broad, it was considered that there is a danger in over-generalizing the rich findings of the case studies. Therefore, the aim was to preserve the openness to the original fieldwork data and a willingness to modify initial assumptions and theories.

In this dissertation, the cross-case analysis and synthesis includes an extensive review of independent evaluations of each individual case. An iterative process of data analysis was used, with initial theories and assumptions being expanded and revised, or abandoned altogether. The author started from individual studies, identifying, collecting and comparing the values arising from them. The data was re-coded concurrently during the cross-case analysis, which included many iteration cycles where the author went through each individual case one by one, identified the value parameters relevant to the case in question, went back to case data

already analysed and recoded it again to identify the possibly missed values in the earlier cycle that were identified in some other case, and so on. Thus, before a deeper understanding was established, analysis was undertaken several times, from overall examination to close investigation of detail and the other way round, and understanding and knowledge was accumulated and developed throughout this process. The process thus followed the essence of the virtues of the *hermeneutic circle* (Gadamer, 1976). As the individual case studies and relevant values within each case were analysed, higher-level patterns which cut across multiple cases could be identified. During the new data analysis process there was also a focus on unexpected observations made from the case study, and recurring themes between individual case studies.

Figure 1 illustrates the research approach and methods and the main contributions of this dissertation work.



**Figure 1.** Overview of the research approach, methods and main contributions.

The synthesized initial framework of value dimensions served as a typology to analyse the individual values arising from the cases. The analysis of the entire collection of separate case studies led to the cross-case conclusions about the value in experience. Cross-case study findings could then be tied together to complement the initial value framework. In summary, the value design and evaluation framework was constructed on the basis of the author's understanding of related theory, the value parameters identified from the individual cases, and synthesized results of the case studies.

### 1.4 Author's contribution to publications

The author has been closely involved in planning, implementing and evaluating all the case studies (except for the first of the two case studies presented in Publication III, where the author participated in the analysis and evaluation of the study findings). so the author knows the data personally. The author has also accumulated her experience and knowledge from case to case. The role of the author in the research work was in helping to determine the key areas of interest and planning for the meaningful data to be collected and the methods to be utilized in each case study, by taking into account the user groups in question as well as the research goals set by the project. The role of the author was restricted to analysing the related user experiences and the success of the adoption from the viewpoint of the direct users of the system. The author examined what happened during the service adoption and usage phases, and interpreted and consequently provided objective accounts and reports of the data gathered to project partners and academics. The contribution of the author to each of the publications is as follows.

*Publication I:* The author designed the user interface and implemented the client application. The author designed, executed and analysed the case study the paper deals with together with a project team. The author was the main researcher responsible of analysing the data, and writing the paper. Dr. Helaakoski was the supervisor of the case study and for formulating the paper.

*Publication II:* The author participated in planning and executing the user study, and was the main researcher responsible for analysing the data collected together with Professor Isomursu and thesis worker Sari Saikkonen. The author was in charge of writing the publication.

*Publication III:* The InfoTag trial was conducted by the researchers of the SmartTouch project before the author's involvement in the project. Professor Isomursu was in charge of writing the publication, and the author participated in the data analysis and paper writing process.

*Publication IV:* The author participated in planning the user data collection together with Professor Isomursu and Ph.D. Kinnula. Actual data collection was conducted together with Ph.D. Kinnula. The author was in charge of analysing the data and writing the paper.

*Publication V:* The author implemented the user tests in Finland together with her colleague, research scientist Juha Häikiö. A Spanish user study was conducted by the Spanish project partners. The author had the main responsibility for analysing the data together with Juha Häikiö, and writing the paper together with Professors Isomursu and Leibar.

*Publication VI:* The co-authors carried the main responsibility for conducting the shaking table tests and analysing the related technical data. The author was the main researcher responsible for planning the user study, collecting data, and analysing the user data. The author had main responsibility for writing the paper.

*Publication VII:* The author and the co-authors shared responsibility for planning, executing, and analysing the study with project team assistants. Sorri and

Leinonen were mainly responsible for writing the publication, because of the author's visiting scholar period in 2010. The author was the main researcher responsible for writing the related research sections, and participated in data analysis with the co-authors.

## **1.5 Structure of the dissertation**

This dissertation is organized as follows. First, a theoretical background of the research is presented in Chapter 2. Chapter 2.1 reviews a broad selection of existing user experience definitions, approaches and frameworks that describe or define user experience. Chapter 2.2 gives a similar type of overview of the concept of value, and Chapter 2.3 takes a look at the relationship between user experience and value. Chapter 2.4 describes previous studies of mobile services conducted with different user groups, and Chapter 2.5 sums up the gaps in related research. Chapter 3 describes the case studies that the dissertation consists of (Publications I to VII), and presents the methods used for data collection in individual cases.

Chapter 4 introduces the author's doctoral research. This section is divided into three parts, where the first (4.1) concerns the author's understanding of the key concepts of this thesis, proposes an understanding and illustration of the term "value in experience", and introduces an initial value framework developed and synthesized from literature. The second part (4.2) utilizes the initial framework in order to re-examine the user experience findings from a value in experience point of view, and then introduces a complemented value design and evaluation framework by relying on the value parameters identified from case studies. The third and last part (4.3) provides design and evaluation implications for novel mobile services from the point of view of different user groups and their relevant value dimensions. Discussion, conclusions, and directions for future research are presented in Chapters 5 and 6.

The original articles are included at the end of the thesis. The articles included in this dissertation are all published in English in peer-reviewed conference proceedings or journals, and are printed at the end of this dissertation in their entirety.

## 2. Related research

This section presents the theoretical background of the dissertation. In what follows user experience theories and frameworks are reviewed and the concept of value and relationship between user experience and value are examined. Furthermore, previous interesting studies of mobile services conducted with different user groups are presented. Finally the gaps in earlier research are considered.

### 2.1 User experience

*“We don’t see and hear with our mind; we see and hear with our experience.”*

(Lobler, 2008)

The notion of experience is inherent to our existence as human beings (Roto et al., 2011). Experience in general covers everything personally encountered, undergone, or lived through (ibid); it is the constant stream that happens during moments of consciousness (Carlson, 1997). User experience differs from ‘experiences in a general sense’, in that it explicitly refers to the experience(s) derived from encountering systems (Roto et al., 2011).

According to Law et al. (2008), a shared definition of user experience is still lacking, and there is still a lack of theoretical focus in the work on user experience (Obrist et al., 2012). There are several reasons why it is difficult to find a universal definition of user experience (Law et al., 2008). First, user experience is associated with a broad range of fuzzy and dynamic concepts. Inclusion and exclusion of particular values or attributes seem arbitrary, depending on the author’s background and interest. Second, the unit of analysis for user experience is too malleable, ranging from a single aspect of an individual end-user’s interaction with a standalone application to all aspects of multiple end-users’ interactions with the company and the merging of the services of multiple disciplines. Third, the landscape of user experience research is fragmented and complicated by diverse theoretical models with different emphases.

### 2.1.1 What is user experience?

Until quite recently, the scope of HCI research was more focused on traditional usability and functional aspects of the system, and more or less neglected the social and emotional phenomena of interaction. But many researchers started to criticize and question this traditional view of HCI community and shifted the focus to researching and designing for enjoyable and engaging experiences by highlighting the non-utilitarian aspects of interaction. The difference between usability and user experience is said to be about emotions: while good usability means the lack of discomfort, good user experience means delighting the user (Blythe and Wright, 2003; Hassenzahl and Tractinsky, 2006). Now user experience is seen as *something* desirable, though what exactly that something is remains open and debatable (Law et al., 2008). Good usability is required for a great user experience, but it is just one part of it (Roto, 2006). Usability is a means to an end (Cockton, 2008a). Thus, usability has now been placed under a more comprehensive user experience concept (Arhipainen, 2009).

Roto (2006) separates different types of experience, stating that we can use the term *user experience* when the user is really using the product or system, not only experiencing a system or object. The term user experience is also recommended by Law et al. (2009) to be applied to products, systems, services, and objects with which a person interacts through a user interface. Thus, Roto (2006) claims that user experience is a special case of experience where the person can *use* a system (product, object or a set of them), with or without a purpose. Using means that the user not only senses the system or witnesses a phenomenon, but also has the opportunity to manipulate or control the system. User experience is thus a subset of experience as a general concept. If there is no system at all, or if the person cannot control the system, we cannot use the term “user experience”. Instead it is better to use just *experience*; how people experience things. Helkkula and Kelleher (2010) present *customer service experience* and understand it as experience in a service setting; a holistic phenomenon, which is subjective, event specific, personal, and individually and socially-constructed.

One popular definition is that from ISO 9241-210 (2009), which defines user experience as “*a person’s perceptions and responses that result from the use or anticipated use of a product, system or service*”. Another definition of user experience is by Alben (1996): “*All the aspects of how people use an interactive product: the way it feels in their hands, how well they understand how it works, how they feel about it while they’re using it, how well it serves their purposes, and how well it fits into the entire context in which they are using it.*” Hassenzahl and Tractinsky (2006) state that user experience is a consequence of a *user’s internal state* (pre-dispositions, expectations, needs, motivation, mood, etc.), the *characteristics of the designed system* (complexity, purpose, usability, functionality, etc.), and the *context* (or the environment) within which the interaction occurs. People do not simply engage in experiences as ready-made; they actively construct them through a process of making sense. Experience is as much a product of what the

## 2. Related research

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user brings to the situation as it is about the artefacts that participate in the experience (Wright et al., 2003).

Roto et al. (2011) describe three different perspectives on user experience:

- *Experiencing* refers to an individual's stream of perceptions, interpretations of those perceptions, and resulting emotions during an encounter with a system. Each individual may experience an encounter with a system in a different way. This view emphasizes the individual and dynamic nature of experiencing the encounter with a system.
- *A user experience* refers to an encounter with a system that has a beginning and an end. It refers to an overall designation of how people have experienced a period of encountering a system. This view emphasizes the outcome and memories of an experience rather than its dynamic nature. It does not specifically emphasize its individual nature because 'a user experience' can refer to either an individual or a group of people encountering a system together.
- *Co-experience* refers to situations in which experiences are interpreted as being situated and socially constructed. It is about user experience in social contexts (Forlizzi and Battarbee, 2004). The emphasis is not only on encountering a system, but also on people constructing and at the same time experiencing a situation together. Co-experience takes place as experiences are created together, or shared with others.

Thus, to emphasize the complex nature of experience, it can be seen to be personal and individual, and in consequence, another person cannot know or determine precisely how one is experiencing it (e.g. Forlizzi and Ford, 2000). In addition, Law et al. (2009) state that only an individual can have feelings and experiences, but a group can experience together. Thus, experience can also be collective and created or shared with other people (Battarbee, 2003). The community forms the social context that, together with other contextual factors, affects user experience (Law et al., 2009). But the experience investigated here is still inside each individual of that group.

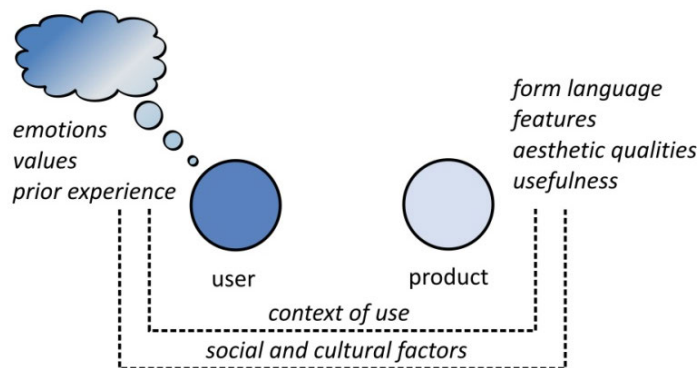
Roto et al. (2011) emphasize the time spans of user experience, and talk about cumulative experience formed through a series of usage episodes and periods of non-use. People can have indirect experience *before* their first encounter through expectations formed from the existing experience of related technologies, brand, advertisements, presentations, demonstrations, or others' opinions. Similarly, indirect experience extends *after* usage, for example, through a reflection on previous usage, or through changes in people's appraisals of use. User experience (UX) can thus refer to a specific change in feeling during interaction (*momentary UX*), appraisal of a specific usage episode (*episodic UX*), or views on a system as a whole, after having used it for a while (*cumulative UX*). The focus and interest in this dissertation lies on cumulative user experience that evolves over time, not on singular user experience episodes.



### 2.1.2 User experience modelling

There are a number of researchers who have investigated user experience and suggested how the concept of user experience may be defined and evaluated in a way that facilitates the design of enjoyable products. In this section, a set of existing user experience models are overviewed in order to gain an understanding of the building blocks of user experience.

According to Forlizzi and Ford (2000) a singular experience is made up of an infinite number of smaller experiences, relating to contexts, people, and products. The simple way to think about what influences experience is to think about the components of a user-product interaction, and what surrounds it (see Figure 2). *User* represents how people influence experience. Users bring to the moment their entire prior experiences, as well as their emotions and feelings, values, and cognitive models for hearing, seeing, touching, and interpreting. *Product* represents how artefacts influence experience. Each product tells a story of use through its form language, its features, aesthetic qualities, and accessibility. In addition, people often impart meaning onto particular products. User-product interactions take place in a *context* of use, shaped by social, cultural and organizational behaviour patterns.



**Figure 2.** Building Blocks of Experience (Forlizzi and Ford, 2000).

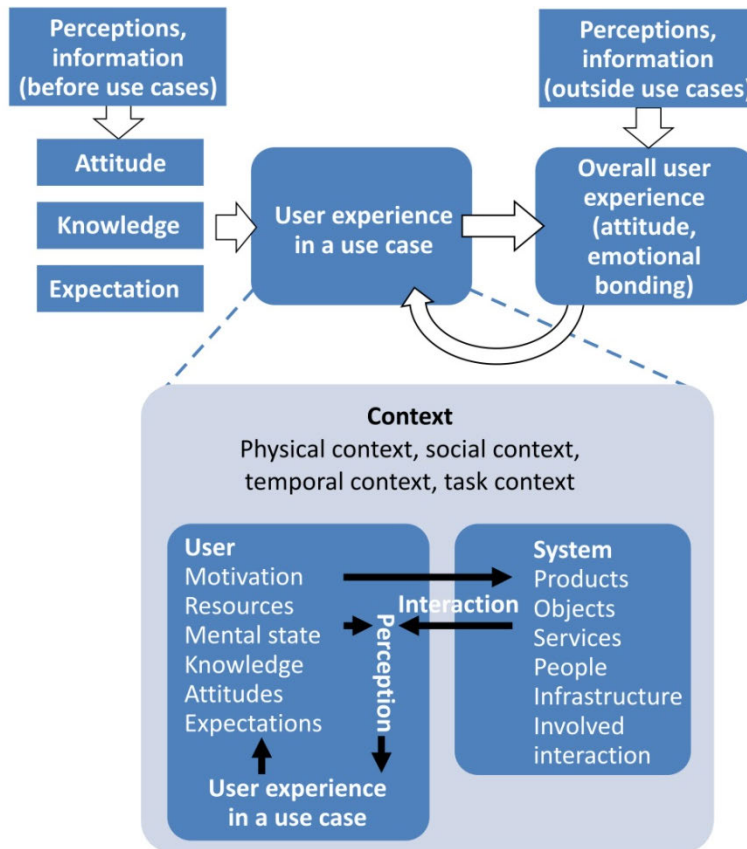
Other user experience models include the conceptual model developed by Kankainen (2003), according to whom user experience is the *result of motivated action in a certain context*. The user's previous experiences and expectations influence the present experience, and the present experience leads to more experiences and modified expectations. To satisfy a need that has motivated the user to act with a product is not enough to guarantee a positive user experience. The performance of a product has to match or exceed the user's expectations.

According to Roto (2006) the user experience in a use case is formed based on the perception and emotional judgment of a specific part of a system after interacting with it. Roto's (2006) model of user experience formation is illustrated in Figure 3. While the top part illustrates the role of use cases in overall user experience for-

## 2. Related research

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mation, the bottom part of the model lists the building blocks of user experience in a specific use case. The existing attitudes and emotional relations before the first interaction case form expectations for the forthcoming user experience. The perception of the system is affected by the user's state, context, and system's interface. The resulting user experience typically affects the user's state, which in turn influences their forthcoming user experiences. Thus, the overall user experience is formed out of use case experiences and perceptions and information received outside the use cases.

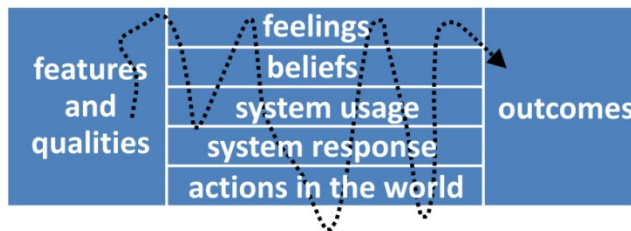


**Figure 3.** User experience building blocks (Roto, 2006).

First presented in Mahlke and Thüring (2007), Mahlke (2007) describes the CUE (Components of User Experience) Model. User experience is gained through the user's interaction with the system. Interaction characteristics primarily depend on *system* properties, but *user* characteristics and *context* parameters may also play an important role. In the CUE Model two types of quality perceptions of interactive systems can be distinguished. *Instrumental* qualities concern the experienced

amount of support the system provides and its ease of use. *Non-instrumental* qualities, on the other hand, concern the look and feel of the system. Hence, while instrumental qualities are closely related to the usability and usefulness of a system, non-instrumental qualities result from its appeal and attractiveness. Both types of qualities are likely to influence the third component of user experience, i.e. the *emotions* that accompany the user's interaction with the system. Emotions are regarded as episodes of subjective feelings accompanied by specific physiological reactions and expressive behaviour. Such emotional episodes may occur repeatedly throughout the interaction with the system and thus shape the user's overall emotional experience of it. All three components of the user experience together determine the actual consequences of the user's experience of an interaction and the user's overall appraisal of the system and thus influence future decisions and behaviour.

Cockton (2008b; 2009) presents User Experience Frames (UEFs) that take a holistic approach to representing user experiences (Figure 4). They expose relationships between design qualities (as indicated by designers' hopes and users' impressions) and unfolding user experiences that will hopefully culminate in worthwhile outcomes. Thus, user experiences are seen as the bridge between design elements and worthwhile outcomes.



**Figure 4.** Schematic User Experience Frame (Cockton, 2008b).

Furthermore, Arhippainen (2009) has developed the U2E-Frame that depicts that when a user is using some product, there are several influencing factors in all parties. A *user* has their personal, social and technological background, and is in a particular psychological state when using the product. Also, a *product* has different characteristics that have an impact on interaction. In addition to aspects of user and product, the *context* where interaction happens has an impact on user experience. A user experiences *usability* of the product when they are interacting with it. Interaction is experienced in the moment of use. However, *user experience includes more than just interaction experience*. The U2E-Frame presents that interaction with a product in a particular context can form experiences which can appear in different levels. Experiences can be *subconscious*, *emotional* or *optimal* and approached from *subjective* or *collective* perspective.

In summary, many researchers have already presented definitions and frameworks to describe user experience. All the aforementioned frameworks entail the

individual user and their unique and personal characteristics, and acknowledge the role of the product qualities and the prevailing context to user experience. What is characteristic to approaches by Forlizzi and Ford (2000) and Kankainen (2003) is that they favour simplicity and use a limited number of concepts instead of encompassing a large number of complex and detailed concepts and categories. The model by Forlizzi and Ford (2000) is very generic and not so relevant as such. They do describe the main factors and their categories affecting user experience, but in their definition the nature of user experience is missing, and, for example, the temporal aspect of UX is not addressed. Whereas Kankainen (2003) brings out the dynamic and temporal nature of UX and emphasizes the importance of previous experiences and expectations on user experience. However, what is notable in Forlizzi and Ford's (2000) model is that it includes users' values as one influencing factor in user experience, an aspect apparently ignored by other researchers (e.g. Kankainen, 2003).

Frameworks by Roto (2006), Mahlke (2007) and Arhippainen (2009) are more complex in their presentation. Mahlke's (2007) CUE-model is very detailed and depends on interaction characteristics and system qualities distinguishing the user's emotional responses to them. The temporal aspect of UX is not taken into account in the view of Mahlke (2007). Arhippainen (2009) describes in detail factors that have an effect on user experiences, but her U2E framework seems a very list-like collection of the key UX factors. However, her perspective is commendable in that she also includes user values as one influencing factor on user experience, and brings out the fact that user experience can be both subjective and collective. In the models user experience extending beyond the core process of exchange and the usage of products and services should be presented in order also to encompass antecedents such as anticipation, and post-usage activities such as remembering and reflecting. Roto's (2006) model appears to be a promising initiative towards illustrating the nature of user experience by, for example, highlighting that overall user experience is formed out of individual use cases. User Experience Frames by Cockton (2009) also have a more detailed focus than some of the aforementioned abstract models, as UEFs attempt to highlight how values unfold and become visible during interaction. UEFs extend beyond first impressions to the motivations that guide human choice. Thus, approaches to user experience by Roto (2006) and Cockton (2008b; 2009) especially were found to be valuable and clarifying in this thesis work.

While reaching a shared definition is not a panacea for resolving a number of problems relating to user experience, it does serve as an initial and crucial step towards an integrated framework of user experience (Law et al., 2009). UX itself cannot be described by describing the UX factors, but UX factors and their main categories can be used to describe the situation in which a person felt a particular UX (Roto et al., 2011). UX factors also help identify the reasons behind a certain experience.

### 2.1.3 Evaluation of user experience

Despite the extensive research on user experience in both industry and academia, there is still a lack of systematic research on how to evaluate and measure UX (Vermeeren et al., 2010). No generally accepted overall measure of UX exists, but UX can be made assessable in many different ways (Roto et al., 2011).

What makes UX evaluation especially challenging is that one person's experience cannot be shared as such by another person. In addition, experience and value may be difficult or even impossible to express to another person (Arhipainen, 2009). As UX is subjective (e.g. Law et al., 2009), it does not have an objective reference, and therefore systematic capture and objective analysis and measurement of user experience is very difficult. Objective usability measures are not reliable measures for UX: we need to know how the user feels about the system (Obrist et al., 2009). Furthermore, predefined metrics may reveal just small parts of the whole UX, and therefore, many UX researchers favour having open, qualitative evaluation methods (Vermeeren et al., 2010). However, the practicability of methods without predefined measures is lower, since data analysis is more difficult with qualitative data.

Furthermore, UX should not only be seen as something evaluable after interacting with an object, but also before and during the interaction (Vermeeren et al., 2010). While it is relevant to evaluate short-term experiences, given dynamic changes of user goals and needs related to contextual factors, it is also important to know how (and why) experiences evolve over time. Moreover, Muller et al. (2003) argue that, if people are to reflect meaningfully on their experiences, they need time to do so.

In summary, capturing information about user experience is challenging, and experimental settings make it even more challenging, as the everyday life context is complex and cannot be fully controlled. In an evaluation situation, challenges in capturing user experience occur at several levels and phases. Firstly, as human experience is always subjective (Greenfield, 2000), the evaluation method should capture the relevant parameters describing the subjective experience, which can then be recorded for analysis by an external observer. Secondly, as user experience is dynamic (Forlizzi and Ford, 2000), it can change and evolve during the process of interaction. Thus, user experience needs to be sampled several times during the use of the product, which often means organizing long-term experiments. Thirdly, interpretation of captured data about user experience is difficult (Vermeeren et al., 2010). What is more, user experience evaluation methods should not disturb or change the actual usage situation so that the actual user experience changes.

Thus, in order to gain as reliable an understanding of user experience as possible, user experience data need to be gathered in real usage situations and from real end-users who have preferably had the service to be evaluated in a personal and long-term use. Case studies can be used in creating a research setup for evoking user experiences and then collecting user experience data about technology

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under evaluation, but the conditions discussed above should be taken into account when planning and conducting user experience studies. As the usage situations, including the physical and social environment, usage tasks, etc., and naturally also the users, may be very different between case studies, it may be necessary to modify the experience collection methods case by case.

The benefits in terms of a rich picture of UX and higher scientific quality by collecting data with a combination of UX evaluation methods are well recognized (Vermeeren et al., 2010). But we need more guidance on which methods work together well, how to effectively analyse the data from different sources, and what kinds of UX data are especially useful (ibid). Isomursu (2008) has discussed the methods and problems related to collecting information about user experience in the context of user studies. These methods are discussed in the following subsections.

### 2.1.3.1 Before-use evaluation

Our abilities to predict our own experiences in a hypothetical or future setting are very limited (Gilbert and Wilson, 1990; Wilson, et al. 2000). But before-use evaluations can become valuable, especially for acquiring information about attitudes and expectations that may be relevant for evaluating the results and impacts of the case study and setting the baseline for the evaluation by describing and measuring the starting point so that improvements and changes introduced by the technology can be identified and measured. The new mobile service often aims at improving or supporting the life of users in some way. For evaluating whether improvement happens, the situation prior to the case study needs to be evaluated. For evaluating improvements, it is crucial to identify the right value parameters that are used for evaluation.

At the beginning of the study period, the users are often introduced to the new technology under evaluation, and perhaps trained in using it. Observing the introduction and training situations allows a good opportunity for exploring the issues related to the adoption of the technology in question. Furthermore, the case study may result in attitude changes that can be identified only if the attitudes before and after the case study can be measured and compared. However, experience shows (e.g. Isomursu et al., 2008) that it may be difficult to predict before the experiment what relevant parameters related to expectations and attitudes might be needed for interpreting the results, as the values and attitudes of users often unfold only during the case study. This could be solved by a deeper user study concentrating on the values and attitudes of the users already prior to the study.

### 2.1.3.2 During-use evaluation

During-use evaluation can focus not only on evaluating the user experience evoked by the technology under evaluation, but also how the technology affects the lives of its users (Isomursu, 2008). As Abowd et al. (2002) have pointed out,

controlled studies in usability laboratories cannot lead to deep, empirical evaluation results. What is needed is real use in an authentic setting. Collecting information about user experiences at the time they happen requires in situ data collection methods (Consolvo et al., 2007) that can be applied during the use of technology. This means that the tools and methods used for collecting user experience data need to be integrated into the everyday practices of the users and therefore need to be quite invisible. The user experience evaluation method may actually “steal the show” (Isomursu et al., 2007) if it is more visible and needs more attention and cognitive processing from the user than the actual technology under evaluation. Thus, the user experience evaluation method should aim at not disturbing or changing the actual usage situation so that the actual user experience changes. However, the fact is that this is extremely difficult, as measurement of a phenomenon itself has effects on that phenomenon (Heisenberg, 1927; Morwitz, et al., 1993). Humans are not very good at analysing what actually caused an experience (Dutton and Aron, 1974), so it can be difficult for users to identify whether the experience was caused by the technology under evaluation or by the user experience evaluation method (or any other event in the life of the user). For example, automated compilation of activity logs makes it possible to discreetly follow the actual usage patterns that have emerged during use.

### 2.1.3.3 After-use evaluation

At the end of the case study the users usually discontinue using the technology under evaluation. This is a point where, typically, a feedback survey is performed. At this stage, the users can report on their user experiences in the form of storytelling and reflect on their experiences. However, as humans are naturally not very good at memorizing experiences, the limitations of after-use methods must be acknowledged. It is extremely difficult for humans to compare even their own experiences when they are separated by time. Human memory of experiences is quite untrustworthy, thus rendering our ability to recall past experiences so that we can compare them with other experiences (e.g. Schultz and Hanusa, 1978) or describe them reliably after time has passed.

After-use evaluation provides an opportunity to evaluate possible changes in the attitudes of the users by comparing situations before and after use, and hearing the explanations of users for possible attitude changes (Isomursu, 2008). This kind of data can be collected from interviews or questionnaires or a combination of both. Experiences indicate that the reply rates for questionnaires made after the user study are higher than questionnaires made before the study. One explanation might be that the users feel they have more to contribute after participating in the user study, as they are able to relate their experiences by sharing stories (Isomursu, 2008). At this point in the case study, users are familiar with the technology, its limitations and possibilities, and feel they better share the language and concepts used by technology developers and researchers. This can be exploited by combining after-use evaluation with brainstorming or other methods suitable for participatory

design. The goal of brainstorming can be to create new ideas for using the same technology for other purposes by generating new scenario proposals, or creating improvement ideas.

### 2.1.4 Design for user experience

It is sometimes difficult to make a sharp distinction between design and evaluation methods (Vermeeren et al., 2010). Design methods often aim to inspire developers when they create new products and designs. As Vermeeren et al., (2010) state, the interest is in finding the means to evaluate the UX of existing concept ideas, design details, prototypes, or final products. The main focus of evaluation methods is to help in choosing the best design, to ensure that the development is on the right track, or to assess whether the final service product meets the original UX targets.

As Wright et al. (2003) have stated, we cannot design an experience, but with a sensitive and skilled way of understanding our users, we can design *for* an experience. Also, no one can design the experience of others, but one can design the *elements* that influence the user experience (Arhippainen, 2009). Users' *values* (covered in the next section) affect their experiences of products and services, and thus this relationship has to be considered in the design process right from the beginning (Kujala and Väänänen-Vainio-Mattila, 2009).

Battarbee (2004) has compared several approaches to learning about the subjective experiences of others:

- *Applied ethnography* – analytical reporting of observations
- *Empathic approach* – observations are balanced with empathy
- *Participatory approach* – supporting the creative thinking of participants
- *Inspirational approach* – people's idiosyncrasies fuel creativity and ideation.

Being user-centred does not mean that designers even agree on how to best involve the user in the design process and to what extent. The roles of the designer and researcher vary. Design ethnography focuses on the practice, and aims at being much less invasive. The ethnographic approach leans on a more rigid theoretical and methodological background than the interpretation-based empathy and inspiration approaches. The empathy-based orientation is built around the designer as a person, but balances this with observations to create a working balancing act and to filter out misinterpretation or over-interpretation. Participatory approaches to user experience support participatory design and a greater involvement of people in the process through the co-construction of an understanding. The inspiration-oriented approach is also a designer-centred, even artistic, approach that treats people as a source of stories and the subject of curiosity. All these approaches can be lauded for being sensitive to people's experiences and supporting design for user experience.



## 2.2 Value

*“People’s behaviour makes sense if you think about it in terms of their goals, needs, and motives.”* (Nobel laureate Thomas Mann)

Values have been understood as intrinsic, lasting and relatively steady beliefs and desirable goals that serve as guiding principles in people’s lives (Schwartz, 1992). Values are standards, from which beliefs, attitudes and consequently behaviours are formulated (e.g. Madrigal and Kahle, 1994). As Friedman (1997) points out, we can say that any human activity reflects human values. Accordingly, individuals show their values through the acquisition of services (Kahle, 1988). Researchers have developed numerous different terms to describe value, where usually the perspective and context within which the value is considered differentiates the concept. But regardless of the extensive literature and research on customer value, it is still argued that the construct requires further refinement and development (e.g. Sánchez-Fernández and Iniesta-Bonillo, 2007; Woodruff, 1997).

### 2.2.1 Value definitions

The first stream of customer-perceived value literature conceptualized value as a uni-dimensional construct, and adopted a cognitive approach to investigating how customers perceive and evaluate value. Zeithaml (1988) characterized “value in exchange”, according to which the perceived value is the consumer’s overall assessment of the utility of a product based on perceptions of what is received and what is given. For example, customers themselves defined value in four ways: (1) value is low price; (2) value is whatever I want in a product; (3) value is the quality I get for the price I pay; and (4) value is what I get for what I give (Zeithaml, 1988). This means-end chain approach explains hierarchically how an individual cognitively runs through the consumption process. Thus, it presents the customers as passive buyers and users to whom the service organizations simply deliver their particular product or service offering with predetermined and controlled value propositions.

These uni-dimensional approaches have been criticized as too narrow and simple to explain customer-perceived value, as they regarded value as a cognitive ratio between service quality and cost, and ignored the multi-dimensionality of the value construct. Thus, the multi-dimensional research approach emerged to acknowledge customer value as a multi-dimensional construct that also included hedonistic and social value in addition to utilitarian value (e.g. Sheth et al., 1991b; Woodruff, 1997; Sweeney and Soutar, 2001; Holbrook, 2006).

Sheth et al. (1991b) have focused in their theory on the development on consumption values, explaining why consumers choose to use or not to use a specific product. According to Sheth et al. (1991b), (1) consumer choice is a function of multiple consumption values, (2) consumption values make different contributions in any given choice situation, and (3) consumption values are independent. Also,

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Sweeney and Soutar (2001) showed that multiple value dimensions explain consumer choice better, both statistically and qualitatively, than does a 'value for money' item and produce superior results when investigating consumption value. Woodruff and Gardial (1996) proposed a 'customer value hierarchy' that took a broader perspective of value than a narrow focus on product attributes and defined the customer value as follows: *"The customer's perception of what they want to happen in a specific use situation, with the help of a product and service offering, in order to accomplish a desired purpose or goal."* Subsequently, Woodruff (1997) defined customer value as a *"customer's perceived preference for and evaluation of those product attributes, attribute performances, and consequences arising from use that facilitate (or block) achieving the customer's goals and purposes in use situations"*. This hierarchical structure of customer value is represented by using a means-end chain where product attributes represent the lowest level and goals and purposes the highest level of the customer value hierarchy. Lower levels are the means by which the higher level ends are achieved.

Thus, according to Woodruff (1997), value is perceived by customers through the use or consumption of a product or service. Vargo and Lusch (2004) introduced this new value perspective as the concept of *"value in use"* in which value is realized when a service is used. Service users are thus both co-creators and judges of service value, and therefore value in use is individual to every user. Sandström et al. (2008) have given the following conceptualization of value in use: *"Value in use is the evaluation of the service experience, i.e. the individual judgment of the sum total of all the functional and emotional experience outcomes. Value cannot be predefined by the service provider, but it is defined by the user of a service during the user consumption."* Value in use is usually conceptualized as a cognitive assessment (Sandström et al., 2008), but it differs from the "value in exchange" view (Zeithaml, 1988), whereby value is produced in the form of a good and exchanged with a customer.

Holbrook (2006) defines customer value as *"an interactive relativistic preference experience"* that occurs to the extent that products perform services, and adopts a phenomenological definition of value by saying so. In other words, the customer value involves an interaction between an object and a subject, and this object-subject interaction is relativistic in comparative, personal, and situational senses. Furthermore, customer value entails subjective hierarchical preferences based on an individual's situation-specific comparisons such as like/dislike and good/bad. Finally, such an interactive relativistic preference attaches not to the object itself, but rather to the relevant consumption experience. This view is contrary to the definition by Boztepe (2007), according to whom customer value is where value refers to the evaluation of some object/product by some subject/user.

Cockton (2008b) adopts the term *"worth"*, and defines it as a balance of value over costs. A worthwhile design delivers sufficient value to its intended beneficiaries to outweigh costs arising from the means. Human activity is guided by motivators and demotivators, and the balance of motivators and demotivators associated with a product or service determines its worth (Cockton, 2009). A happy ending requires outcomes to be worthwhile, i.e. with positive consequences outweighing

negative ones. Cockton's (e.g. 2009) Worth Maps reveal a relationship between outcomes (worthwhile/adverse) and service attributes mediated by user experience. They make a strong point, namely that value can only arise through user experiences (also detailed by UEFs). Worth in experience is the result of active user engagement with a mobile, and not the passive receipt of a pre-defined set of values.

Kujala and Väänänen-Vainio-Mattila (2009) clarify the concept of value from the user's point of view by suggesting that the perceived value of the product is not located in system/product properties, but arises as a consequence of the user's perception and experience of a system/product. Perceived value is the result created through user-product interaction in a particular context. In addition, the user brings their psychological values, needs, and goals to that interaction. Thus, the resulting perceived value also depends on the individual who perceives a product or system and the psychological values that individual person possesses.

Vargo (2008) and Helkkula et al. (2010) have characterized "*value in context*" as value experienced by customers within their individual phenomenological contexts, not only related to the actual use of the service but also including the imaginary or anticipated use of the service. Helkkula et al. (2012) further proposed a concept "*value in the experience*" as individual service customers' lived experiences of value that extends beyond the current context of service use to include past and future experiences and service customers' broader lifeworld contexts.

To conclude, value perceptions may differ according to usage situation (Anckar and D'Incau, 2002), which indicates that the benefits of mobile services are dependent on the context in which they are used (Åkesson, 2007). Customer value is a dynamic concept because the perceived value of a product or service may change over time (van der Haar et al., 2001). But the context in which users experience value do not necessarily equate with the service contexts proposed by the service provider. Vargo and Lusch (2008) recognize the phenomenological, experiential nature of value, where actors makes sense and determine value of service experientially in a specific context, and define value as "*always uniquely and phenomenologically determined by the beneficiary*".

Definitions that give no account of the capability of users to imbue services with value are easily refutable. Furthermore, means-end models by e.g. Zeithaml (1988) ignore contextual factors and regard value perception as a cognitive process. Woodruff and Gardial (1996) noted that customers' value judgments are determined and subject to change within the constraints of a particular use situation. Their customer value hierarchy started to reflect the complexity and dynamics of the concept, but it did not go more deeply into various dimensions of value. Cockton's (e.g. 2009) view on 'worth' is not a simple ratio calculation, but involves a judgment of whether benefits are worth sacrifices. Value definition by Woodruff (1997) incorporated both desired and received value and emphasized that value stems from customer's learned perceptions, preferences, and evaluations, and that customer value thus changes over time. The perspective of value in use by, e.g. Vargo and Lusch (2004), ignores the different phases of user experience but acknowledges the user's role in value co-creation. But the approach of value in

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context (e.g. Helkkula et al., 2010) fills this void by emphasizing that it is possible for service customers to experience value even before they have direct experience or use the service.

There is a need to have an extended view of user value beyond the narrower, traditional perspectives of value that fail to address the full scope and nature of user experience, and that see value as something pre-defined and embedded in a product by the service provider and then recognized by users. In this work especially the views of 'worth' (e.g. Cockton, 2008b), 'value in context' (e.g. Helkkula et al., 2010) and 'value in the experience' (Helkkula et al., 2012) created the basis for the development of value framework and proposition of 'value in experience' concept, as they were seen to be good initiatives striving to address a more holistic perspective of value.

### 2.2.2 User values

*"We do not see things as they are; we see things as we are."* (The Talmud)

How a user experiences value depends largely on that particular user's personal and unique values and internal conditions (cf. Forlizzi and Ford, 2000; Kaasinen, 2005). When we think of our value, we think of what it is important to use in life (Schwartz, 2006). Each of us holds numerous values that are ordered by importance relative to one another, and these value "priorities" or "hierarchies" characterize us as individuals (ibid). Schwartz's (2006) view of values is that they serve as internalized guides to individuals in their lives; people use them as standards and criteria for evaluating and justifying actions (rarely with a conscious weighing of alternatives or their consequences). Actions become more attractive and valued subjectively to the extent they promote the achievement of valued goals.

Holbrook (1999) makes a clear distinction between '*value*' and '*values*', and defines '*value*' as the outcome of an evaluative judgment, whereas '*values*' are the standards, rules, criteria, norms, goals, or ideals that serve as a basis for an evaluative judgment. According to Sánchez-Fernández and Iniesta-Bonillo (2007), in contrast to the term '*value*', '*values*' are the implicit criteria that an individual uses when forming a preference judgment. Thus, perceived value and personal values are not the same concept, but are clearly distinct.

Lages and Fernandes (2005) define service personal values as a customer's overall assessment of the use of a service based on the perception of what is achieved in terms of their own personal values. Furthermore, the use of a service can be a way to fulfil and demonstrate users' personal values (Lages and Fernandes, 2005). Allen and Ng (1999) suggest that psychological values shape users' evaluation of products in two ways. First, users evaluate a product's utilitarian meaning and make an attribute-by-attribute judgment. Second, users evaluate a product's symbolic meaning with an affective, intuitive and holistic judgment. Furthermore, Madrigal and Kahle (1994) have stated that even though a scale is missing by which to assess personal values, they are considered better predictors

of an individual's behaviour and even more important than the effect of attitude on user behaviour (Durgee, 1996).

Kujala and Väänänen-Vainio-Mattila (2009) propose the term '*user values*' that is employed for users' motivations as in psychology, i.e. to describe the users' psychological values that affect their views as to what kind of purpose, functions and characteristics are important to them in a certain usage situation and context. The values represent both users' preferences as to what is important to them and aversions to what they want to avoid. Thus, user values are users' internal conceptions of what is important in a certain usage context, and they are not perceptions of products.

Values can be used to predict or explain the acceptance and attractiveness of new systems or products in organizations or by masses or consumers (Kujala and Väänänen-Vainio-Mattila, 2009). Also, Jurison (2000) and Kim et al. (2007) have concluded that a higher perceived value indicates a greater willingness on the part of the user to adopt the technology. The extensions of the original TAM model now include value-related aspects, and for example, Kaasinen (2005) identifies perceived value as one of the four factors of user acceptance. According to Kaasinen (2005), values define the key features of the services that are appreciated by the users and other stakeholders, the main reasons why the users are interested in new services.

### 2.2.3 Value dimensions

Individuals and groups have different value priorities or hierarchies (Schwartz, 2006). What distinguishes one value from another is the type of goal or motivation that the value expresses (ibid). A sample of customers may express preferences for hundreds of attribute and consequence value dimensions (Woodruff and Gardial, 1996). Value dimensions are stated in the language of the customer, which often differs from the language of the seller (Woodruff, 1997). The customer value hierarchy given by Woodruff (1997) suggests that desired value is composed of preference for specific and measurable dimensions, namely the attributes, attribute performances, and consequences linked to goals for use situations. Different types of value might emerge from users' experiences with services (Boztepe, 2007).

Hirschman and Holdbrook (1982) described consumers as either problem-solvers or seekers of fun and enjoyment, and thus refer to utilitarian vs. hedonic consumption. Babin et al. (1994) followed the same categorization and developed a value scale that assesses these two dimensions of consumer value:

- *Utilitarian* – instrumental, task-related, rational, functional, cognitive, and a means to an end
- *Hedonic* – entertainment and emotional worth; non-instrumental, experiential, and affective.

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A framework of consumer value created by Sheth et al. (1991b) includes five value dimensions:

- *Functional value* – effective task fulfilment, whether a product is able to perform its functional, utilitarian, or physical purposes, monetary value or superiority compared with the alternatives
- *Social value* – social approval and the enhancement of self-image among other individuals, product or service use with others
- *Emotional value* – aroused feelings or affective states
- *Epistemic value* – experience of curiosity, novelty or knowledge gained
- *Conditional value* – situational circumstances that impact choice.

These value dimensions were further complemented with categories of user values identified by Kujala and Väänänen-Vainio-Mattila (2009), mostly based on psychological literature (e.g. Maslow, 1970; Schwartz, 1992):

- *Growth and self-actualization value* – self-actualization, creating, independent thought and action
- *Traditional value* – respect, commitment, and acceptance of the cultural customs and ideas
- *Safety value* – security, social order, healthy, comfort, freedom from fear
- *Universal value* – understanding, appreciation, tolerance, and protection for the welfare of all people and for nature.

Schwartz's (1992) value model has been used extensively for analysing the development of value priorities across time and between groups of people around the world. The model structures human values into ten value types and nearly 60 individual values. They are the basic values that individuals in all cultures recognize. Different value types serve either individual interests or collective interests, and some value types have features of both. The value model is based on the principle that values are always ordered by relative importance. Actions in pursuit of any value have consequences that conflict with some values but are congruent with others. In the following the value types as defined by Schwartz (1992) are summarized:

- *Power* – wealth, authority, social power, preserving public image and social recognition
- *Achievement* – demonstrating competence, especially with a view to obtaining social approval
- *Hedonism* – pleasure and sensual gratification
- *Stimulation* – a need for arousal and variety that keeps activation and attention at an optimal level

- *Self-direction* – self-respect, independent thought and action, e.g. freedom, curiosity, creativity and choosing one's own goals
- *Benevolence* – wellbeing of the people one interacts with closely on an everyday basis, including, for example, helpfulness, loyalty, honesty, and responsibility
- *Conformity* – not performing actions that are likely to harm or upset others or violate social norms, for example obedience and politeness
- *Tradition* – respect towards customs and ideas that have been accepted to represent shared experience and fate
- *Universalism* – welfare of all people and nature, including e.g. equality and wisdom
- *Security* – safety, harmony and stability in society, sense of belonging.

Holbrook (1994; 1999) suggested a typology of consumer value that is a more comprehensive approach to the value construct, and defined more sources of value. It has three key underlying dimensions, namely those between:

- 1) *Extrinsic value* (product or experience serves instrumentally as a means to an end) versus  
*Intrinsic value* (consumption experience is appreciated for its own sake as a self-justifying end-in-itself)
- 2) *Self-oriented value* (the effect the product or experience has on me) versus  
*Other-oriented value* (how the product or experience affects others)
- 3) *Active value* (value perceived through the direct use of some product) versus  
*Reactive value* (appreciation of some consumption experience wherein an object affects oneself rather than vice versa)

Lee et al. (2011) classified the dimensions of values as either:

- *Consumer values (CV)* – internally based beliefs that guide consumer's behaviour when purchasing products or services, typically generalizable across consumer behaviour situations
- *Perceived product attributes (PPA)* – externally based and typically contingent on the product itself, i.e. product-specific.

Sweeney and Soutar (2001) developed four value dimensions to assess customers' perceptions of the value of a consumer durable good:

- *Emotional* – the utility derived from the feelings or affective states that a product generates
- *Social* – the product's ability to enhance social self-concept

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- *Quality/performance* – the reduction of product's perceived short-term and longer term costs
- *Price/value for money* – perceived quality and expected performance of the product.

Lages and Fernandes (2005) have developed the Service Personal Values (SERVPAL) scale that presents three individual dimensions of service value:

- *Peaceful life* – pleasurable life, tranquility, safety and/or harmony
- *Social recognition* – gaining respect from others, social recognition and status
- *Social integration* – strengthening of friendships, becoming more integrated in the group, better relationships at the social, professional and family levels.

Boztepe (2007) has identified four major categories of use value (sub-categories are further elaborated with more detailed concepts):

- *Utility* – utilitarian consequences of a product, encompassing the sub-categories of convenience, quality and performance, economy
- *Social significance* – socially oriented benefits, encompassing the sub-categories of social prestige and identity
- *Emotional* – affective benefits of a product, encompassing the sub-categories of pleasure and sentimentality
- *Spiritual* – spiritual benefits such as good luck and sacredness.

There have also been efforts to identify value dimensions specific to certain usage contexts. For example, Clarke (2001) suggested value proposition dimensions related specifically to m-commerce, as follows (later completed by Åkesson, 2007):

- *Ubiquity* – service available everywhere and anytime; content relevant to user's situation
- *Convenience* – time and place utility for users; good overview of service offerings and contents within the service
- *Localization* – relevance depending on user's geographical position; adaptation to the time of day
- *Personalization* – personal relevance through individual preferences.

Furthermore, Åkesson (2007) added another dimension to Clarke's (2001) description of the dimensions of value proposition, namely:

- *Socialization* – user's willingness to contribute user-generated content, desire to share experiences, ideas and opinions, support for community building.

Socialization value can thus be seen more as an interaction with others than the appreciation received from the others.



The theory by Sheth et al. (1991b) defines a complex multi-dimensional structure for perceived value, but it can be seen to ignore some sources of value. Both the contents and structure of values in Schwartz's (1992) theory have been validated in over 70 countries around the world, but they describe the basic, universal values. Holbrook's typology (1994; 1999) was one of the approaches that contributed more to the understanding of the nature of perceived value and defined more sources of value than previous studies. But the complexity of its structure might make its use in practice complicated for capturing the different dimensions of value.

Woodruff (1997) states that new qualitative techniques are needed to explore a broader, more complete range of desired value dimensions, particularly related to consequences. However, value classifications have been criticized (Le Dantec et al., 2009) because they restrict the analysis to a set of preconceived values rather than inquiring about the values that appear and are relevant in the particular usage context. Furthermore, doubts have been expressed as to whether any value classification confined to a paper could be comprehensive (Friedman et al., 2006). There is a real danger that value classifications can reduce the scope of analysis, therefore leaving out important context-specific details.

#### **2.2.4 Evaluation of and design for value**

Good design should result in good outcomes, and these are a vital element of user experience (Cockton, 2009). It is thus essential that designers develop a clear shared understanding of design purpose (i.e. the 'ends' of design), and keep this entirely separate from any consideration of the 'means' of design (i.e. the design elements that enable interactive UXs) (ibid). Designing worth means designing things that will motivate people to buy and use products (Cockton, 2006).

Although the conceptual importance of customer value is recognized in organization environments, its application in real-life studies lags behind, because the practical use of the concept still poses difficulties (van der Haar et al., 2001). One of the problems is that customer value can be defined at different abstraction levels and, consequently, has to be measured at these different levels. The different approaches to taking into account values in design work do not yet have clearly established activities or methods for identifying user values and integrating them into practical design processes (Kujala and Väänänen-Vainio-Mattila, 2009). Nevertheless, identifying values, implementing them into design work and evaluating the success of this implementation can be seen as essential activities.

But it is challenging to determine and measure the value, since it is evaluated so individually and personally. People's inner thoughts and explicit speech are an essential part of sense making that illuminate but do not, and are not able to, fully reveal lived experience (Helkkula et al., 2012). In addition, users' iterative sense making is not a linear process (ibid). Furthermore, people do not usually think about their values and may therefore have difficulties in verbally stating them (Hoyer and MacInnis, 2007). Users may not even recognize their own values, and the underlying values behind more self-explanatory values might remain hidden. In psy-

## 2. Related research

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chology, it is well known that some values are unconscious or socially not desirable to mention. Perceived value also may easily vary, especially due to the changing conditions related to the users themselves and across different evaluation contexts.

Woodruff and Gardial (1996) have developed Values and Lifestyles (VALS) methods for measuring consumer value. VALS segments people according to their enduring beliefs, and consists of categories such as innovators, achievers, thinkers, etc. However, these categories are very stereotypical and concerned only with generalities, even though they have their basis in reality (Boztepe, 2007). Such groupings can help designers establish the general positioning of a product, but they fail to help designers identify details that constitute a difference in people's experiences with the product (Boztepe, 2007). Also, this approach does not sufficiently take contextual factors into account.

Other established customer value measures, such as the Customer-Perceived Value Measurement scale (PERVAL) by Sweeney and Soutar (2001), consider customer value and its measurement as a linear process that involves pre-, in-, and post-service consumption phases, or simply as a judgment of value based on in-use experience, usually on the perception of some type of customer trade-off between perceived benefits and sacrifices. Other traditional approaches to measuring customer value emphasize the predefined value categories in the context of a particular type of service, and do not incorporate a more longitudinal perspective (Holbrook, 1994; Zeithaml, 1988).

The existing methods are often based on observing users' reactions to existing products. Since experiences are attained through activities, among other things, various other ways of doing things should also be looked at (Boztepe, 2007). By examining the activities surrounding the use of the service, we could learn more about the ways by which the service experience leads to desirable consequences and value (*ibid*).

Worth Maps connect means to ends and look beyond designs and usage to a broader range of interdependent connections between designs, usage, outcomes, evaluations and beneficiaries (Cockton, 2009). They allow designers to indicate which feelings are expected to arise during an interaction and when, and how these feelings will then shape the course of subsequent interaction. They are network structures, where design means comprise design elements (materials, features, qualities) and user experiences. Together, these means should combine to produce worthwhile outcomes. User experiences in worth maps are treated as the means to an end of worthwhile outcomes, but the quality of the user experience will impact on the worth achieved by a design (*ibid*). Positive means-end chains indicate the expectations of designers that design elements will enable positive user experiences that result in a worthwhile outcome (Cockton, 2009).

A laddering approach is used to capture user cognitions about products by asking users to identify important product attributes and then recursively asking why these particular attributes are important and those not (Cockton, 2008a). This ascent is repeated up the ladder until a user can say only that something really matters to them. This approach identifies associations that are important, frequent, and credible to consumers, and has widespread use (*ibid*).

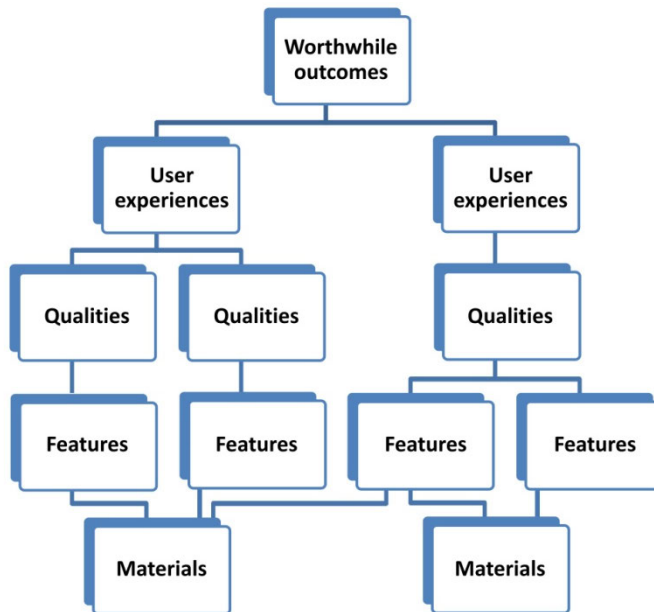
Kujala and Väänänen-Vainio-Mattila (2009) argue that user involvement is essential in identifying user values, interpreting the practical meaning of the values and implementing the values in products. Many traditional value measures focus on after-use evaluations of a specific service and do not take into account how the imagined experiences may influence user value perceptions. In order to really consider the user's point of view, users should be able to direct the focus of the future product and not just react to existing designs (Kujala and Väänänen-Vainio-Mattila, 2009). Furthermore, even if the user values were known in the early phases of development, the interpretation of the meaning of user values is still value-loaded. Developers' perceptions may be biased, as they view system goals and user preferences through their own set of values and assumptions.

As stated by Parasuraman (1997), no single measurement scale is sufficient for capturing so complex a construct as value, which involves also many variables. Furthermore, research methods that aim at objective approximations and generalized outcomes from large samples are not applicable; instead, interpretive methods or techniques, such as narratives, that focus on the subjective experience and attempt to understand how users make sense of it can be used to collect data in relation to value (Helkkula et al., 2012). Even though there is an advantage in the ease and speed of deductive approach and analysis, difficulties arise if a respondent is driven into a set of pre-determined values that cannot be perfectly related to the problem (Lages and Fernandes, 2005). Predefined scales could be used in conjunction with interpretive methods, as both these approaches can provide complementary information and understanding considering the nature and experience of user value.

### **2.3 Relationship between user experience and value**

The relationship between user experience and user-perceived value has not gained much attention and remains little researched and defined. However, such an investigation is vitally important, as customer-perceived value and the meanings of service experiences are no longer seen as fixed and linked to service attributes and characteristics (Helkkula and Kelleher, 2010). In contrast, each individual customer is now seen to form their personally perceived meanings based on their personal and subjective experiences (ibid).

Cockton's (e.g. 2009) Worth Maps reveal a relationship between outcomes (worthwhile/adverse) and service attributes mediated by user experience (Figure 5). They make a strong point that value can only arise through user experiences (also detailed by UEFs). User experiences are seen as the bridge between design elements and worthwhile outcomes. Cockton highlights that there has to be an active, engaged, and involved user presence, not simply passive usage, for worthwhile outcomes. Thus, worth in experience is the result of active user engagement with a mobile, and not the passive receipt of a pre-defined set of values.



**Figure 5.** Worth Map (adapted from Cockton, 2008b).

Research findings by Helkkula and Kelleher (2010) reveal that customer service experiences (i.e. experience in a service setting) are the basis for customer value perceptions. As Frow and Payne (2007) put it, value resides not in the object of the consumption itself, but in the experience of the consumption. Customers do not passively accept the value propositions presented by the service provider, but instead uniquely experience and create value within their own contexts. Thus, customers are active seekers of meaning, rather than just passive buyers or users of products or services (Helkkula and Kelleher; 2010). They do not perceive value solely in a cognitive fashion, but they perceive and experience value through their cumulative lived and imaginary experiences (ibid).

According to Sandström et al. (2008) value in use is the assessment of the total service experience, which includes both the functional and emotional dimensions. Furthermore, individual and situational filters influence the evaluation of service experience and value. However, this view regards the value in use as a cognitive judgment process of service usage experience (also Vargo and Lusch, 2004), and ignores the time spans of user experience and value evaluation.

As Helkkula and Kelleher (2010) state that, due to the cognitive-affective multi-dimensional nature of customer-perceived value, it is important to evaluate perceived value from the perspective of the individual's consumption experience. Their findings indicate that customers experience service and value in their own contexts, and thus, the analysis of the customer service experience must be aware of the effect of contexts, past experiences, and value perceptions. Customers' ser-

vice experiences and perceptions of value are inextricably intertwined with their current and past customer service experiences (Helkkula and Kelleher, 2010).

## 2.4 Studies of mobile services for different user groups

An overview is provided here of mobile service user studies conducted with different user groups. This review gives some initial understanding and characterization of different types of people as mobile service users, and interesting related research considering the case studies part of this thesis.

As the age of adoption and use of mobile phones is getting lower and lower, studies are also emerging of very young **children's** use of mobile technology. The most prominent research into this user group seems to be focused on parent-child and peer relations, and on mobile applications developed for gaming and educational purposes. For example, a mobile gaming experience called "Savannah" was designed and explored with ten children between 11 and 12 years of age to encourage the development of children's conceptual understanding of animal behaviour (Facer et al., 2004). In this 'Savannah' mobile gaming and learning project it was discovered that the game's physical nature arguably contributes to the directness of the experience, and to children's enjoyment of the activity out in the field. A user study also revealed that even this young age group has grown up expecting rich and immersive media experiences. In a study by Näsänen et al. (2009) a system called "Meaning" was tested and evaluated, which enabled both teachers and children to share media with parents via smartphones in near-real-time fashion. The children were eager to express their experiences to the parents via the mobile media, and they also used photography as a type of tool to interact with their peers in face-to-face situations. Findings revealed that the competencies of children varied significantly; for example, among the children there were radically differing levels of ability in using a camera.

Mobile services for mobile learning purposes have also been designed and directed for **adolescents**, usually in the form of games (e.g. by Spikol and Milrad, 2008; Hwang and Chang, 2011). In the previous mobile service studies it has been discovered that fun, collaboration, challenge, and multidisciplinary approaches extended beyond the four walls of the traditional classroom learning create the most promising opportunities for teens' involvement and engagement. For example, Theng et al. (2007) implemented "Mobile G-Portal", a group of mobile devices, as learning assistant tools supporting collaborative sharing and learning for geography fieldwork, and tested the system with 39 secondary school students. The study findings revealed that students are technology-savvy and have considerable experience in using mobile phones. Thus, for this type of user group, usefulness was more important than usability as their main criteria in accepting and adopting mobile technology.

Most services developed and targeted on **college students** appear to be intended mainly for utilitarian purposes. Previous studies of college students as mobile service users reveal that for them mobile services should be developed

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and targeted that address them both as individuals and as part of a larger peer group. Survey results by Kennedy et al. (2008) of nearly 2,000 students mainly between ages of 17 and 21 revealed that the students are very technology-savvy, and regularly use a wide range of traditional and emerging technologies in their daily lives. They are also overwhelmingly positive about the use of ICT to support their studies. Chen and Katz (2008) revealed that the mobile phone is “a must” for college students also for keeping in contact with their family and fulfilling family roles. Students use mobile phones for the purpose of sharing experiences and for emotional and physical support with their parents. McClatchey (2006) investigated the consumption of mobile services among students between the ages of 19 and 27 years and found that students use mobile services for communicating with their peers and for both utilitarian and hedonic purposes, and more so hedonically. For students, data services such as SMS and content download are mainly hedonic, whereas voice communications are mainly utilitarian. Reference groups also pressure young people to conform to their peers’ choice of mobile service providers and play a key role in shaping how they consume mobile services. A mobile vocabulary study system “PhotoStudy” was developed to support the collaborative use of images generated by camera phones (Joseph et al., 2005). The PhotoStudy was tested with EFL students of an average age of 28.4. In the study it was found that participants placed value on the feature that allows them to collaborate with a friend.

For **older adults** mobile services have been mainly designed for the purpose of assistive technology, especially for supporting everyday life and offering greater independence to the older person and also in some cases easing the caregiver’s burden. For example, different types of reminder support for persons with memory disorders (Donnelly et al., 2010), medication management solutions (Nischelwitzer et al., 2007), navigation aids (Ziefle and Bay, 2006), support to older persons suffering from chronic diseases (Nischelwitzer et al., 2007), and so forth, have been developed and targeted on older populations. Kurniawan et al. (2006) explored issues related to the use of mobile phones by older people, and concluded that people over the age of 60 use mobile phones for very limited purposes, and avoid using more complex functions. The older users reported that the main reason of owning mobile phones was in case of an emergency. Ziefle and Bay (2006) discovered that older adults’ performance of navigation tasks is consistently lower compared to that of younger adults. In older people a lowering of memory and spatial ability was the main reason. Pinsker et al. (2008) have tested a therapy-management-system with study participants with a mean age of 64.4 years, and discovered that most problems were related to the small alphanumeric keypad, which caused the entry of wrong values, and the complexity to change such entries. Häikiö et al. (2007) developed a solution where an NFC-enabled mobile phone was used to enable home-dwelling older people to choose their meals to be delivered by means of a home care service. The average age of study participants was 76.6 years, and results revealed that a touch-based user interface can provide an easy-to-learn and adoptive user interface paradigm for older people, to be used

in applications integrated with the everyday life of its users. Also, e.g. Rukzio et al. (2006) have discovered that older people prefer direct mobile interaction techniques.

Service design should not be based on the generic models of the users (Abrás et al., 2004), but nevertheless, target user definitions are often at the level of very basic user characteristics, such as age, gender, and study background. Such an approach does not help designers develop insights and identify the linkage of users' in-depth service needs, motivations, and values to technology features (Kujala and Väänänen-Vainio-Mattila, 2009). Differences in people's background characteristics largely determine the differences in life circumstances to which people are exposed, which, in turn, affect their value priorities (Schwartz, 2006). Value-oriented segmentation is proven to be better than the traditional approaches, such as demographics, in segmenting users (Pura, 2005). Woodruff and Gardial (1996) have developed Values and Lifestyles (VALS) methods to measure consumer value. VALS segments people according to their enduring beliefs. VALS can be seen as a key contribution in the move from demographic to psychographic market segmentation.

## 2.5 Gaps in related research

The concept of 'value' has received extensive interest in research in the fields of psychology, marketing and more recently, human-computer interaction (HCI), but there is still complexity and lack of consensus in the conceptualization, dimensions and measurement of value (e.g. Sánchez-Fernández and Iniesta-Bonillo, 2007). In the past decade, user experience has received considerable attention in HCI research. Many researchers have already presented alternative models, perspectives and definitions to describe user experience, but one obvious outcome is a huge number of diverse views that are disintegrated and scattered in different forms and contexts. A shared definition of user experience is still lacking (e.g. Law et al., 2008). Even though user experiences are seen as the basis for user value perceptions (Helkkula and Kelleher, 2010), the relationship between user experience and value has not been given much attention.

The uni-dimensional approaches of value have their advantage in simplicity, but they fall short in reflecting the complexity of users' perceptions of value. The traditional perspective, concerning what you give for what you get (e.g. Zeithaml, 1988) is a very narrow view of the concept, and overlooks for example the situational context of use, and the emotional and hedonic aspects of phenomena. This money-spent-for-product-quality-view of value seems to also exclude a range of communication products (Boztepe, 2007). Furthermore, it does not focus on the users' part in the co-creation of value. Scholars have acknowledged that this conceptualization of value is a narrow approach to a concept that is essentially multi-dimensional (e.g. Holbrook, 1994; Sweeney and Soutar, 2001), and involves more than just a rational and cognitive assessment of utility.

The emergence of multi-dimensional models of perceived value provide more holistic (and complex) approaches to the nature of value, but these multi-

dimensional constructs are conceptually ambiguous, explain less variance than is explained by their dimensions taken collectively, and confound relationships between their dimensions and other constructs (cf. Sánchez-Fernández and Iniesta-Bonillo, 2011). The source of value has been the major disagreement among different theories. The question is whether value is something subjectively assigned by the user and independent of the product's physical qualities, or something embedded in the object and recognized by the user (Boztepe, 2007). A purely cognitive and objectivistic approach positions value as inherent in the object, existing before a subject interacts with or evaluates with it. But the service experience does not exist until the user perceives it, and thus, the company will never be able to create the experiences or offer predefined value (Vargo and Lusch, 2004). Rather than embedded in goods and services, value is centred in the experiences of the users (cf. Frow and Payne, 2007).

A user may derive value at any time during the user experience (Woodruff, 1997). It is essential to look beyond the static aspects of user experience, beyond short-term experiences, and investigate the temporal aspects of UX, i.e. how UX changes over time (Law et al., 2009). As Helkkula and Kelleher (2010) state, due to the cognitive-affective multi-dimensional nature of customer-perceived value, it is important to evaluate perceived value from the perspective of the individual's user experience. Thus, the discussion of value should be conducted and developed together with a discussion on user experience. However, there has been little research to develop an empirically based understanding of value across the full scope, all time spans, of user experience.

To summarise, the field is troubled by vaguely defined terminological concepts of value and user experience, and confusion and inconsistency in using the terms. There is no clear basis for choosing between alternative models, perspectives and definitions. Many existing value constructs seem too narrow and generic, and complementation of value dimensions would increase the constructs' applicability and usefulness across different service contexts. As stated by Cockton (2008a), it is important to evaluate value above the level of abstract product attributes and immediate functional or psychosocial consequences. Service judgment should be made by outcomes and lasting impacts that endure beyond interaction, and not by the qualities of user experience during interaction (Cockton, 2006).

What is more, the understanding of users is often at the level of very basic user demographics, but such an approach does not help designers develop insights and identify the linkage of users' in-depth service needs, motivations, and values to technology features (Kujala and Väänänen-Vainio-Mattila, 2009). Design work should not be based on generic models of the users (Abrams et al., 2004). Differences in people's background characteristics largely determine the differences in life circumstances to which people are exposed, which, in turn, affect their value priorities (Schwartz, 2006). Gaining an understanding and acting on users' personal values is seen as a powerful tool to better comprehend user behaviour and reach the potential users (Durgee, 1996), and thus, more research is needed on identifying the important value dimensions of different user groups in order to



close the gap between what developers and service providers believe that the users value and what the users actually value.

Thus, there is a need for an extended view of value beyond the narrower, traditional perspectives that give no account of the user's role in value co-creation and fail to address the full scope and nature of user experience and value. Previous definitions also pose problems due to their lack of sufficient consideration of other definitions. Further empirical research into investigating and interpreting user-perceived value is needed in order to increase generalizability across contexts and extend coverage over different stages of user experience and dimensions of value.

## **3. Overview of the case studies**

The data for this dissertation was collected within the context of different technology research projects during the years 2007–2011 while the author was working at the VTT Technical Research Centre of Finland. The author's contribution and role in the case studies has already been presented in Section 1.4.

### **3.1 Individual case studies**

An overview is provided in what follows of the seven individual mobile service case studies that form part of this dissertation. Value in experience evaluation of these cases studies is presented in Section 4.2.

#### **3.1.1 Mobile application for university students (Publication I)**

The author came to work at VTT in the spring of 2007 as a research trainee working on her Master's Thesis. The author worked on the Fummas (Future Mobile Marketing Solutions) project which included a case study of the "Mora" mobile service that was based on a Java-based mobile client providing mobile access to the intranet of the campus area for its students and personnel. Mora was launched at the Finnish campus in the city of Raasepori in the autumn of 2007. Factors that facilitate and trigger, and respectively hinder, the adoption and use of mobile services were researched in the case study, and the main findings were reported in a journal article (Publication I). During the field trial, the Mora mobile service gathered 67 registered users, and of those 52 users provided their feedback for the user study. The majority of the users were male, and less than 25 years old. They were relatively experienced mobile service users and familiar with different kind of downloadable mobile applications.

#### **3.1.2 NFC-enabled mobile learning concept for teenagers (Publication II)**

After completing her Master's Thesis and gaining Master's Degree, the author became involved in a SmartTouch project, which explored and evaluated applications

and services based on Near Field Communication (NFC) technology in various domains. SmartTouch developed a mobile context-sensitive learning concept called the Amazing NFC. In the field trial a total of 228 students between the ages of 14 and 15 experimented with the Amazing NFC urban adventure in the spring of 2008. The Amazing NFC concept is an Amazing Race -style survival game for teenagers providing learning skills and knowledge essential to everyday life and familiarizing them with their home town. An objective was to trial the developed learning concept for the target group by utilizing Near Field Communication (NFC) technology. User experiences and added value evoked by the service were investigated by means of a variety of data collection methods. The results of this case study are published in a conference paper (Publication II) that also achieved a Best Paper Award at the CSEDU 2009 conference.

#### **3.1.3 Touch-based access to Mobile Internet for the general public (Publication III)**

During the SmartTouch project an information tag trial was also arranged. In this study, 2,650 NFC tags providing access points to selected Mobile Internet content were distributed in the autumn of 2007 in public places in the city of Oulu, Finland, to be used by anyone passing by. The tags, providing a mixed-reality user interface to access the Mobile Internet, were called "information tags" to depict the specific nature of information access. In the trial a total of 238 users were recruited, primarily to use other NFC-based application concepts in the SmartTouch project rather than the information tags. Information tags provided an add-on service that all the recruited users were able to use during the trial period. All the study participants were adults, the youngest being 22 years old and the oldest 72 years old. The average age was 40. From this trial user experiences related to consuming Mobile Internet content and services were analysed, and these findings were combined with the relevant findings from the Amazing NFC trial, and introduced in a journal article (Publication III). Regarding the Publication III, the user experience analysis and evaluation in this dissertation will only focus on the information tag trial findings.

#### **3.1.4 NFC-supported school attendance supervision for children (Publication IV)**

Later during 2008 a field study was arranged of the attendance supervision system supported by NFC technology in the SmartTouch project. The findings of the study are presented in a journal article (Publication IV). The study was conducted at a local primary school in Oulu, Finland, where two classes with a total of 23 pupils between the ages of 6 and 8 participated in marking their arrival at and departure from the school by touching a reader device or an NFC-enabled mobile phone with a smart contactless card. The aim of the system was to simplify at-

### 3. Overview of the case studies

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tendance monitoring by replacing manual roll-calls. Parents were able to receive real-time information on their child's attendance details. The objectives of the field study were to examine the value the attendance supervision concept brings to the stakeholders, as well as the attitudes of each user group concerning the use of the system. Information about user experience and value created for stakeholders was obtained by using a variety of data collection methods and examining the findings from the viewpoint of three end-user groups (children, parents and teachers).

#### **3.1.5 Touch- and audio-based medication management support for older visually impaired users (Publication V)**

In 2009 within the HMFMe (HearMeFeelMe) project experiences and the possibilities of using modern mobile communication technology in supporting older adults in medication management were explored. A novel Near Field Communication (NFC)-based solution to support medication management is presented in a conference paper (Publication V). The service allows visually impaired older users to manage their daily medications autonomously by providing them with the means to identify medicines and retrieve personal medication information. In order to demonstrate the feasibility of the concept, an early prototype called BlindNFC was implemented. It is an NFC-enabled PDA with a basic functionality of reading the medicine name and dosage information aloud by the user touching the medicine package. The service concept was tested and evaluated with user studies in Finland and Spain, where altogether 39 older people with vision impairments participated in the studies. In Spain, 62% of participants were aged between 60 and 74, whereas in Finland the average age of participants was 71 years. Study participants all had a varying degree and combination of different functional limitations. Several participants also had clearly decreased motor and cognitive skills.

#### **3.1.6 Mobile phones as seismic sensors for university students (Publication VI)**

The author spent a one-year period as a visiting scholar at the University of California at Berkeley between 2010 and 2011. At UC Berkeley the author worked on the iShake project where the objective was to research the validity of modern smart phones to be used as mobile earthquake sensors. The user experience findings of the developed iShake system are presented in a conference paper (Publication VI). The iShake system is an inventive use of smartphones as seismic sensors to measure and deliver the ground motion intensity parameters produced by earthquakes. Shaking table tests and field trial with approximately 30 iShake users were implemented to experiment and evaluate the functionality and scalability of the iShake system. In addition, user experiences were investigated, with 59 iShake users contributing their feedback through a questionnaire. The majority of the 59 iShake respondents were under 35 years old, and most of them were male.

Research included participative planning with a focus group for designing and conceptualizing how to improve iShake for future use.

#### **3.1.7 Wayfinding aid for elderly people with memory disturbances (Publication VII)**

On the VESC (Value Creation in Smart Living Environments for Senior Citizens) project, the author focused on the problem of the reduced ability of elderly people to successfully navigate in unfamiliar (and familiar) environments. In this study the prototype of a wayfinding aid was tested on predefined routes. Nine subjects, aged 59–90 years (with a median age of 84 years) participated in the user study at a rehabilitation unit in Pyhäjärvi, Finland. For evaluating the developed technological wayfinding aid, the “Wizard of Oz” method was used in which technology being refined is simulated to appear as a coherent entity for the user (Veldkamp et al., 2008). The orientation advice was given through three modalities, namely visual, audio and tactile signals. Three two-day test events were conducted; the first one in December 2009, the second in January 2010 and the third in June 2010. The findings from user tests are presented in conference publication (Publication VII). The severity of dementia of the subjects was between mild and severe, Mini-Mental State Examination (MMSE) scores (Folstein et al., 1975) were between 3 and 23 (average 12) and walking conditions ranged “from frail to hobby skier”. The user experience data obtained in this study remained sparse, as interviewing proved to be an unsuccessful method for acquisition of information on users’ subjective perceptions due to their age and severe memory disturbances.

#### **3.1.8 Summary**

Table 1 summarizes case studies contributing to this dissertation and the resulting articles. Each study is described in the corresponding articles in more detail.

### 3. Overview of the case studies

**Table 1.** Summary of the case studies and articles.

Publication	Concept	Place and Time	Duration	Users
(I) Case study of application-based mobile service acceptance and development in Finland	"Mora" mobile intranet application for university students	Raahe, Finland, autumn 2007	2 months	67
(II) Learning through NFC-enabled urban adventure – user experience findings	NFC-enabled "Amazing NFC" mobile learning service for teenagers	Oulu, Finland, spring 2008	Amazing NFC lesson (~3 hrs)	228
(III) Touch-based access to Mobile Internet – user experience findings	Touch-based access to mobile internet for general public	Oulu, Finland, autumn 2007	~6–8 weeks	238
(IV) User experiences with mobile supervision of school attendance	NFC-supported school attendance supervision for children	Oulu, Finland, autumn 2008	14 weeks	23
(V) Touch- and audio-based medication management service concept for visually impaired older people	Touch- and audio-based medication management support "BlindNFC" for visually impaired older people	Oulu, Finland, and Spain, autumn 2009	~1–2 hours	39
(VI) iShake: mobile phones as seismic sensors – user study findings	Mobile phones as seismic sensors for university students	California, USA, beginning of 2011	2 days	59
(VII) Wayfinding aid for the elderly with memory disturbances	"Wayfinding" aid for older people characterized by memory disturbances	Pyhäjärvi, Finland, Dec. 2009, Jan. and June 2010	Three separate test events	9

### 3.2 Data collection methods in case studies

Benbasat et al. (1987) state three main reasons why case study research is viable in information system research strategy. First, the researcher can study information systems in a natural setting, learn about the state of the art, and generate theories from practice. Second, the case method allows the researcher to answer "how" and "why" questions, that is, to understand the nature and complexity of the processes taking place. Third, a case approach is an appropriate way to research an area in which few previous studies have been carried out. Thus, in doing a case study, the goal is to expand and generalize theories and not to enumerate frequencies (Yin, 2003). Case studies are acknowledged as being generalizable to theoretical propositions, not to populations (Yin, 2003).

The case study research approach was discussed in more detail in Section 1.3. In this section there is an attempt to pursue the following principles of user experience evaluation in the case studies:

- Evaluating user experience in a situation as close to actual realistic usage situation as possible to avoid the need for users to imagine or predict their experiences in a hypothetical situation,
- getting the users to employ the service in long-term and personal use in order to go beyond the novelty effect and achieve as reliable user experiences as possible,

- collecting information on and descriptions of the experience before and after and also at the time it happens in order to avoid the need to rely on the memories of the user in describing the experience,
- combining different data collection methods that are complementary, and
- using the direct subjective information given by the person having the experience.

Thus, in case studies included in this dissertation a variety of data collection methods have been utilized that are highly complementary (Yin, 2003), and the methods for capturing an objective account of subjective user experience in various contexts were tailored separately to each individual case study. The appropriate methods were selected based on prevailing study conditions and given research intentions. Since describing and understanding user experience is complex, as user experience is always multifaceted and difficult to verbalize and describe, the combining of different data collection methods increases the reliability and validity of the results (Isomursu et al., 2007). Furthermore, cumulative (Roto et al., 2011) user experience data was collected and examined over longer time spans, for example before usage to first encounter with the service, across episodes of usage to reflection of usage that frames anticipation of future periods.

Following Roto's (2006) classification, this thesis studies user experiences where users have really used and experimented with the evaluated mobile services, and user experience is understood as a subjective experience unique to the individual person in question. Thus, in mobile service case studies real user experiences were achieved based on a personal use of the evaluated service. In the case studies, the primary sources of data were the direct end-users, i.e. the people who engage directly and actively with the system and subjectively interpret the experience. The study adopted a phenomenological approach for understanding user experience, i.e. user experience is understood as a subjective, first-person phenomenon (Greenfield, 2000) that cannot be experienced directly by another person. In case studies, subjective descriptions of user experiences were collected mainly through questionnaires and semi-structured interviews. These descriptions were complemented with observations which provided an external interpretation of experiences. Observation included in some cases both direct observation of behaviour triggered by the user experience, and observation of the use and usage patterns through automatically compiled log data.

In this dissertation, finding the appropriate data collection methods for different user groups and service usage contexts raised an important question with every use case. Each case study set its new, unique challenges for how to capture experiences and also how to analyse and interpret the captured data. User experience evaluation methods used throughout the case studies can be divided into three phases: (1) before, (2) during, and (3) after use evaluation. Each evaluation phase had its specific goals, evaluation focus, and set its own requirements for the evaluation methods. In what follows, the data collection methods utilized in different case studies are overviewed in more detail.

#### 3.2.1 Before use

In the Amazing NFC case study (Publication II), before the start of the study two teachers were interviewed in order to investigate their expectations, doubts, thoughts and attitudes towards the evaluated technology and learning concept. Prior to the Amazing NFC lesson how the students learned to use NFC technology was also observed, and what kind of spontaneous reactions and discussion took place on the introduction of the concept. A mobile questionnaire was used to capture information about their expectations and attitudes towards the mobile learning experience before the lesson. In the medication management user study (Publication V) the older users were interviewed prior to the usability tests with the BlindNFC prototype in order to gain an understanding of users' backgrounds, previous experience with technology, needs for daily support and practices and needs related to medication. Within case Mora (Publication I) and the iShake user study (Publication VI) the potential users were encountered face-to-face when promoting the application. In the same context, the users' initial expectations and thoughts regarding the iShake service were preliminarily explored. Within the user study of the wayfinding aid (Publication VII) the participating elderly users were observed when being introduced and equipped with the wayfinding aid prototype.

#### 3.2.2 During use

The user experiences during the Amazing NFC lesson (Publication II) were collected through video recordings and the automatic creation of log data about how the pairs of students progressed on the urban adventure track. In the school attendance supervision case study (Publication IV) classroom observations were made to collect information e.g. about how well the pupils had learned to use NFC technology, and what kind of routines they had established after using the system for some time. All the children participating in the trial as well as their teachers were interviewed on the same occasion in order to investigate their thoughts and experiences about the technology and service concept under evaluation. In the information tag trial (Publication III) the first data source was the automatically generated logs about use. The logs provided information about who used the tags, which tags were used, and when the tags were used. Information tag users (theatre pilot users and five restaurant pilot users) were also observed in actual use situations. In the medication management study (Publication V) the participants were observed when they were carrying out usability tests with the BlindNFC prototype. During the iShake user study (Publication VI) a real-time mobile questionnaire was utilized to record various dimensions of users' subjective experience evoked by the use of the iShake application. During the wayfinding test events (Publication VII) the subjects were observed by videotaping, audio recording, recording with walker-mounted cameras, and taking notes on-site in order to capture the user experiences at the time they occur, as the older people being observed are in natural settings.



#### 3.2.3 After use

The feedback from the Java-based mobile application case study (Publication I) was collected via paper and web questionnaires after two months' field study. In the Amazing NFC trial (Publication II) the students filled out a second mobile questionnaire collecting data about the user experience immediately after use. The students and teachers were also requested to fill out a web questionnaire within two weeks of the trial. In the school attendance supervision study (Publication IV) some of the students' parents were interviewed by phone, and feedback was collected from the rest of the parents through paper questionnaires. In order to gain the real hands-on experiences by the parents, interviews were conducted and questionnaires were delivered after six weeks from the beginning of the case study when the parents had had time to experiment for a longer period of time with the attendance supervision system. In the information tag case (Publication III) data about the user's subjective experience was collected immediately after the study with questionnaires. In addition, some additional interviews were conducted for a set of trial users. After the wayfinding test events (Publication VII) the participants were interviewed. In the Amazing NFC case study (Publication II) a workshop was arranged with twelve students to explore their experiences with the Amazing NFC. The workshop included participatory features, i.e. the students participated in designing how to iterate the concept for future use. Within the iShake study (Publication VI) brainstorming session was arranged with a small focus group for planning and visioning together how to improve iShake for future use.

#### 3.2.4 Summary

A summary of the number of users in case studies, the data collection methods, and valid users for each method are presented in Table 2.

### 3. Overview of the case studies

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**Table 2.** Number of users and data collection methods in case studies.

Case	Total # of users	User type	Data collection method	Total # of users for the method	Time of data collection
Publication I	67	University students	Observation during promotion events	50–100	Before use
			Questionnaire (paper and web)	52	After use
Publication II	228	Secondary school students	Teachers' interviews	2	Before use
			Mobile questionnaire	133	Before use
			Observation of learning	30	Before use
			Video recording	50	During use
			Videos shot by students	4	During use
			Log data	228	During use
			Mobile questionnaire	133	After use
			Web questionnaire	81	After use
			Web questionnaire for teachers	8	After use
			Workshop	12	After use
			Publication III	238	General public
Observation	~146	During use			
Feedback forms	26	During use			
Videotaping of usability testing	5	During use			
Questionnaire	188	After use			
Interviews	11	After use			

### 3. Overview of the case studies

Case	Total # of users	User type	Data collection method	Total # of users for the method	Time of data collection
Publication IV	23	Primary school pupils	First classroom observation and interviews with first-grade class	16 pupils 1 teacher	During use
			Second classroom observation and interviews	16 pupils 1 teacher	During use
			Classroom observation and interviews with special-needs class	7 pupils 1 teacher 1 teaching assistant	During use
			Phone interviews with parents of special-needs class	6 parents	After use
			Paper questionnaires for participating first-graders' parents	14 parents	After use
			Paper questionnaires for non-participating first-graders' parents	3 parents	After use
Publication V	39	Vision impaired older people	Interviews	39	Before use
			Observation	34	During use
			Interviews	34	During use
Publication VI	59	University students	Informal chats during promotion activities	~20	Before use
			Pilot test	2	Before use
			Mobile questionnaire	59	During/ after use
			Brainstorming	3	After use
Publication VII	9	Memory impaired older people	Observation	9	Before use
			Videotaping	9	During use
			Audio recording	9	During use
			Observation	9	During use
			Interviews	9	After use

## 4. Results

### 4.1 RQ1: What is value in experience and what are the relevant value dimensions?

The subsequent sections give an overview of the key terminology used in this thesis. These concepts have been defined during this thesis process. What follows also introduces the conceptual model of value in experience (ViE) and presents the initial value framework synthesized from literature.

#### 4.1.1 Description of the key concepts

In this dissertation the term **mobile service** refers to services that can be used independently of temporal and spatial constraints, and that are accessed through a mobile device (cf. Heinonen and Pura, 2006), i.e. the user interacts with a mobile service through a mobile device.

Here the term **user experience** refers to the subjective, dynamic and comprehensive phenomenon where the experience is formed in user's interaction with the service in prevailing contexts and the surrounding environment (Arhippainen, 2009; Forlizzi and Ford, 2000). Users add their own unique values (see below), personality, limitations, knowledge, and skills to the user experience ingredients and by giving their own personal and individual contribution to the experience users make it authentic.

**User values (UV)** are understood here as internal and user-specific ground rules for life that user carries always with them (e.g. Schwartz, 1992). Values are appreciated and aspired to as ends in themselves (e.g. Cockton, 2009; Lee et al., 2011). They are relatively general and enduring tendencies and valuations of objects, but they also affect other fields in life such as (service) consumption (Schwartz, 1992). Values form the user's own, personal value hierarchy (Schwartz, 1992) that guides the user when they form specific expectations, needs and personal goals for the service usage, and they reflect what user desires to achieve in consequence of the user experience (Kujala and Väänänen-Vainio-Mattila, 2009). User values then guide the user when they interpret the user experience, i.e. the user evaluates the user experience on the grounds of their own value hierarchy (cf. Woodruff, 1997; Lages and Fernandes, 2005; Allen and Ng,

1999). By using the service the user reflects their own personal value priorities, i.e. aspire to achieve values that are important to them (cf. Kahle, 1988).

**Service values (SV)** refer to a more utilitarian type of values (e.g. Holbrook, 1994; Lee et al., 2011). The user value formation process starts from utilitarian values, and they refer to user-perceived functional and cognitive value of the service, which often relate to a service's meaningful and measurable qualities, usability and performance (cf. Woodruff, 1997; Cockton, 2009). They are often definable more objectively than the internal user values. They are instrumental values; they act as a means for end to achieve something else, i.e. to fulfil the personal values (cf. Woodruff and Gardial, 1996; Cockton, 2009). Utilitarian values refer to qualities related to a service that the user evaluates, and these service qualities act as practical actions for achieving the higher level goals the user has, and they occur especially during the interaction process between the user and the service (cf. Babin et al., 1994; Boztepe, 2007). In consequence, the user develops preferences and desires for certain service qualities based on the results consequent from them (Kujala and Väänänen-Vainio-Mattila, 2009).

The evidence from other researchers suggests that dimensions of value can be identified. **Value dimension** refers to different types of values that together constitute individual's personal value hierarchy (e.g. Woodruff, 1997; Sweeney and Soutar, 2001). The user has personal preferences and desires for specific value dimensions, i.e. value priorities, in a given context with a specific service. Different **value parameters** determine a particular value dimension, i.e. the value parameter is a lower level construct contributing to a higher level value dimension.

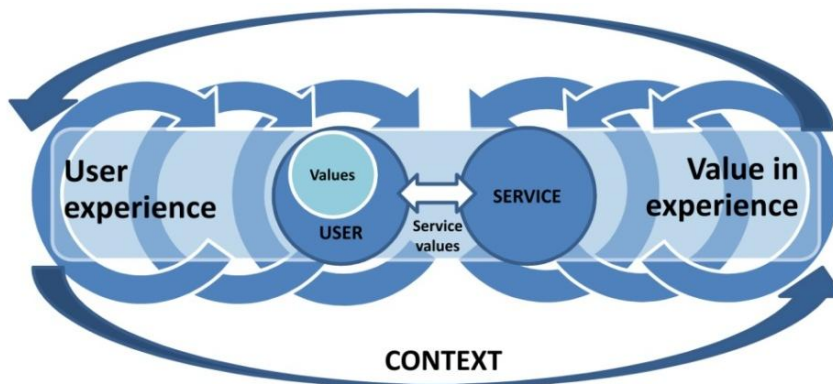
**Designer value** is here understood as value that the end-users are expected or assumed to gain by adopting the new service, i.e. the intended value (cf. Cockton, 2005). This is the viewpoint of the developers during the planning, design and implementation phases, and of the researchers when planning for the data collection and analysis in case studies. Naturally, designers' and other stakeholders' personal internal values also have an effect on the design choices, and designers' own subjective values are reflected through the design.

#### 4.1.2 Conceptual model of value in experience

By relying on the existing theory and analysis of user experience and value, a conceptual model (Figure 6) was created that illustrates the value in experience (ViE), and highlights the importance of the user's internal values, as well as the way the value in experience is interrelated to user experience. The main contribution here is the understanding gained of how the user experience and value are tied together. This perspective is not expected to provide an exclusive alternative to other definitions. This view of value in experience, where value pertains to experience, reconciles the different approaches reviewed so far. The objective was not quantification but instead conceptualization of value in experience as a phenomenon.

To reflect the close interrelationship between user experience and value, the term "**value in experience (ViE)**" is used here for the user perception of value.

Value in experience refers to **“the user’s iterative (conscious and subconscious) interpretation and evaluation of user experience, according to how qualities and consequences of experience assist or hinder the user in fulfilling their personal values in the prevailing contexts”**. Thus, value is perceived individually and personally. The user’s personal values, prevailing situational usage context, and the service itself all influence the value in experience. The term “value in experience” addresses the full scope of user experience, that the user evaluates and interprets value in an iterative way during all stages of the user experience, also including anticipated future and past remembered experience. The experiential view of value by Frow and Payne (2007) is adopted (with a broader sense and interpretation), according to whom value resides not in the object of consumption itself, but in the experience of consumption. Thus, users do not passively accept the value propositions presented by the service provider, but they uniquely experience the value within their own personal contexts. As value in experience is closely tied to experience, it therefore carries the properties of user experience (Boztepe, 2007). Thus, it is important to gain a knowledge on the aspects of user experience and how to understand and enhance it. The key elements of the concept are described below.



**Figure 6.** Value in experience (VIE).

In summary, the following aspects are important in characterizing value in experience (these key elements are illustrated with examples that emerged from the case study analysis covered in Section 4.2):

- **Closely tied with UX** – It is often difficult to talk about the user experience or user-perceived value separately since, in practice, they seem to be closely tied together. It is as difficult to argue unambiguously about the source of value. As Frow and Payne (2007) put it, value resides not in the object, but rather in the experience itself. Thus, what people actually desire are not services, but the experiences services provide, the main stimulus for the term value in experience. Thus, a view is taken here in which the value and user

experience are closely tied and dynamically interrelated (consistent with Helkkula and Kelleher, 2010).

*EXAMPLE: For example, in Publication IV the value priorities of the children became evident from their subjective descriptions of the user experience. The value that became clearly visible when children described their experience with the service was that the children seemed to understand and embrace how the system created value for parents and school.*

- **Guided by user values** – User values guide the user when they interpret the user experience, i.e. the user evaluates user experience on the grounds of their own value hierarchy. Values form user's own personal value hierarchy that guides the user when they form specific expectations, needs and personal goals for the service experience, and they reflect what the user desires to achieve in consequence of the experience (cf. Woodruff, 1997; Kujala and Väänänen-Vainio-Mattila, 2009). Thus, value in experience is individually determined and cannot be pre-defined by the service provider.

*EXAMPLE: Publication V illustrates how designer values do not always correspond with users' value in experience, as it is difficult, if not impossible, to predict and understand all the details of how users will experience value. Older users had a fear of the novel service adoption possibly reducing their social contacts, and thus affecting the socialization value dimension. The importance of this value was not anticipated during the design phase. Contrary to the intended designer value, the users' desire for independence did not stand out as an important value for this user group.*

- **Iterative** – Value in experience is not constructed in a linear chain of sense making, instead, users experience value in dynamic processes of experiencing and interpreting user experience in an ongoing, iterative way based on understanding and sense making between previous, current and future experiences.

*EXAMPLE: In Publication II users made sense of the current value in experience based on an anticipated value in experience. Students had hoped to see physical and problem-solving tasks and activities at the control points, but they felt that the tasks and the information provided at control points were not interesting and challenging enough to make the urban adventure truly motivating and thrilling. Also, students felt that if they could have competed against each other on the adventure track it would have created more motivation and excitement.*

- **Evolves over time** – Value in experience emphasizes user's perception of value over the entire course of user experience (cf. Roto et al., 2011). Thus, the user may derive value at any time during the user experience (Woodruff, 1997), and value in experience may vary over time as the level of experience users have with a service alters (cf. Parasuraman, 1997).

EXAMPLE: *In Publication IV it became evident how children make sense of value in experience and how it evolves over the entire course of their user experience. [before trial:] Children had been extremely excited when they had heard they could participate in the experiment. [participating in design:] Children clearly valued that they were able to make their own contribution by participating in the design of the visual outlook of the card. [start of the trial:] Children were very proud and excited that they were given contactless smart cards of their own. For many children the possibility to participate in the trial appeared to be a boost to their self-esteem. [during trial:] Children quickly learned to use touch-based interaction and the login process was soon integrated into their everyday routines at school. Operating the technological service also seemed to provide the children with a way to demonstrate competence. What is more, as not every class in their school had the system in use, this offered the children a means for status differentiation and gave social recognition among their peers. [after some time:] Children noticed some good things the attendance supervision system had brought to their own lives, in addition to providing value for their parents and teachers.*

- **Properties of UX reflected in ViE** – The total user experience of a service cannot be limited to single usage episode, as it is a continuum taking shape as a result of a series of smaller user experience units, i.e. the focus here is on cumulative user experience (consistent with the emphasis by Roto et al., 2011). User experience is a dynamic and continuous phenomenon that evolves and changes over time. Previous experiences influence current and future ones, the phases of experiencing overlap and there is no fixed sequence from anticipating to reflecting.

EXAMPLE: *In Publication III the entire course of user experience is well addressed, i.e. that overall user experience consists of overlapping use cases that together contribute to cumulative user experience by modifying it over time. Users felt that tags offered an easy and convenient access to Mobile Internet content, and touching a tag to access Internet content was experienced as pleasant. The users expected the content to be highly relevant and integrable with their current contexts and needs. However, users discovered that some content available through the tags did not make full use of the location or was not updated throughout the trial. Users also discovered tags that did not respond to touch. Also, as some of the content that was made accessible by the tags was video with sound, users were embarrassed or startled by the loudness of the sudden sound. Users also felt that with some tags the download times were too long. Thus, users expressed their disappointment at the content provided through the tags.*

- **Conscious and subconscious** – Users are constantly, both consciously and subconsciously, evaluating and modifying their value in experience.

EXAMPLE: *Publication IV reveals how the users' sense making process moves backwards and forward as they interpret their value in experience sub-*



*consciously and consciously in complex and on-going processes. Parents were expecting the service to reduce unnecessary doubt by offering an access to child's attendance details and increase the security of their children, leading to peace of mind. But after using the system for some while parents reported that following child's attendance details was not very practically realized in the system and did not integrate well with their daily routines. However, the system was found to be valuable in the sense that it would notify the parents immediately in situations where the child for some reason does not arrive at school or in day care. But parents realized that the system could cause extra concern and worry instead of a feeling of safety, as the child might, for example, lose the card or forget to log into and out of school. Parents also started questioning what good the system would bring to them in a possible future situation where they would get the information that something has happened to their child, if something could have been done to prevent that from happening?*

- **Context-dependent** – Value in experience may vary across evaluation contexts (cf. Åkesson, 2007). Changing external contextual factors may cause users to revise, revisit, and reinterpret their user experiences, and thus modify value in experience. Value in experience is based on how the user interprets and evaluates user experience in a certain context. The mobile user changes their contexts several times a day, and even during every use episode. Context refers not only to the physical surroundings but also to the social and temporal context, as well as the task context that is related to the current motivation for interaction (Roto, 2006). The context sometimes also affects the service in question in the case of context-sensitive systems.

*EXAMPLE: Publication III illustrates how users' value in experience is largely dependent on and determined by the specific usage situation. It became evident that the nature of Mobile Internet content was felt to be best suited to personal use, as users felt that consuming it in more public places reduced the interaction between people.*

As has been stated before, the following main **building blocks** of user experience (e.g. Forlizzi and Ford, 2000; Hassenzahl and Tractinsky, 2006) naturally also affect value in experience: **User**, **Context**, and **Service**. In summary, the user's interaction with the service takes place in a certain context, where also the characteristics of the user as well as features of the service affect the interaction and user experience formation.

Helkkula et al. (2012) have conceptualized "value in the experience" as "individual service customers' lived experiences of value that extend beyond the current context of service use to include also past and future experiences and service customers' broader life world contexts". In defining "value in the experience" they present the following VALEX (value in the experience) propositions: 1) Value in the experience is individually intra-subjective and socially intersubjective; 2) ...can be both lived and imaginary; 3) ...is constructed based on previous, current, and imaginary future experiences and is temporal in nature; and 4) ...emerges from

individually determined social contexts. The author has the same notion of the first three propositions, and they also emerged in this research work through the cross-case analysis and synthesis in RQ2. However, considering the last proposition, the author questions the “focus on subjective experience in a social context” and the positioning of “value in the experience” in a social context, as this proposition seems to ignore other aspects of context, such as task, physical, and temporal contexts (cf. Roto, 2006). Furthermore, Helkkula et al. (2012) do not address the role of user values in the user experience – value perception process.

### 4.1.3 Initial value framework

Several existing value frameworks identified from the literature presenting numerous different classifications and categories of types of value were reviewed in Section 2.2.3. However, many of the existing value constructs appeared to be too narrow, and complementing value dimensions was seen to increase the constructs’ applicability and usefulness across different service contexts. For example, limiting the understanding to the narrow point of view of service attributes will lead to one missing some important shades of value. What users really want will not be expressed primarily as thresholds for service attributes (Cockton, 2008a). Here, the belief was that users prioritize value dimensions other than those related to service attributes, such as consequences of service experience (cf. Woodruff and Gardial, 1996).

Work by Sheth et al. (1991b) was seen to best provide a foundation for extending the existing value dimensions, as their theory has been validated through an extensive investigation of the variety of fields in which the concept of value has been evaluated. In addition, Schwartz’s (1992) widely used model of human values was utilized as a prime basis for the construction of a value framework. Both the contents and structure of values in Schwartz’s model have been validated in over 70 countries. The construction of the value framework is also consistent with Woodruff’s (1997) and Cockton’s (2009) positive means-ends chains that connect from concrete product attributes with worthwhile outcomes via qualities and a range of usage consequences. The design means comprise design elements (materials, features, and qualities) and user experiences. Together, these means should combine to produce worthwhile outcomes. User experiences are treated as means to an end of worthwhile outcomes, but the quality of the UX will impact on the worth achieved by a design.

Thus, the initial value framework (see Table 3 for value dimensions and their descriptions) developed and utilized in this dissertation was based on concepts used previously in the literature. The framework was used as a foundation for analysing the value in experience in individual case studies. In the framework, the value dimensions were divided into two abstract categories leaning to a classification by e.g. Lee et al. (2011), according to whom perceived product attributes (PPA) are specific to the individual and typically contingent on the product itself (i.e. product specific), and consumer values (CV) are internal and typically gener-

alizable across consumer behaviour situations and the need for emotional end-states. Consequently here the value dimensions are divided into two categories, those of *service value (SV)*, and *user value (UV)*. Here, the *user values (UV)* refer to the user's subjective intrinsic values. They are self-purposeful, i.e. they are valued as they are. *Service values (SV)* are instrumental values that refer to the values the user derives through service qualities and performance. They act as a means to the end of achieving something else, i.e. fulfilling the personal values (cf. Woodruff and Gardial, 1996).

**Table 3.** Initial value framework (synthesized from literature).

Category	Value dimension		Description
<b>SERVICE VALUES (SV)</b>	<b>Functional value</b> (Sheth et al., 1991a; Holbrook, 1994; Clarke, 2001; Kim et al., 2007)	<b>Convenience</b> (Boztepe, 2007)	Ease of use, availability, accessibility, appropriateness, monetary value or superiority compared with the alternatives
		<b>Quality and performance</b> (Sweeney and Soutar, 2001; Boztepe, 2007)	Efficiency, performance, saving of time and money, durability, reliability
	<b>Personalization value</b> (Clarke, 2001)		Personal relevance through individual characteristics, requirements, and preferences
	<b>Localization value</b> (Clarke, 2001)		Relevance depending on user's geographical position and usage situation
<b>USER VALUES (UV)</b>	<b>Social value</b> (Sheth et al., 1991a; Schwartz, 1992; Sweeney and Soutar, 2001; Holbrook, 2006)		Social approval, social recognition, status, power, achievement, enhancement of self-image
	<b>Hedonic value</b> (Sheth et al., 1991a; Schwartz, 1992; Sweeney and Soutar, 2001; Holbrook, 2006)		Aroused feelings and affective states, fun, play, enjoyment, pleasure
	<b>Stimulation and epistemic value</b> (Sheth et al., 1991a; Schwartz, 1992)		Experience of curiosity, novelty or gained knowledge, a need for arousal and variety
	<b>Growth and self-actualization value</b> (Schwartz, 1992; Kujala and Väänänen-Vainio-Mattila, 2009)		Creation, independent thought and action, freedom, choosing own goals, self-respect
	<b>Socialization value</b> (Åkesson, 2007)		Desire to share experiences, ideas and opinions, support for community building, sense of belonging, social interaction
	<b>Traditional value</b> (Schwartz, 1992; Kujala and Väänänen-Vainio-Mattila, 2009)		Respect, commitment, acceptance of the cultural customs and ideas
	<b>Safety value</b> (Schwartz, 1992; Kujala and Väänänen-Vainio-Mattila, 2009)		Security, social order, healthy, comfort, freedom from fear
	<b>Benevolence value</b> (Schwartz, 1992)		Honesty, helpfulness, responsibility, loyalty

The value dimensions listed in the table above were assumed to contribute together with user-specific combinations and emphasis to value in experience. Other researchers' work was used to support and clarify the description of value dimensions. For different users the dimensions of value may be differentially weighted, and value dimensions make also varying contributions depending on different

service usage situations. In later sections of this thesis, these constructs are utilized in order to capture value in experience in individual mobile service case studies. Based on interpretive value in experience analysis of empirical UX research, value dimensions are modified and further complemented to better depict the concept of value in experience within a mobile service usage context.

### 4.1.4 Summary

Value in experience is characterized and illustrated here with key propositions of the construct so as to conceptually illuminate the close interrelationship of value and user experience, and an initial value framework is presented, consisting of a set of key value dimensions. Based on a literature review, these value dimensions were synthesized and they are further developed in the second research question.

## 4.2 RQ2: Based on case studies of novel mobile services, how is value in experience manifested?

In the following sub-sections the user experience data from seven individual mobile service case studies is examined and analysed from a value point of view, concentrating more specifically on analysing value in experience of a specific user group in the case study in question. In addition, designer value from case studies is identified and analysed. The starting point for this work was the belief that the original research material collected on user experience and analysed in the case studies provides insights with regard to the question of value in experience. The assumption was that the value priorities of the users would become evident from their subjective descriptions of the user experience. By utilizing the initial value framework (Table 3) developed and introduced in RQ1, value parameters from individual mobile service case studies are interpreted and categorized. In this research work, the purpose is to provide an understanding and present a rich description of value dimensions that are relevant for specific user groups and service domains in given usage contexts. The new analysis results were supported by examining the original field work data gained from the case studies. Unexpected observations and recurring themes within the user groups could then be discovered and articulated.

This analysis is conducted according to the interpretation of the author, and it reveals the value in experience perceived by the study participants themselves. The analysis concentrates only on values that were relevant for the users in the context of the given service. The value formation in the case studies is analysed in more detail from the following two viewpoints:

- 1) The value that the end-users were *expected* or assumed to gain by adopting the new service. This is the viewpoint of the developers during the planning, design and implementation phases, and of the researchers when planning for the data collection and analysis, i.e. the *designer value*.

Participatory design methods were used during the service concept design, where the service and technology providers, researchers, representatives of users, and secondary users planned and designed the service concept in close cooperation.

- 2) The value the direct, primary end-users *perceived* by using the service, i.e. the *value in experience*. In the value analysis the focus is restricted to the first-hand users of the system. Also, the value is explored from the viewpoint only of subjectively perceived value, i.e. the value that could be identified through the subjective experiences of the users.

The section that follows presents the process used to establish the more detailed description for the value dimensions presented in initial value framework (Table 3). Value dimensions are further elaborated with value parameters used previously in the literature. The parameters were modified to depict value in the given service contexts. The analysis concentrated on value parameters that were relevant and important for the users in the context of the trialled service, and other values are excluded from the discussion. This work is done by relying on the analysed user experience data and users' own comments, and author's own evaluations based on the deep personal understanding of research data. The understanding and analysis of designer values originates from the co-creation process (Mager, 2009) that involved discussions, workshops and service concept evaluations between technology and service providers, researchers, and representatives of end-users.

The variety of value parameters identified in individual case studies (expressed in square brackets [...]) are, furthermore, organized according to previously identified higher-level value dimensions (see Table 3). The value parameters are categorized to make values more concrete and to make it easier to trace their relations back to the higher-level value dimensions. Thus, each short examination and analysis of case study findings is followed by a case-specific table summarizing the values identified in the case study. What is more, value parameters that 1) came true for the users are marked with (+) on the table, and respectively value parameters that 2) did not come true are marked with (-).

Since from the literature it was not possible to derive previously validated items existing for all the relevant value parameters that emerged from the data analysis, new parameters were also generated from the data. The wording of the value parameters was influenced by other items used to measure similar concepts. The suggested novel parameters are, furthermore, linked with the appropriate value dimensions.

#### 4.2.1 Case: Mora (Publication I)

Here the value formation in the case Mora is examined from two different angles, namely from the point of view of designer value, and users' value in experience.

## 4. Results

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### 4.2.1.1 Designer value

The guiding design and research goals used during the development phase of the Mora service are presented in this section. The major source of information for most of the data and communication processed in the Mora service was the existing information system, i.e. the campus web intranet. The campus students and personnel were using the intranet for accessing up-to-date news, events and important announcements in their study community, as well as the study group's weekly schedule. The Mora mobile service was intended as an extension of this campus web intranet.

Thus, case Mora focused on the additional value of mobility, which means the possibility to access, produce and send information, products and services at any time and from anywhere, regardless of the user's location or the time of day [*availability; appropriateness*]. The main idea behind the service concept was to offer ease and flexibility of accessing important information about the study community; the mobile service would free the users from traditional time and place constraints even more efficiently than internet services [*flexibility; superiority*]. In summary, the design goals of the Mora service were very much focused on utility. The supplementary strategy used for promoting the service to the potential users was to make the test-users feel that they were privileged to have a mobile service like Mora exclusively on their campus, and to have the opportunity to participate in the service testing and development [*empowerment; achievement; participation*].

### 4.2.1.2 Value in experience

This section presents the analysis of user experience data from the point of view of value in the experience of campus community members using the Mora service.

In general, the users had a positive attitude towards mobile services. Users valued highly the possibility of using the mobile phone as a channel to access the content of the campus intranet [*technology suitability; availability; appropriateness*]. They considered the service easy to use [*ease of use*], and also stated that downloading and installing the Mora application was easy [*ease of adoption*]. They found it important that they could control the use of Mora by deciding when and where they use the service [*flexibility; empowerment*]. Adapting provided information according to user's contextual information was seen as a desirable feature [*context-sensitivity*]. In addition, users reported that they would like to be able to filter the content of Mora related to their personal interests and needs [*adaptation*]. However, these properties were not featured in the service currently under evaluation. In users' opinions, the Mora service provided topical and useful information [*up-to-dateness; relevance*]. But as a whole, the service did not provide much novel value compared to existing web-based intranet [*novelty; superiority*]. Furthermore, special circumstances dependent on trial settings, i.e. the expected short continuation of the trial, might have had an effect on how users' perceived the service. Users reported that they were also willing to use the service in the future even though the current use of the service did not happen on a regular basis.

## 4.2.1.3 Summary

Table 4 lists and groups designer values and value in experience identified in case Mora according to value dimensions.

**Table 4.** Values identified in case Mora (values on white depict designer value; values on black value in experience; and values on grey were found in both).

user values (UV)			
Growth and self-actualization	Stimulation and epistemic	Socialization	Traditional
+ <input type="checkbox"/> empowerment	<input type="checkbox"/> - novelty	<input type="checkbox"/> participation	
Safety	Social	Hedonic	Benevolence
	<input type="checkbox"/> achievement		
service values (SV)			
Functional (Convenience)	Functional (Quality and performance)	Personalization	Localization
+ <input type="checkbox"/> availability		<input type="checkbox"/> - adaptation	<input type="checkbox"/> - context-sensitiveness
+ <input type="checkbox"/> appropriateness		<input type="checkbox"/> - relevance	+ <input type="checkbox"/> up-to-dateness
<input type="checkbox"/> - superiority			
+ <input type="checkbox"/> flexibility			
+ <input type="checkbox"/> ease of adoption			
+ <input type="checkbox"/> ease of use			
+ <input type="checkbox"/> technology suitability			

**Appendix A** describes in more detail the positive and negative outcomes of the value parameters that were identified in the case Mora.

It can be concluded that the designer values set for the Mora service were not fulfilled to the extent that was expected. The utility value, i.e. functional value dimension, was realized through providing the users with useful and topical information on the service and offering them flexibility in the use of the service. In terms of added value of mobility, the users valued highly the new possibility of accessing the intranet content through a mobile device, but however, this new concept did not provide enough novelty value in itself. Thus, the stimulation and epistemic value dimension were not realized within Mora. In addition, the expected value dimensions of social and socialization were not identified to clearly contribute to value in experience. Furthermore, localization and personalization values were not utilized to the extent users would have wished for, and therefore, the

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users were not provided with an additional advantage and superiority over the web intranet solution. In the end, the users perceived Mora to be only a mobile substitute for an existing solution.

### 4.2.2 Case: Amazing NFC (Publication II)

In the following the value formation in the case Amazing NFC is examined from the points of view of designer value, and users' value in experience.

#### 4.2.2.1 Designer value

Traditional classroom learning awards credits based on student performance, and typically takes place in an identifiable classroom space. Here, the guiding design and research goal was to create a new learning approach that would attract young people to learning and maintain their interest, and would also help remove some of the formality associated with the traditional learning experience [*enjoyment; superiority*]. The objective was to provide a novel educational service that would focus on situated learning in real-life contexts, outside a traditional classroom [*context-sensitiveness; novelty*]. The idea was to create an intrinsically motivating learning experience on a mobile phone – which many young people are comfortable using and enthusiastic about [*appropriateness*]. In the learning concept it was decided to utilize NFC technology that suits the requirements for physical interactions very well [*technology suitability*]. NFC was also expected to be an intuitive, easy-to-learn and use interaction technique for the target user group in question [*ease of adoption; ease of use*].

The concept was called “Amazing NFC” after the well-known TV series called “Amazing Race” [*play*]. The educational goals of the Amazing NFC lesson were to provide the students with knowledge related to landmarks, public buildings and offices in their hometown, and practical skills related to dealing with public authorities in mundane everyday tasks [*learning*]. Mobile technology was also used to encourage both independent and collaborative learning experiences [*social interaction; independence*] and to help raise learners' independence and self-esteem [*self-esteem*].

#### 4.2.2.2 Value in experience

As there were two end-user groups, value perception in the case of Amazing NFC is consequently examined from these two viewpoints. In what follows the value types that were analysed to be the most important and relevant for the students and their teachers are discussed in more detail.

The learning experience was social, as **students** were instructed to work in pairs, which was also preferred by nearly everyone [*social interaction*]. Students valued that they could go from one control point to another on their own and at their own pace [*independence; empowerment*]. However, students strongly criticized the Mobile Internet content provided: “*I would like to have more interesting*



*content and more difficult questions at the control points!*" [challenge]. A majority of students reported that the tasks and the information provided at control points were not interesting and challenging enough to make the urban adventure truly motivating and thrilling [enjoyment]. Nor did students think that they had learned lot of useful information during the lesson [learning]. They had hoped to see more physical and problem-solving tasks and activities at the control points [variety]. During the lesson they also called and sent text-messages to their classmates to find out how they were doing and how many control points they still had to go [social comparison]. Students also felt that, if they could have competed against each other on the adventure track, it would have induced more motivation and excitement [play; social recognition].

Students thought that it was easy to discover the tags located at the NFC control points, and the navigation from one control point to another was considered easy as well [discoverability]. However, searching for and finding the tag for access was experienced as part of the excitement of the adventure: "Tags should be somehow hidden so it would be more interesting to search for them." [challenge; enjoyment; play]. Clearly the most interesting control point was the visit to the zoological museum, and the average time used for the visit was the longest during the lesson. At the control point located inside the zoological museum, content and related questions integrated seamlessly with the physical activities required and the context of use, as students were able to interact and experience the space and environment they visited [integrated usage experience; context-sensitiveness]. However, as the students were cycling along the adventure track, the rainy, windy and cold weather during some lessons might have affected some students' experiences.

Findings revealed that teenagers adopted the new technology and touch-based interaction quickly, and in their opinion NFC technology suited the learning concept well [ease of adoption; technology suitability]. The use of NFC phone and touching the tags was felt to be effortless and natural, and teenagers enjoyed trying out the new technology [ease of use; appropriateness; novelty]. In addition, they stated their preference for this new learning concept over the traditional learning experience [superiority].

**Teachers** found the trial trustworthy [reliability]; students could not get lost or get into trouble, as the teachers could follow their progress on the track in real time through a web interface, and contact them if needed [security; freedom from fear]. Teachers felt it was good that learning could be taken out of the traditional classroom and 45-minute teaching style [novelty; variety]. Teachers expressed a doubt about NFC technology having the taint of decoration; that in practice NFC would not bring any added value to the learning concept [technology suitability]. They agreed that students had learned and received new information to an expected extent [learning]. They saw the concept as an excellent way to familiarize students with their hometown, and for students to learn life-skills and gain more confidence to visit different public buildings and offices in the city [self-esteem]. Teachers were of the opinion that the lesson had also helped students becoming more independent [independence]. They also agreed that the monitoring of students' progress on the track was easy through the web-based interface [ease of use; appro-

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*priateness*] and had received all the necessary information through it [*availability; awareness*]. Teachers identified that the main benefit of the Amazing NFC lesson was moving the teaching situation and learning experience from the traditional classroom into real-life contexts that also included social interaction between students [*social interaction; superiority*].

### 4.2.2.3 Summary

Table 5a lists and groups designer values and value in experience identified from the point of view of **students** according to the value dimensions.

**Table 5a.** Values identified in relation to students (values on white depict designer value, values on black value in experience and values on grey were found in both).

user values (UV)			
<p>Growth and self-actualization</p> <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> <input type="checkbox"/> independence</li> <li><input checked="" type="checkbox"/> <input type="checkbox"/> empowerment</li> <li><input type="checkbox"/> <input type="checkbox"/> self-esteem</li> </ul>	<p>Stimulation and epistemic</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> <input checked="" type="checkbox"/> learning</li> <li><input checked="" type="checkbox"/> <input type="checkbox"/> novelty</li> <li><input type="checkbox"/> <input checked="" type="checkbox"/> variety</li> <li><input type="checkbox"/> <input checked="" type="checkbox"/> challenge</li> </ul>	<p>Socialization</p> <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> <input type="checkbox"/> social interaction</li> </ul>	<p>Traditional</p>
<p>Safety</p>	<p>Social</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> <input checked="" type="checkbox"/> social recognition</li> <li><input checked="" type="checkbox"/> <input type="checkbox"/> social comparison</li> </ul>	<p>Hedonic</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> <input checked="" type="checkbox"/> play</li> <li><input type="checkbox"/> <input checked="" type="checkbox"/> enjoyment</li> </ul>	<p>Benevolence</p>
service values (SV)			
<p>Functional (Convenience)</p> <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> <input type="checkbox"/> ease of adoption</li> <li><input checked="" type="checkbox"/> <input type="checkbox"/> ease of use</li> <li><input checked="" type="checkbox"/> <input type="checkbox"/> appropriateness</li> <li><input checked="" type="checkbox"/> <input type="checkbox"/> technology suitability</li> <li><input checked="" type="checkbox"/> <input type="checkbox"/> superiority</li> <li><input checked="" type="checkbox"/> <input type="checkbox"/> discoverability</li> </ul>	<p>Functional (Quality and performance)</p>	<p>Personalization</p>	<p>Localization</p> <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> <input type="checkbox"/> context-sensitiveness</li> <li><input checked="" type="checkbox"/> <input type="checkbox"/> integrated usage exp.</li> </ul>

Table 5b lists and groups designer values and value in experience identified from the point of view of **teachers**.

**Table 5b.** Values identified in relation to teachers (values on white depict designer value, values on black value in experience and values on grey were found in both).

user values (UV)			
Growth and self-actualization	Stimulation and epistemic	Socialization	Traditional
<input type="checkbox"/> self-esteem	<input type="checkbox"/> learning	<input checked="" type="checkbox"/> social interaction	
<input type="checkbox"/> independence	<input type="checkbox"/> novelty		
	<input checked="" type="checkbox"/> variety		
Safety	Social	Hedonic	Benevolence
<input checked="" type="checkbox"/> security		<input type="checkbox"/> play	
<input checked="" type="checkbox"/> freedom from fear		<input type="checkbox"/> enjoyment	
<input checked="" type="checkbox"/> awareness			
service values (SV)			
Functional (Convenience)	Functional (Quality and performance)	Personalization	Localization
<input type="checkbox"/> ease of use	<input checked="" type="checkbox"/> reliability		<input type="checkbox"/> context-sensitiveness
<input type="checkbox"/> appropriateness			
<input type="checkbox"/> technology suitability			
<input type="checkbox"/> superiority			
<input checked="" type="checkbox"/> availability			
<input type="checkbox"/> ease of adoption			

**Appendix B** describes in more detail the positive and negative outcomes of the value parameters that were identified in case Amazing NFC.

The same service was revealed to produce very different value perceptions among the two user groups. In summary, the expected value types in this case were not fully realized. The design goal of providing a novel and attracting learning experience was fulfilled to the extent that students clearly expressed their preference for this new learning concept over existing practice. In addition, functional value dimension was delivered to users, as the technical implementation of the concept with the NFC technology was proved successful; the students adopted the touch-based interaction quickly and reported that the technology in question suited the concept well. However, the educational goals set for the lesson were not met, as the students felt that they had not learned useful information or skills during the Amazing NFC lesson, therefore the expected value of learning was not

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fulfilled. In addition, the goal of providing an intrinsically motivating learning experience failed to the extent that students were disappointed at the content and related tasks provided during the lesson and felt that they were not challenged enough, leading to a shortcoming in the expected stimulation and epistemic value. This was an interesting finding, as it was contradictory to teachers' conception of the matter.

Furthermore, the aspect of competition was not utilized, even though that would have added a necessary element of excitement and thrill to the experience, and thus would also have produced play, enjoyment and social recognition values. However, the value of social interaction was somewhat surprisingly revealed to have a stronger effect on value in experience than was expected during the design phase of the concept. In addition, some conflicting values were identified. For example the students reported that the NFC tags were easy to find at the control points, thus providing discoverability value and at the same time expressed a hope that the tags could be hidden in less obvious places in order to provide more excitement and challenge in "treasure hunting".

An interesting finding was related to how differently these two user groups experienced value in relation to this same service, and how differently they also considered the realization of some relevant values. For example, teachers felt that values of self-esteem and learning were provided through the service, contrary to students' experiences. Also, teachers were not so convinced of the suitability and "goodness" of the NFC-based service solution. In addition, for teachers the quality and performance, and safety value dimensions emerged as value priorities related to this service, dimensions that were absent in the set of students' value priorities.

### 4.2.3 Case: InfoTag (Publication III)

In what follows the value formation in the case InfoTag is examined from two different angles, namely from the point of view of designer value, and value in experience of the users.

#### 4.2.3.1 Designer value

In this case, the focus was on enabling physical browsing, i.e. accessing internet content and services through objects in the physical world. The technology used for implementing physical browsing user interfaces was NFC, which was seen to allow physical mobile interactions in an intuitive way [*ease of adoption; ease of use*]. The expected main benefit of touch-based Mobile Internet access was that the user does not need to type or remember the long and complicated URLs needed to access the Mobile Internet content [*availability; efficiency; superiority*].

Yet another guiding design and research goal was to solve the service discovery problem by bringing the service access points physically to the mobile usage situations the user might face, and visualizing services in users' everyday environment [*discoverability*]. In addition, Mobile Internet services and content were made

available at the locations where they are most needed [*context-sensitiveness*]. Thus, one of the expected strengths and opportunities of the concept was identified in its potential to combine the internet experience with the situated and embodied experience evoked by the physical surroundings, social context and physical sensations [*integrated usage experience*]. The physical interaction of touch was expected to make the consumption of the Mobile Internet more usable, easier and faster for the users compared to existing practice [*appropriateness; technology suitability; efficiency*].

#### 4.2.3.2 Value in experience

Values that were identified to have most relevance and importance for the users within the InfoTag usage context are discussed in more detail in the following.

In addition to offering an easy and convenient access to Mobile Internet content, touching a tag to access Internet content was experienced as pleasant [*ease of adoption; ease of use; appropriateness; technology suitability; efficiency; superiority*]. Users also quickly learned the visual cues indicating the presence of digital content and services [*discoverability; availability*]. The users expected the content to be highly relevant and integrable with their current context and needs, and were very disappointed when it failed to be so [*relevance*]. This observation was repeated in several comments, and the users also expected digital content to be up-to-date [*up-to-dateness*]. Many users were disappointed that the content of some tags was static, which meant that it was not updated during the trial. In addition, some content available through the tags did not make full use of the location, but the users expected the knowledge about their location to be automatically processed by the service: “*If I download restaurant information in Oulu, I certainly do not want to receive information about restaurants in Helsinki! I immediately stopped using information tags when I realized this*” [*context-sensitiveness*]. Thus, users expressed hopes of better utilizing the possibilities of the digital platform for providing location-aware services.

The implications of Mobile Internet use in public places for the social context and interaction were found to strongly affect the value perceptions [*integrated usage experience; social interaction*]. In addition, as some of the content that was made accessible by the tags was video with sound, users seemed embarrassed or startled by the loudness of the sudden sound [*social approval*]. Some users were also annoyed by the long download times of the content [*performance*]. Users discovered tags that did not respond to touch, since some of the tags that the users found were visible and available for touching but not operational because they were broken or set up to work only with certain devices for specific users. User found these situations very annoying and reported that encountering non-functional tags diminished the usage experience [*reliability*].

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### 4.2.3.3 Summary

Table 6 lists and groups designer values and value in experience identified in case InfoTag according to the value dimensions.

**Table 6.** Values identified in case InfoTag (values on white depict designer value, values on black value in experience and values on grey values found in both).

user values (UV)			
Growth and self-actualization	Stimulation and epistemic	Socialization	Traditional
		<input type="checkbox"/> - social interaction	
Safety	Social	Hedonic	Benevolence
	<input type="checkbox"/> - social approval		
service values (SV)			
Functional (Convenience)	Functional (Quality and performance)	Personalization	Localization
<input checked="" type="checkbox"/> ease of adoption	<input checked="" type="checkbox"/> efficiency	<input type="checkbox"/> - relevance	<input type="checkbox"/> - context-sensitiveness
<input checked="" type="checkbox"/> ease of use	<input type="checkbox"/> - reliability		<input type="checkbox"/> - integrated usage exp.
<input checked="" type="checkbox"/> appropriateness	<input type="checkbox"/> - performance		<input type="checkbox"/> - up-to-dateness
<input checked="" type="checkbox"/> availability			
<input checked="" type="checkbox"/> discoverability			
<input checked="" type="checkbox"/> technology suitability			
<input checked="" type="checkbox"/> superiority			

**Appendix C** describes in more detail the positive and negative outcomes of the value parameters that were identified in case InfoTag.

In contrast to existing and cumbersome practice, the InfoTag users valued the new approach of touching a tag to access Internet content highly. Also, the visual cues embedded in the everyday environment were successful in acting as indicators of services available through the information tags. Thus, the primary designer value of providing functional value was fulfilled. However, users expressed their disappointment at the content provided through the tags, as it was more of a static nature and not fully context-sensitive or sensitive to their current needs, as opposed to their expectations. This emerged further as the use of tags was clearly most frequent at the beginning of the trial, and rather quickly faded with time. The users explained this phenomenon frequently by highlighting that, when they had seen the content once, it did not interest them anymore. Therefore, the localization or personalization value was not fulfilled to the extent users had been expecting.

As the Mobile Internet content was often accessed in the public contexts, users considered that the use of service reduced social interaction with other people. In addition, user experience and value was clearly diminished by the encounter with tags that were not operational, and some users were also annoyed by the long download times of the content, thus diminishing quality and performance value. The value of social interaction was not initially taken into account during the design phase, but it became evident that the nature of current Mobile Internet content was most suited for personal use, and users felt that consuming it could reduce the interaction between people.

#### 4.2.4 Case: School attendance (Publication IV)

In what follows the value formation in the case School attendance is examined from the point of view of designer value and value in experience of the users.

##### 4.2.4.1 Designer value

Traditionally, teachers monitor students' attendance every morning with roll-calls, and mark absences and delays in a back-end system. In addition, the parents of young children regularly call their children's or teacher's mobile phones to ensure that the child has made their way to school safely. Thus, the guiding design and research goals were to 1) simplify attendance monitoring and replace manual roll-calls [*appropriateness; ease of use; superiority*] with NFC technology that has been found to be intuitive and natural interaction technique that does not incur much cognitive load for users [*ease of adoption; technology suitability*], 2) increase the reliability of absence control by eliminating errors caused by manual recording [*reliability*], 3) save the teacher's time in marking absences by giving full responsibility for marking arrivals and departures to the children [*efficiency*], and 4) provide parents with real-time information on whether their children have arrived at school or not, and when they have left the school [*availability; awareness*], thus 5) increasing the feeling of safety [*security*]. Careful measures and precautions were also taken to ensure information security and guarantee children's privacy. In addition, the children were given the opportunity to participate in the system design, and by that feel that their voices were heard and their opinions valued [*respect; empowerment; participation*].

##### 4.2.4.2 Value in experience

As there were three end-user groups, value in experience in the case School Attendance is consequently examined from three points of views. In what follows value types that were assessed as being the most important and relevant to the children, parents, and teachers are discussed in more detail.

The **children** quickly learned to use touch-based interaction and the login process soon integrated into their everyday routines at school [*ease of adoption; ease of use; technology suitability; compatibility*]. Children had been extremely excited

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when they had heard they could participate in the experiment, and they only had positive thoughts about the attendance supervision: *“Awfully nice, mega!”* [*enjoyment; novelty; superiority*]. Children felt that supervision by their parents and teachers through the system was very important, and for many children the possibility of participating in the trial and using the system appeared to be a boost to their [*self-esteem*]. One child had got really excited when he received the card, which was similar to the card his father used at work. Children clearly valued the fact that they could actively help teachers and parents by creating useful and valuable information for them, and especially by easing their parents' worries [*value creation; empowerment*]: *“Mom and Dad know at what time you have arrived at school and left home, and if you have stayed in detention”*. Children had also noticed some good things the attendance supervision system had brought to their own lives: *“It’s also nice that you don’t need to phone when you have arrived at school”* [*superiority*]. The technology-supported service seemed also to provide the children with a way of demonstrating competence [*achievement*]. They were very proud and excited that they were being given contactless smart cards that were on their own [*responsibility*]: *“A proud and eager pupil has remembered well.”* Children clearly valued that they were able to play their part by participating in the design of the visual outlook of the card [*empowerment; participation*]. In addition, children saw it as a sign of trust of their skills that operating the reader device was on two class peers' responsibility on one day of a week [*independence; respect*]. This was also valued by the children, as they saw this as a source of special pride for the whole class, not just for those two children in question [*respect*].

Also, as not every class in their school used the system, this offered the children a means for [*status*] differentiation, and gave [*social recognition*] among their peers: *“For the children this has been an important and big thing, since not all the classes use these cards, so in that way children now have a chance to stand out and they have something that others do not have”* [*social comparison*]. However, many of the pupils knew that secondary school students had received NFC mobile phones for attendance supervision and they seemed to be a little jealous of this. One of the children said, *“Smart cards could have been given to the secondary school students and we could have had the touch mobile phones”* [*social comparison*]. Clearly, mobile phones were valued as devices and status symbols more than smart cards. In general, children accepted without question parents' and teachers' authority in protecting them through attendance supervision. The children did not wonder why they had to do the login and did not resist new practices; they simply regarded it as a natural part of school routines [*conformity*]. This is well illustrated in the following excerpt from one of the teachers: *“Nowadays children have seen so many kinds of things that they don’t marvel at things like this.”* Nor did any type of behaviour attempting to manipulate the system come out: *“For a child it is just part of their life”*. But this might be different with older children and teenagers.

**Parents** were expecting the service to reduce unnecessary doubt by offering an access to their child's attendance details [*availability*] and increase the security of their children, leading to peace of mind [*security*]. One parent stated that in her



opinion it is good that you can monitor your children, since “...*life is changing all the time; it is becoming more fierce.*” About half of the parents were satisfied with the service and thought that it added value for them [*superiority*]. The system was also found to be valuable in that it will notify the parents immediately in situations where the child for some reason does not arrive at school or in day care [*awareness*]. However, even though security was the value type most visibly observed among parents, the service in its current form caused mixed feelings as regards the security value: “*What does it help to get the information that something has happened, if something could have been done to prevent that from happening!*” It turned out that some parents felt that the system brought only the same feeling of safety as calling on a mobile phone [*superiority*].

In addition, in a few parents' opinion the system could cause extra concern and worry instead of increasing the feeling of safety, as the child might, for example, lose the card or forget to log into and out of school [*reliability; security; freedom from fear*]. Also, parents reported that following their children's attendance details was not realized very practically in the system and did not integrate well with their daily routines [*appropriateness; compatibility*]. Parents who chose not to participate in the field study considered the trial to be a technology-led project: “*The safety of the child is created through the genuine presence of an adult and not through a supervision system.*” In their opinion children of this young age should not be given new technology, as the number of new things in the first-graders' world is already enough. They also thought that the system would reduce or even remove the human [*responsibility*] and safety-ensuring activities regarding children's security in the school environment: “*If parents cannot trust that the teacher knows where the children are (ill, at school, on vacation etc.), something is really wrong*” [*freedom from fear*]. In conclusion, even though the parents in general thought positively of it, the current implementation of the system still seemed to create some confusion and insecurity rather than increase the feeling of children's safety [*technology suitability; performance*]. One unexpected finding was related to situations where the parents are separated. In those cases the system was seen to provide a parent not living with the child with an increased feeling of involvement and [*belonging*] in the life of the child.

Participating **teachers** were open to new ideas, and volunteered for the trial. They had a very positive attitude towards new technology in general, and felt that the system brought welcome [*variety*] to everyday teaching. It was their responsibility for integrating and supervising the adoption of the new practice in their class. After a short while, the system became an integral part of the children's school day [*ease of use; ease of adoption; technology suitability; compatibility*]. Teachers felt that the system supported them in fulfilling their responsibilities more reliably [*responsibility; reliability; conformity*] and efficiently by eliminating manual work and decreasing the chance of human error in marking children's attendance details [*appropriateness; efficiency; superiority*].

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### 4.2.4.3 Summary

Table 7a lists and groups designer values and value in experience identified from the point of view of **children** according to the value dimensions.

**Table 7a.** Values identified in relation to children (value parameters on white depict designer value, values on black value in experience and values on grey were found in both).

<b>user values (UV)</b>			
<b>Growth and self-actualization</b>	<b>Stimulation and epistemic</b>	<b>Socialization</b>	<b>Traditional</b>
<input checked="" type="checkbox"/> <input type="checkbox"/> empowerment	<input checked="" type="checkbox"/> <input type="checkbox"/> novelty	<input checked="" type="checkbox"/> <input type="checkbox"/> participation	<input checked="" type="checkbox"/> <input type="checkbox"/> compatibility
<input checked="" type="checkbox"/> <input type="checkbox"/> independence			<input checked="" type="checkbox"/> <input type="checkbox"/> conformity
<input checked="" type="checkbox"/> <input type="checkbox"/> self-esteem			
<b>Safety</b>	<b>Social</b>	<b>Hedonic</b>	<b>Benevolence</b>
<input type="checkbox"/> <input type="checkbox"/> security	<input checked="" type="checkbox"/> <input type="checkbox"/> respect	<input checked="" type="checkbox"/> <input type="checkbox"/> enjoyment	<input checked="" type="checkbox"/> <input type="checkbox"/> value creation
<input type="checkbox"/> <input type="checkbox"/> awareness	<input checked="" type="checkbox"/> <input type="checkbox"/> achievement		<input checked="" type="checkbox"/> <input type="checkbox"/> responsibility
	<input checked="" type="checkbox"/> <input type="checkbox"/> social recognition		
	<input checked="" type="checkbox"/> <input type="checkbox"/> social comparison		
	<input checked="" type="checkbox"/> <input type="checkbox"/> status		
<b>service values (SV)</b>			
<b>Functional (Convenience)</b>	<b>Functional (Quality and performance)</b>	<b>Personalization</b>	<b>Localization</b>
<input checked="" type="checkbox"/> <input type="checkbox"/> ease of adoption	<input type="checkbox"/> <input type="checkbox"/> efficiency		
<input checked="" type="checkbox"/> <input type="checkbox"/> ease of use	<input type="checkbox"/> <input type="checkbox"/> reliability		
<input checked="" type="checkbox"/> <input type="checkbox"/> technology suitability			
<input checked="" type="checkbox"/> <input type="checkbox"/> superiority			
<input type="checkbox"/> <input type="checkbox"/> appropriateness			
<input type="checkbox"/> <input type="checkbox"/> availability			

Table 7b lists and groups designer values and value in experience identified from the point of view of **parents** according to the value dimensions.

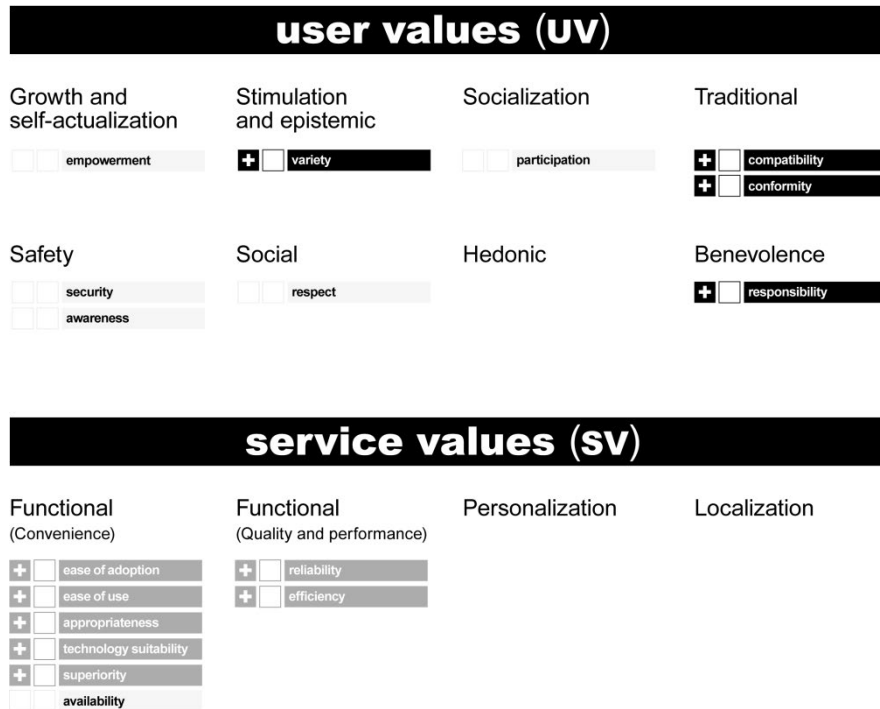
**Table 7b.** Values identified in relation to parents (values on white depict designer value, values on black value in experience and values on grey were found in both).

<b>user values (UV)</b>			
<b>Growth and self-actualization</b>	<b>Stimulation and epistemic</b>	<b>Socialization</b>	<b>Traditional</b>
<input type="checkbox"/> <input type="checkbox"/> empowerment		<input checked="" type="checkbox"/> <input type="checkbox"/> belonging <input type="checkbox"/> <input type="checkbox"/> participation	<input type="checkbox"/> <input checked="" type="checkbox"/> compatibility
<b>Safety</b>	<b>Social</b>	<b>Hedonic</b>	<b>Benevolence</b>
<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> security <input checked="" type="checkbox"/> <input type="checkbox"/> awareness <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> freedom from fear	<input type="checkbox"/> <input type="checkbox"/> respect		<input type="checkbox"/> <input checked="" type="checkbox"/> responsibility
<b>service values (SV)</b>			
<b>Functional (Convenience)</b>	<b>Functional (Quality and performance)</b>	<b>Personalization</b>	<b>Localization</b>
<input type="checkbox"/> <input checked="" type="checkbox"/> appropriateness <input checked="" type="checkbox"/> <input type="checkbox"/> availability <input type="checkbox"/> <input checked="" type="checkbox"/> technology suitability <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> superiority <input type="checkbox"/> <input type="checkbox"/> ease of adoption <input type="checkbox"/> <input type="checkbox"/> ease of use	<input type="checkbox"/> <input checked="" type="checkbox"/> reliability <input type="checkbox"/> <input checked="" type="checkbox"/> performance <input type="checkbox"/> <input type="checkbox"/> efficiency		

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Table 7c lists and groups designer values and value in experience identified from the point of view of **teachers** according to the value dimensions.

**Table 7c.** Values identified in relation to teachers (values on white depict designer value; values on black value in experience; and values on grey were found in both).



**Appendix D** describes in more detail the positive and negative outcomes of the value parameters that were identified in School Attendance Supervision.

The interesting finding was that all of the stakeholders perceived the service differently and placed different types of value on the service. Even though the guiding designer value of the service was to increase the feeling of security, the study findings revealed that in its current form this goal was not always met. About half of the parents felt that the system indeed adds value for them, especially in situations where the child does not arrive at school or in day care as planned. But in some parents' opinions the system did not bring real value when compared to an already established practice. In addition, many parents feared that the technology would remove responsibilities from the teachers, whereas teachers themselves felt that it helped them to fulfil their responsibility. Thus, the current implementation of the system still seemed to create some confusion and insecurity. However, the system was felt to facilitate teachers' work by eliminating the need for a teacher to answer parents' worried calls during the school day, and making the recording of

attendance details more reliable, thus bringing the expected functional value. Stimulation and epistemic value dimension were also perceived contradictorily between the user groups: children and teachers felt that the system brought a welcomed change and variety to school routines, whereas parents considered the novelty of the system to be a negative aspect.

In sum, children prioritized the social, hedonic, benevolence, and growth- and self-actualization value dimensions, and for parents the safety, benevolence and traditional value dimensions appeared most relevant, whereas teachers considered the functional, traditional and benevolence values most important. Initially, it seemed that the system would primarily serve teachers and parents, whereas the children would do all the work without obtaining any direct benefits. But the value that became clearly evident when children described their experience was that the children seemed to understand and embrace how the system created value for parents and school. Thus, the children seemed to be the group most pleased with the system. This might be because of the inadequate understanding of values not directly related to the utility values of the service, and the lack of attention given to them at the design and research planning phases.

When comparing the findings to the results obtained in Isomursu et al. (2011) it was noticed that especially the service values (SV) were ignored in the previous value analysis based on Schwartz's framework. In addition, enjoyment, novelty, participation and compatibility values that were identified as relevant value priorities among schoolchildren were missed in the previous analysis. In the case of the value in experience of parents, values of compatibility and awareness were missed in this earlier publication. Furthermore, compatibility value was also missed in the value analysis of teachers.

#### **4.2.5 Case: BlindNFC (Publication V)**

In what follows the value formation in the case BlindNFC is examined from the points of view of designer value and value in experience of the users.

##### **4.2.5.1 Designer value**

The main guiding design goal within the case of BlindNFC was to allow visually impaired older users to manage their daily medications autonomously by providing them with the means of identifying medicines and retrieving personal medication information [*discoverability; availability; superiority; adaptation*]. The study addressed the problem of medication non-adherence, which incurs a risk of taking prescribed medicine in a way not intended by the doctor [*security*]. A further aim was to provide support for more independent living by older people through more autonomous medicine management [*independence*]. The service itself was designed so that it does not require the user to make significant changes in the practices they have followed so far in medication management, i.e. it would integrate or support the users' existing personal practices for medication management

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[*compatibility*]. Furthermore, the touch-based interaction was expected to provide an easy-to-learn usage paradigm for the users [*ease of adoption; ease of use; technology suitability*].

### 4.2.5.2 Value in experience

Values that were identified as having most relevance and importance for the users within the BlindNFC usage context are discussed in more detail below.

Findings revealed that users' attitudes towards the service were positive. However, some of the users were a little sceptical regarding the usefulness of the solution: "*I'm doubtful*", "*I don't believe I want a device like this for myself*". The lack of previous experience with technology was likely to have had an effect on users' attitude towards the technology-based solution; some users expressed doubt and worry about their own competence with technology use: "*How difficult it would be to use this?*", "*This is more suitable for young people*" [*ease of use; compatibility*]. However, it turned out that, once the users had tried reading the NFC tag with the BlindNFC once or a couple of times, they got the hang of it very quickly and successfully completed the task [*ease of use*]: "*When you learned what with the aim was of this, it was easy!*" [*ease of adoption; achievement*].

On the whole, older users reported a high degree of satisfaction in the use of the BlindNFC, together with the solution it offers for acquiring important medicine information [*technology suitability; discoverability; availability*]: "*This is interesting, very exciting!*", "*Really good!*" [*enjoyment*]. However, most users stated that they were not currently willing to adopt the system for continuous use, especially as many of them had over time established methods for managing their medications, and were therefore observed to be reluctant to change their ways [*compatibility*]; either they were able to handle medication management by themselves or else they relied on the support of other people. Therefore, they felt that the system could not provide real added value for them [*superiority*]. Another reason for users' somewhat hesitant point of view for service adoption might have been the fear that those close to them who help them in medication management would not then have a need to visit them so often anymore [*social interaction*].

### 4.2.5.3 Summary

Table 8 lists and groups designer values and value in experience identified in case BlindNFC according to the value dimensions.

**Table 8.** Values identified in case BlindNFC (values on white depict designer value, values on black depict value in experience and values on grey were found in both).

user values (UV)			
Growth and self-actualization	Stimulation and epistemic	Socialization	Traditional
<input type="checkbox"/> <input type="checkbox"/> independence		<input type="checkbox"/> <input checked="" type="checkbox"/> social interaction	<input type="checkbox"/> <input checked="" type="checkbox"/> compatibility
Safety	Social	Hedonic	Benevolence
<input type="checkbox"/> <input type="checkbox"/> security	<input checked="" type="checkbox"/> <input type="checkbox"/> achievement	<input checked="" type="checkbox"/> <input type="checkbox"/> enjoyment	
service values (SV)			
Functional (Convenience)	Functional (Quality and performance)	Personalization	Localization
<input checked="" type="checkbox"/> <input type="checkbox"/> ease of adoption		<input type="checkbox"/> <input type="checkbox"/> adaptation	
<input checked="" type="checkbox"/> <input type="checkbox"/> ease of use			
<input checked="" type="checkbox"/> <input type="checkbox"/> availability			
<input checked="" type="checkbox"/> <input type="checkbox"/> discoverability			
<input checked="" type="checkbox"/> <input type="checkbox"/> technology suitability			
<input type="checkbox"/> <input checked="" type="checkbox"/> superiority			

**Appendix E** describes in more detail the positive and negative outcomes of the value parameters that were identified in case BlindNFC.

Study participants all had a varying degree and combination of different functional and cognitive limitations, which clearly set its own challenges in designing a system for this particular user group. In addition, the older users were not experienced technology users, which was likely to have had an effect on users' perceptions of the new technological solution. Nevertheless, the users were able to learn to use the touch-based interaction technique. Users' evaluations about the service concept were positive and they thought that it would be valuable especially when new medicines are taken into a medication plan. Thus, the expected functional value was delivered to users. However, in the end the users expressed being somewhat reluctant in adopting the system into long-term use, the main reason for which stemmed from the fact that most of the users had already established their own unique procedures (often through the help of other people) for managing medications and compensating for their reduced functional capabilities, and they were observed to be reluctant to change these ways. This was contradictory to the guiding design value, where the BlindNFC service was expected to conform to a traditional value, i.e. compatibility. In addition, many had a fear of system adoption possibly reducing their social contacts, and thus affecting the socialization value dimension, which was not anticipated during the design phase. Thus, quite sur-

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prisingly, users' desire for independence in their everyday life did not stand out as an important value type. In addition, the security value through providing the means for more safe medication was not visible within the user group.

### 4.2.6 Case: iShake (Publication VI)

In what follows the value formation in the case iShake is examined from the point of views of designer value and value in experience of the users.

#### 4.2.6.1 Designer value

It was assumed that if people were offered a free service on their mobile phone, they would voluntarily participate in creating valuable data for other users as well as helping emergency response [*value creation; participation*]. The primary design goal behind the iShake system was to provide users with important earthquake notifications on a mobile device that they are accustomed to use and carry with them at all times [*ease of use; flexibility; technology suitability*], which therefore makes their owners always reachable by critical earthquake data based on user's location of interest [*appropriateness; availability; context-sensitiveness; superiority*]. The service was also designed to provide users with useful and important information regarding earthquake preparedness in order to help them educate themselves and increase their chances for surviving in future disasters [*learning; awareness; security*]. Furthermore, the service was identified to have the potential to ease the worry of close relatives and friends by sharing detailed location data between users in the event of an earthquake [*freedom from fear*]. The service was also expected to have potential in contributing to emotional recovery after an earthquake by offering a channel for sharing one's own experiences and feelings with other iShake users affected by the same ordeal [*social interaction; belonging*].

#### 4.2.6.2 Value in experience

The users considered the iShake application as straightforward and easy to use [*ease of use; appropriateness*]. The users felt that iShake would give them a better feeling of safety in the event of an earthquake, and most of them placed value on the possibility of being able to receive critical information about future earthquakes on their mobile phone [*flexibility; technology suitability; security; availability; superiority*]. The users expressed the hope for sharing location data with their close relatives and friends, so they identified iShake as having great potential also to help ease their concern for other people's safety [*freedom from fear*]. In addition, the majority reported that they considered iShake to be a very exciting and important mobile application, and thought the information and instructions provided on iShake on earthquake preparedness were useful and interesting [*novelty; learning; awareness*]. Receiving earthquake notifications that were adapted to their location was felt to be very important, and users also stated that they would like to have the notifications personalized, based on their unique preferences and



needs [*context-sensitiveness; adaptation*]. Thus, users expressed a desire to be directed with the most relevant and valuable earthquake notifications and safety instructions [*relevance*]. However, users considered that video content is not very socially appropriate since loud voices could easily disturb other people [*social approval*].

For engaging and motivating the users to provide data for iShake, the users themselves suggested that a kind of competition could be created with a ranking system of individual users' contributions [*social recognition; social comparison; participation*]. In addition, users reported that they would like to be given tangible feedback on how their data had helped someone, in order to know that they had actually accomplished something valuable [*achievement; value creation*]. Users reported not being especially eager to share their own experiences and emotions about earthquakes with other iShake users via the application, but they were more interested in reading other iShake users' messages about and experiences of earthquakes.

#### 4.2.6.3 Summary

Table 9 lists and groups designer values and value in experience identified in the case of iShake according to the value dimensions.

**Table 9.** Values identified in case iShake (values on white depict designer value, values on black depict value in experience and values on grey were found in both).

user values (UV)			
Growth and self-actualization	Stimulation and epistemic	Socialization	Traditional
	<input checked="" type="checkbox"/> <input type="checkbox"/> learning <input checked="" type="checkbox"/> <input type="checkbox"/> novelty	<input checked="" type="checkbox"/> <input type="checkbox"/> participation <input type="checkbox"/> <input type="checkbox"/> social interaction <input type="checkbox"/> <input type="checkbox"/> belonging	
Safety	Social	Hedonic	Benevolence
<input checked="" type="checkbox"/> <input type="checkbox"/> security <input checked="" type="checkbox"/> <input type="checkbox"/> awareness <input type="checkbox"/> <input checked="" type="checkbox"/> freedom from fear	<input type="checkbox"/> <input checked="" type="checkbox"/> social recognition <input type="checkbox"/> <input checked="" type="checkbox"/> social approval <input type="checkbox"/> <input checked="" type="checkbox"/> social comparison <input type="checkbox"/> <input checked="" type="checkbox"/> achievement		<input checked="" type="checkbox"/> <input type="checkbox"/> value creation
service values (SV)			
Functional (Convenience)	Functional (Quality and performance)	Personalization	Localization
<input checked="" type="checkbox"/> <input type="checkbox"/> ease of use <input checked="" type="checkbox"/> <input type="checkbox"/> availability <input checked="" type="checkbox"/> <input type="checkbox"/> appropriateness <input checked="" type="checkbox"/> <input type="checkbox"/> flexibility <input checked="" type="checkbox"/> <input type="checkbox"/> technology suitability <input checked="" type="checkbox"/> <input type="checkbox"/> superiority		<input type="checkbox"/> <input checked="" type="checkbox"/> adaptation <input type="checkbox"/> <input checked="" type="checkbox"/> relevance	<input checked="" type="checkbox"/> <input type="checkbox"/> context-sensitiveness

**Appendix F** describes in more detail the positive and negative outcomes of the value parameters that were identified in case iShake.

The main designer value was fulfilled, as users were identified as placing most value on the possibility of being able to receive critical information about earthquakes and valuable information to better prepare themselves for future disasters on a device that is always at hand. Therefore, these strongly contributed to functional, and stimulation and epistemic values. Users also felt that iShake gave them a better feeling of safety and placed potential value on the application providing them with information on the whereabouts of their family and friends, thus also contributing to freedom from fear. Both value dimensions of personalization and localization became clearly visible as users reported that having iShake earthquake notifications personalized according to their location was very important, and also expressed the hope of getting further personalization based on their unique preferences and needs. However, contrary to initial expectations, users did not place noticeably value on the possibility of utilizing the system for the purpose of emotional relief. From the analysed user experience data it could be concluded that value creation for other users and first response was an even more significant source of value than was assumed initially, and also identified as a great source of motivation and commitment for active use of the system. The social value was not yet harnessed in the current solution, but it became clear that iShake users would place great deal of value on social recognition and achievement.

### 4.2.7 Case: Wayfinding (Publication VII)

In what follows the value formation in the case Wayfinding is examined from the point of views of designer value, and value in experience of the users.

#### 4.2.7.1 Designer value

Study participants suffered from dementia, and memory loss with disorientation is often the first symptom of dementia, which is always a safety risk. Because of the decreased ability in orientation, people with memory disturbances become increasingly more dependent on the help of other people when carrying out their daily activities. The goal in this case study was to develop a prototype of a technological solution to help the elderly with memory disturbances with wayfinding. The main expected values in the study were the increased [*security*] of the older people and the better perceived control of their own lives [*empowerment*], contributing thus to more [*independence*] and better quality of living. This was also expected to have a positive effect on users' [*self-esteem*] since being able to go out and carry out daily activities in the outdoor environment was expected to give the older user a feeling of success [*achievement*]. The combination of modalities was decided based on a prior-evaluation of each individual user's preferences and sensory faculties [*adaptation*]. Furthermore, multimodality was utilized in order to lessen the physical and cognitive burden placed on the older user during the wayfinding

tasks [*appropriateness; technology suitability*]. Because of participants' diminished abilities in walking and functional and motor skills, the wayfinding prototype system did not require the user to occupy their hands, further contributing to the experienced value of easy and comfortable use [*ease of use*].

#### 4.2.7.2 Value in experience

The advanced age of the study participants, as well as their clearly diminished cognitive and functional abilities set clear and unique challenges in designing the wayfinding system and making it usable for them. Furthermore, great challenges were encountered when trying to collect rich user experience data from them. In order to compensate for users' diminished capabilities, the use of multimodal wayfinding cues and the selection of combination of them according to individual users' preferences and capabilities were considered essential, thus contributing to [*adaptation*] value. By taking into account users' inexperience and unfamiliarity with technological devices and their incapability in comprehending and learning to operate them, the wayfinding prototype developed did not require any direct intervention or interaction from the user [*appropriateness*]. Furthermore, the wayfinding aid was carefully designed so that it would not occupy the user's hands as this was seen to be too cumbersome and burdening [*ease of use; technology suitability*].

Observations revealed that, regardless of the challenges and restrictions set by their diminished functional and cognitive abilities, by relying on the wayfinding aid the majority of the users succeeded in wayfinding with a few misinterpretations [*ease of use*]. Wayfinding support has the potential to motivate and empower older people to perform their daily activities by reducing their need to depend on other people's help [*independence; empowerment*]. Thus, the dignity of the older person can be raised by providing feelings of success [*achievement*] when the older person manages to stay mobile in outdoor environments without being dependent on other people [*self-esteem*]. In addition, the [*security*] during the daily activities and wayfinding tasks can be improved. However, circumstances dependent on trial settings, such as the discreet help from nurses during the wayfinding tasks might have had an effect on users' value perceptions.

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### 4.2.7.3 Summary

Table 10 lists and groups designer values and value in experience identified in case Wayfinding according to the value dimensions.

**Table 10.** Values identified in case Wayfinding (values on white depict designer value, values on black value in experience and values on grey were found in both).

user values (UV)			
Growth and self-actualization	Stimulation and epistemic	Socialization	Traditional
<input checked="" type="checkbox"/> <input type="checkbox"/> independence			
<input checked="" type="checkbox"/> <input type="checkbox"/> empowerment			
<input checked="" type="checkbox"/> <input type="checkbox"/> self-esteem			
Safety	Social	Hedonic	Benevolence
<input checked="" type="checkbox"/> <input type="checkbox"/> security	<input checked="" type="checkbox"/> <input type="checkbox"/> achievement		
service values (SV)			
Functional (Convenience)	Functional (Quality and performance)	Personalization	Localization
<input checked="" type="checkbox"/> <input type="checkbox"/> ease of use		<input checked="" type="checkbox"/> <input type="checkbox"/> adaptation	
<input checked="" type="checkbox"/> <input type="checkbox"/> appropriateness			
<input checked="" type="checkbox"/> <input type="checkbox"/> technology suitability			

**Appendix G** describes in more detail the positive and negative outcomes of the value parameters that were identified in case Wayfinding.

The user group in question was a very challenging one, as it was comprised of older people suffering from memory disturbances. The subjects in this study were significantly older and their MMSE scores lower than in previous user studies conducted by other researchers. Problems were expected with information acquisition from the subjects, as there are only some previous experiences of data gathering with the very aged (Schwartz et al., 1998; Suzman et al., 1992). Also, memory disturbances were expected to bring their own challenges, as the user group in question tends to forget recent events and questions presented in the interview, and they may also have abstract thinking and verbal ability impairments (Edwards, 1993).

As anticipated, user experience data collection from the users turned out to be very challenging, and practically impossible. In addition, the subjects had difficulties in comprehending the questions, and experienced great troubles in communicating their own feelings and thoughts regarding their subjective user experience

of the technological solution in question. Thus, the relevant value types in this case were difficult to determine unambiguously and reliably. As a result, from this user group only presumed value perceptions that were heavily based on observations and researchers' expert evaluations could be identified. The result of this analysis and evaluation process was seen to support the designer value dimensions identified during the design and planning phase.

#### **4.2.8 Complemented value design and evaluation framework**

As can be seen from case study evaluations presented in the previous section, the number of aspects playing a role value in experience formation is extensive and diversified. The previously developed initial value framework is here complemented on the basis of cross-case analysis and synthesis. The description and categorization of the case-specific value parameters are given in Table 11 below. Other researchers' work was used to support the description and naming of value parameters. The identified case-specific value parameters that contributed to the users' value in experience are mapped with the higher level value dimensions. The framework shows how different user groups prioritized different values, and what values became repeatedly visible across different cases (these value parameters are highlighted) and appeared therefore to be more general types of values not as dependent on the specific user, context, or service domain. The positive and negative outcomes of the case-specific relevant value parameters are not shown in this table, since the realization of individual values fluctuated relatively much across the cases.

**Table 11.** The complemented value design and evaluation framework.

Category	Value dimension		Value parameter	Description	Cases
<b>SERVICE VALUES (SV)</b>	<b>Functional value</b>	<b>Convenience</b>	<b>Ease of adoption</b>	Easy to take into use	1, 2, 3, 4, 5
			<b>Ease of use</b> (Holbrook, 1994)	Easy and straightforward to use	1, 2, 3, 4, 5, 6, 7
			<b>Availability</b> (Holbrook, 1994; Boztepe, 2007)	Easily available and accessible service content	1, 2, 3, 4, 5, 6
			<b>Discoverability</b> (cf. Åkesson, 2007)	Easily discoverable service offering and the contents within	2, 3, 5
			<b>Flexibility</b> (cf. Åkesson, 2007)	Flexible usage everywhere and anytime	1, 6
			<b>Appropriateness</b> (Boztepe, 2007)	Convenient and pleasant to use	1, 2, 3, 4, 6, 7
			<b>Technology suitability</b> (cf. Boztepe, 2007)	Technological implementation supports and complements the solution	1, 2, 3, 4, 5, 6, 7
	<b>Quality and performance</b>	<b>Quality and performance</b>	<b>Superiority</b> (Sheth et al., 1991a)	Superior compared with existing solution and alternatives	1, 2, 3, 4, 5, 6
			<b>Reliability</b> (Boztepe, 2007)	Reliable and trustworthy functionality	2, 3, 4
			<b>Performance</b> (Sweeney and Soutar, 2001)	Redemption of expected functions and purposes	3, 4
	<b>Personalization value</b>	<b>Personalization value</b>	<b>Efficiency</b> (Holbrook, 1999; Boztepe, 2007)	Support to effective task fulfillment, saving of time and effort	3, 4
			<b>Adaptation</b> (cf. Clarke, 2001)	Adaptation according to personal preferences, needs and limitations	1, 6, 7
			<b>Relevance</b> (cf. Clarke, 2001)	Information and content of high relevance	1, 3, 6
	<b>Localization value</b>	<b>Localization value</b>	<b>Context-sensitiveness</b> (Clarke, 2001)	Adaptation according to contextual situation	1, 2, 3, 6
			<b>Up-to-dateness</b> (cf. Åkesson, 2007)	Up-to-date and topical content, adaptation according to time of day	1, 3
<b>Integrated usage experience</b> (cf. Åkesson, 2007)			Digital and physical experiences support each other	2, 3	

Category	Value dimension	Value parameter	Description	Cases
<b>USER VALUES (UV)</b>	<b>Social value</b>	<b>Social recognition</b> (Schwartz, 1992)	Support for positive social recognition	2, 4, 6
		<b>Social approval</b> (Sheth et al., 1991a, Schwartz, 1992)	Support for social approval	3, 6
		<b>Social comparison</b> (cf. Sweeney and Soutar, 2001; Lages and Fernandes, 2007)	Support for positive comparing and positioning oneself with meaningful others	2, 4, 6
		<b>Achievement</b> (Schwartz, 1992)	Support for feeling of achievement through the demonstration of competence	4, 5, 6, 7
		<b>Status</b> (Schwartz, 1992; Holbrook, 1999)	Support for enhancement of social status and image	4
		<b>Respect</b> (Kujala and Väänänen-Vainio-Mattila, 2009)	Support for feeling of being respected by others	4
	<b>Hedonic value</b>	<b>Enjoyment</b> (Schwartz, 1992; Sweeney and Soutar, 2001)	Support for feeling of pleasure and affective states	2, 4, 5
		<b>Play</b> (Holbrook, 1999)	Support for feeling of play and fun	2
	<b>Stimulation and epistemic value</b>	<b>Learning</b> (Sheth et al., 1991a)	Support for gaining novel knowledge and skills	2, 6
		<b>Novelty</b> (Sheth et al., 1991a)	Support for feeling of novelty	1, 2, 4, 6
		<b>Challenge</b> (Schwartz, 1992)	Support for feeling of challenge and curiosity	2
		<b>Variety</b> (Schwartz, 1992)	Support for feeling of variety and stimulation	2, 4
	<b>Growth and self-actualization value</b>	<b>Independence</b> (Schwartz, 1992)	Support for independent thought and action	2, 4, 7
		<b>Self-esteem</b> (Schwartz, 1992)	Support for enhancement of self-respect	2, 4, 7
<b>Empowerment</b> (cf. Schwartz, 1992)		Support for feeling of empowerment; choose own goals and gain control of own life	1, 2, 4, 7	

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Category	Value dimension	Value parameter	Description	Cases
<b>USER VALUES (UV)</b>	<b>Socialization value</b>	<b>Social interaction</b> (Lages and Fernandes, 2007)	Support for strengthening social interaction and relationships with others	2, 3, 5
		<b>Belonging</b> (Schwartz, 1992)	Support for feeling of togetherness and involvement	4
		<b>Participation</b> (cf. Akesson, 2007)	Support for feeling of participation, taking part and engaging in something	4, 6
	<b>Traditional value</b>	<b>Compatibility</b> (cf. Schwartz, 1992)	Support for compatibility with existing practices and way of living	4, 5
		<b>Conformity</b> (Schwartz, 1992)	Support for matching behavior to prevailing social norms ("what is right")	4
	<b>Safety value</b>	<b>Security</b> (Schwartz, 1992)	Support for feeling of security and wellbeing	2, 4, 6, 7
		<b>Freedom from fear</b> (Kujala and Väänänen-Vainio-Mattila, 2009)	Support for sense of freedom from fear and "peace of mind"	2, 4, 6
		<b>Awareness</b>	Support for feeling of consciousness and knowledge of important aspects in life	2, 4, 6
	<b>Benevolence value</b>	<b>Responsibility</b> (Schwartz, 1992)	Support for fulfilling and performing duties and responsibilities	4
		<b>Value creation</b> (Schwartz, 1992)	Support for helping and bringing benefits to other people	4, 6

Value in experience is not a passive receipt of a pre-defined set of values from developers or researchers; instead, users subjectively experience value. For different users the components of value may be differentially weighted. User's experience with the service was also revealed to simultaneously evoke both positive and negative emotions regarding value dimensions. However, it appears that even though the users individually experience value, individual users also seem to share similar types of experiences with other users of the particular service. Thus, as experience can be collective and created or shared with other people (Bartabee, 2003), the value in the experience is individually intrasubjective and socially intersubjective (Helkkula et al., 2012). Regarding the relevant value dimensions of different user groups, they appeared to differ substantially in their priorities (cf. Schwartz, 2006), as one very interesting finding was that different user groups experienced very different values in relation to the very same service (such as in Publications II and IV).

The above summarized value dimensions identified from the literature and complemented with the empirical findings from case studies are not mutually exclusive, and the same experience with a service can convey different dimensions of value simultaneously and to varying degrees (cf. Boztepe, 2007). Value in expe-



rience is also subject to change across different contexts and over time (Sánchez-Fernández and Iniesta-Bonillo, 2007). Thus, value dimensions make differential contributions in specific usage contexts with different service domains, which is congruent with the findings by e.g. Sheth et al. (1991b). There also seems to be a trade-off between relevant values, since there is no absolute importance of any one value (Schwartz, 2006). Thus, users are ready to settle for less of other values in order to gain more of their relevant prioritized values. Some values appear to contradict one another, whereas others are compatible (cf. Schwartz, 2006). It was discovered that it wasn't possible to unambiguously prioritize the value parameters identified in the case studies, because they worked together in such a way that no single value was so superior to others that it would be sufficient on its own; instead, user's relevant values contributed accumulatively to value in experience.

Value dimensions could be identified that:

- 1) **Manifested in most cases** – Service values (SV) were most commonly found to be relevant and important across the cases by the users, and especially the Convenience value dimension. Furthermore, the Context-sensitiveness became clearly evident in more than half the cases within the Localization value dimension. In addition, from the Social value dimension, the Achievement value parameter became visible in more than half cases. Also a Novelty value was identified as important in over half the cases within the Stimulation and Epistemic value dimension, Empowerment value within the Growth and Self-actualization value dimension, and respectively Security value within the Safety value dimension.
- 2) **Were characteristic of some specific user group(s)** – Social, Hedonic, Stimulation and Epistemic, and Growth and Self-actualization value dimensions, for example, became clearly visible among children and teenagers.
- 3) **Were characteristic to some specific service usage context** – The Quality and Performance value dimension seemed to be most relevant within work-related service purposes, the Safety value dimension in services intended for increasing security and awareness, and the Social value together with the Benevolence value dimension in services that contributed to value co-creation.

In brief, the understanding here suggests that several value dimensions explain value in experience better than does a single value dimension, and they would therefore provide better insights and results when examining the value in experience.

### 4.3 RQ3: What are the design and evaluation implications for different user groups?

As Wright et al. (2003) have stated, we cannot design an experience, but with a sensitive and skilled way of understanding our users, we can design *for* experience: *“Design for experience requires the designer to have ways of seeing experi-*

*ence, to talk about it, to analyse the relations between its parts and to understand how technology does or could participate to make that experience satisfying*". Furthermore, according to Arhippainen (2009), no one can design the experience of others, but one can design the elements that influence the user experience. To continue, Boztepe (2007) states that claiming that design creates value would perhaps be an overstatement, but design starts with the intention to generate value. Developing the capacity of objects for value is suggested as a better definition of design's role in value creation (Boztepe, 2007). In order to develop that capacity, it is essential for designers to have a good understanding of users' contexts and reasons for and methods of infusing services with different dimensions of value. The designers need to know what kind of experience they are aiming to achieve, and use that as a starting point for identifying what kind of design solutions need to be used to achieve those goals (ibid). As stated by Cockton (2008a), the right question is "what do users really want"?

### **4.3.1 Support to design and evaluation**

Here, the purpose is to help develop novel services in a way that they have the potential to attract their target population and generate better user experiences and value. The complemented value design and evaluation framework can be utilized to interpret what specific values in different usage contexts and situations provide the greatest potential for maximizing the value in experience for users. The following difficult questions should be answered in order to deliver superior user value: What do the users actually value, and of those aspects that users value, which ones would produce the best advantage? However, one needs to keep in mind that people have an enormous capacity and tendency to value services that sometimes have nothing to do with the intentions of their developers (cf. Boztepe, 2007).

Design for value in experience should start by collecting data from the users. Researchers should find out what value dimensions users prioritize, and which of these value dimensions are most important in the specific context and relevant to the target group of the service, how pleased the users are with value in experience at the moment considering these most relevant value dimensions, what are the causes of contentment/discontent in relation to most important dimensions, and how the user would like the value to change in the future. The values should be integrated into service design processes, and consequently, the results and following users' value in experience evaluated. Although users form very heterogeneous groups in their behaviour, some users tend to be directed by very similar motivations and desires for services. Therefore, it might be possible to classify the individuals by the degree of similarity in their value priorities, i.e. through value-based segmentation (Pura, 2005).

Research methods that require people to evaluate their experience of using a service do not adequately capture the perceptions of non-users or prospective users of the specific service (Helkkula et al., 2012). Users should be able to direct

the focus of the future product and not just react to existing designs (Kujala and Väänänen-Vainio-Mattila, 2009), as such imaginary experiences (Helkkula et al., 2012) might result in future service innovations and development ideas. This is especially important in contexts where service innovations are at such an initial stage that users or service providers do not have access to users' prior perceptions or expectations in order to form a basis for their value judgments.

Defining the targeted values and focusing on them from the very early design phase helps to focus the design on the most essential issues and key features of the service that are appreciated by the users. The involvement of users and gaining a deeper understanding of them ensures that the service will be suitable for its intended purpose in the environment in which it will be used (Abrás et al., 2004). The aim of value design and evaluation framework is to help designers to have a concrete focus and understanding of the (otherwise abstract concept) value in experience. The framework can be used as a foundation when selecting appropriate and relevant service features that respond to users' internal value priorities. Although the service may entail many useful features, those features may not respond to users' prioritized values, and thus it is essential to understand and identify the key values of the service in question and concentrate on them. Based on the target user group, intended service usage domain and the task the service is planned to fulfil, the designer can better dictate the most important and relevant service features prevalent in that individual service case, and then put effort and focus on those aspects and their antecedents.

Experience and value are subjective and only the individual concerned can know and feel their own experience, and we others can only analyse and interpret them. In addition, experience and value may be difficult or even impossible to express to another person (Arhippainen, 2009). But, as Arhippainen (2009) has pointed out, by using a combination of approaches for comprehensively understanding other people's experiences, we maximise our chances of revealing the deeper aspects of experience, which are difficult to convey verbally or in any other way. Thus, we should listen to *what people say* in order to find out the explicit knowledge that people are able to express in words; watch *what people do* and *what they use* in order to obtain information on observable experience; investigate *what people think and know* to achieve their perceptions of experience; and understand *how people feel* in order to be able to empathize with them. The findings here strongly suggest that the evaluation of value in experience cannot be restricted to individual user experience episodes in a sporadic occasion, but it should be treated as an ongoing evaluation within the full scope of user experience.

Furthermore, users' perceptions about what a technology does and how it works shape their orientation towards it (Poole et al., 2008). Thus, as stated by Boztepe (2007), it is essential for the service to have sufficient visible cues to signal its potential value for the users. Service qualities are treated as cues, or indicators, of value, they are interpreted by the user and they reside in the service. Through their visible and intrinsic characteristics, cues convey certain potential uses and meanings, which can be evaluated against the requirements of the user's context and user values.

In addition, new value manifestations need also to be taken sufficiently into account when utilizing the value framework for designing for and evaluating value in experience of mobile services. Value is context- and situation-specific, and can change from one context to another, not to mention its subjective and dynamic nature that shapes value from one user to another. The value design and evaluation framework acts as a guide for articulating and understanding the user's value in experience, but it cannot be treated blindly as an all-inclusive framework that will capture all the imaginable value manifestations across all user groups, services and usage contexts. Thus, one needs to utilize the framework with an open mind, acknowledge the likely emerging novel value manifestations and complete the collection of value parameters when necessary. However, the author believes that the majority of the value dimensions included in the framework is likely to remain applicable also to other types of digital services.

### 4.3.2 Characteristics of value in experience for different user groups

What follows is an overview of the different user groups that were present in individual case studies. They are examined here more closely through the value dimensions that became clearly visible and were identified as most important for them in that particular service usage context.

#### 4.3.2.1 Children

The debut age for mobile phone usage has fallen over the years, so for children of a young age too it is today more like the norm to possess a mobile phone. It seems that for the vast majority of children the mobile phone has been given to them so that their parents could contact them whenever needed. This provides parents with an important psychological component in the form of surveillance, at the same time as providing children with more freedom without physical control. However, e.g. Jarkievich et al. (2008) have observed the dual nature of mobile phones in children's everyday use; phones are simultaneously serious and important communication tools for parents, but are also being treated and valued primarily by children themselves as resources for acting locally in the group, sharing media content and for bonding with peers.

#### *Important values*

Publication IV explored children's experiences with school attendance supervision service. The value that became clearly evident when children described their experiences with the service was **Benevolence**. The children appreciated that they could provide valuable information to their parents. They were also very proud that they were given responsibility for taking care of their very own smart cards. The other value dimension that was identified as most important and relevant to the children was **Social**. The service and related technology provided children with

special opportunities for achievement and a way to demonstrate competence. The children were proud that were able to master the technical components. As the trial did not involve the whole school, it provided them with a means for status differentiation. The children felt that it was 'cool' to possess a smart card and this was a source of pride to them. Using the service gave them social recognition among their peers. It also became evident that the technology was used as a means of positioning oneself in a social system when the children compared their smart card-based service with the same NFC phone-based service that was used in the secondary school. The mobile phone clearly possessed a higher status value than the smart card. The **Growth and Self-actualization** value also became evident, as for many children the trust of adults seemed to be a boost to their self-esteem. The children were also very proud that they were able independently to use the service without help from the teacher. The **Hedonic** value also became visible in this user group. The children were very excited when they heard they were participating in the trial and would get 'Robo' cards of their very own, a similar type of card to one some of their parents used at work.

#### *Design implications*

In this dissertation, the case study with children was conducted in the confines of a school environment, which therefore limits the investigation of children's user experience to a more utility-related usage. But other user studies, e.g. by Facer et al. (2004), have revealed that even this young age group has grown up expecting rich and immersive media experiences. The study findings here revealed interesting information on the following children's value priorities that may also be assumed to be valid in other usage settings such as homes and school yards.

- *Socially oriented benefits* – utilize the importance for social recognition and status differentiation among peers, as well as a feeling of achievement through the demonstration of competence
- *Support for growth and self-actualization* – provide opportunities for independent action, feeling of empowerment, support for the enhancement of self-respect
- *Arousal and variety, and affective benefits* – provide experiences of novelty, curiosity, fun and play
- *Feeling of importance* – provide opportunities for a feeling of trust and respect by significant people in their lives, a feeling that their actions matter and have meaning to other people.

#### 4.3.2.2 Teenagers

The mobile phone has become an everyday appliance not only among Finnish teenagers, but among young people in different parts of the world (Oksman and

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Turtiainen, 2004). As case Amazing NFC demonstrated, teenagers are a tough target group when designing mobile services. For young people, mastering new communication technology has become the norm (ibid). As they have seen and experienced “everything”, their standard for services increases. They have high expectations concerning new technology and the content and quality of the service. Their experience and considerable knowledge in using mobile devices means that this user group is hard to amaze or even satisfy.

### *Important values*

In Publication II the user group was comprised of teenagers who experimented with a novel mobile learning service. **Socialization** was one of the value dimensions most visibly observed among this user group. The students valued highly the possibility of collaborating with a friend throughout the lesson, and reported that working in pairs was one of the best things in the experience. Students also formed bigger groups during the lesson. They also gained **Growth and Self-actualization** value through the nature of the service concept that enabled them to go through the lesson on their own and at their own pace. However, the service caused mixed feelings towards the actual value delivered for **Stimulation and Epistemic**, the most prominent individual values of which were challenge and variety. One factor contributing to a negative perception of the content provided and related tasks may be the association made by naming Amazing NFC after the popular TV show “Amazing Race”. The naming might have set expectations and mental impressions that were not fulfilled, i.e. students felt that the service did not provide them with a sufficient degree of challenge and excitement to maintain their interest and motivation during the lesson. Students were expecting more activities, especially physical and problem-solving tasks and competitions, and were disappointed when the Amazing NFC experience failed to deliver these. Thus, **Hedonic** value was also observed to be important, as teenagers clearly stated a desire for excitement and thrill in “treasure hunting”, which, however, was not fulfilled to the extent they were expecting. In addition, **Social** value became visible as students identified the lessons having a potential to provide enthralling opportunities for social recognition and comparison.

### *Design implications*

Teenagers seem to have developed their own culture in using mobile communication devices, from which we can ascertain, for example, their focus in the use of text-based communication channels. The mobile handset is also used to fill the empty moments of everyday life; for example playing mobile games helps teenagers pass their free time. As case Amazing NFC demonstrated, teenagers desire more interaction with their friends, and this phenomenon is emphasized by how teens use mobile communication to maintain their social contacts and form new relationships (Oksman and Turtiainen, 2004). The mobile phone also serves teens as an important instrument for defining their relationship with others and presenting

themselves. Mobile communication has also increased the freedom in teens' relationships with their parents (ibid), and freedom is something young people embrace. As discussed above, the study findings provided information on the most relevant value dimensions for teenagers in the context of the given service, and they could be translated into the following design recommendations:

- *Support for growth and self-actualization* – provide opportunities for independent action, a feeling of empowerment, support for the enhancement of self-respect
- *Socially active* – provide novel possibilities and forms of social interaction
- *Construction of social identity* – provide a channel to demonstrate social status and comparison among peers
- *Innovative ways of interacting with media content* – provide novel possibilities to be innovative and physically engaged
- *Intrinsically motivating attributes* – focus on aspects such as challenge, competition, and excitement (Malone and Lepper, 1987); getting to use one's own skills in the fullest range possible helps make activities enjoyable and intrinsically satisfying (cf. Brandtzæg et al., 2003).

#### 4.3.2.3 University students

College students are very commonly used as test subjects since they are so easy to recruit as study participants. However, it can be questioned how well the college students represent the general population (if the service is targeted on the general public). According to Parasuraman (2000), the technology-readiness construct refers to people's "propensity to embrace and use new technologies for accomplishing goals in home life and at work". Students are considered to have a higher technology readiness to use innovative technology in their personal and academic lives than the general population.

##### *Important values*

In Publication I the mobile service was specifically intended for college students, whereas in Publication VI the mobile service was eventually targeted on a wider population, yet most of the study participants were university students. Values that became most clearly visible in Publication I were those related to service values; **Convenience**, **Personalization**, and **Localization**. The students placed great value on the new possibility of accessing important information via their mobile phones, and experienced a greater degree of freedom and flexibility in accessing that content. They found it important that they could control the use of the service by deciding when and where to use it. In addition, the students clearly showed a desire for customized information that would be adapted to the individual users based on their contextual information, personal preferences and needs. Even

though the goal of the Mora service was to increase the usefulness of the campus intranet by offering a mobile access to intranet content, during the study it was revealed that this goal was not met to the extent that could have been possible. The students placed great value on convenience, but it was concluded that mobility does not provide enough added value for the users with the Mora service in its current form. It seems that many students felt that they could already access almost the same content via the web; Mora is just a mobile substitute for the existing solution.

In Publication VI the most relevant value dimensions identified were **Convenience**, **Safety**, and **Benevolence**. Here too users placed most value on the possibility of receiving critical information on their mobile phones, i.e. the device that is always at hand. Thus, the novel service was able to provide superior value compared with the existing solutions. Users also reported that the service would not only provide a better feeling of safety for themselves, but also had the potential to ease the concern of their close relatives and friends by providing information on the whereabouts of their family and friends. Value creation for other users and first response was seen as a great source of motivation and commitment for active use of the service. Users wanted to know how their phone's data was used to provide valuable information and help other people during crises, thus also revealing the prominence of **Social** value. Users also experienced it as very important to be able to receive information that was automatically adapted according to their location, thus marking the high relevance for **Localization** value.

### *Design implications*

The study findings here revealed interesting information on the university students' value priorities and they could be translated into the following design recommendations:

- *Convenience* – provide flexible and effortless access to the service
- *Socially oriented benefits* – provide support for social recognition and comparison
- *Personal relevance* – provide content and information of high relevance, customized according to user's personal preferences and needs and current contextual information
- *Balance between demands and control of interaction* – offer the possibility of using and developing skills, and the availability of decision-making authority or freedom of action; the user's feeling of being in control of interaction (cf. Brandtzæg et al., 2003)
- *Superiority over existing solution* – ensure the significance of relative advantage (Rogers, 1995); a new service solution should be better than the "goodness" of the current one.



for the users could be analysed. It was also discovered that older users may have some difficulties in comprehending the intended purpose of the service and trying to imagine the future situation of using the service. Therefore, the actual practical use of the solution is essential in order to communicate the benefits of the service to the user, and for the user to better understand how the service brings them value. Here **Convenience, Personalization and Growth- and Self-actualization** value dimensions became most visible. The service solution was adapted to each individual user according to the user's preferences and sensory faculties making use of different modalities. Furthermore, the service was developed in as easy and comfortable a way to use as possible to lessen the physical and cognitive burden placed on the older user. The users succeeded in wayfinding tasks with the help of the aid, and thus the service was seen to provide motives and empowerment for these older people to cope with their daily activities independently without having to rely on the help of other people.

### *Design implications*

An individual's decline with age is likely to affect two or fewer capabilities. This is not a population for which concentrating on one or two specific problem areas will provide a widely applicable solution. Services need to be more customizable and flexible than ever according to the rapidly changing life conditions. This proved especially true in Publications V and VII where a great need for modifying the service was identified based on e.g. individual older users' differing sensory faculties. Also, older users in particular have a limit to how much cognitive activity they can engage in simultaneously. The question for designers is how much of that capacity must be used in coping with the interface and how much is available to apply to the users' real task. It is important that a mobile solution for the elderly places minimum cognitive demands on the user to avoid causing distraction and confusion.

Jones and Marsden (2006) emphasize that new mobile products will only be accepted and seen as providing something valuable if they fit in with the other things that fill the user's life, i.e. a mobile service should work in harmony with the things around it and integrate with the user's other resources. This was felt to be especially true with older users, as one important aspect identified in Publication V was that the solution needs to integrate or support the individual established procedures and methods created and adopted by the users, since a safe, predictable environment is more critical as capacities for coping with change wane (cf. Schwartz, 2006). The findings on older people's value priorities emphasized the following aspects to be taken into account in the design processes:

- *Compatibility* – ensure compatibility with the user's existing way of living and integrability to the individual established practices the user has followed
- *Customizability and flexibility* – support adaptability; services that can change in order to better support the repeated tasks and particular behavioural characteristics of each individual user

- *Multimodality* – re-direct some of the information processing from e.g. the visual channel to hearing; the other impairments of the users are then complemented and the cognitive load reduced
- *Socialization* – Support the existing ones and promote making new social contacts.

#### 4.3.2.5 General public: universal design

As these seven different case studies point out, mobile service user groups are very heterogeneous. These differing populations, some of whom may be functionally limited by age, disability, or life status, i.e. all potential users, deserve the right to be acknowledged and respected. The digital revolution has dramatically changed how we access information, services, and goods nowadays. However, the restrictions imposed by services designed without regard to the needs and special characteristics of differing populations are significant but often unrecognized. In this way some user groups are often left behind by this technological development, thus posing a threat to their ability to participate in society, communicate, and be equal citizens. In consequence, also mobile service design needs to be more accommodating of individual differences.

In this examination, teachers in the case Amazing NFC (Publication II) and consequently parents and teachers in the case School attendance (Publication IV) are omitted from closer analysis, as their number was limited and the focus was set on user groups whose value in experience was not so closely tied to their role as a teacher or parent and determined by work and parental responsibilities. As life circumstances impose constraints on pursuing or expressing values, people adapt their values to their life circumstances by upgrading the importance they attribute to values they can readily attain, and downgrade the importance of thwarted values (Schwartz, 2006). Thus, analysis of their value in experience was considered not to bring very many meaningful conclusions from the point of view of the general public.

#### *Important values*

In Publication III the mobile service was based on a touch-based interaction technique to make the information access easier and faster for all users, and especially valuable for those who have a limited ability to use mobile phones due to e.g. limited vision or poor hand-eye coordination or for reasons of illiteracy. The most relevant value dimension visible was **Convenience**. The novel mobile service provided a new way of accessing service content, which was perceived as very easy and convenient in contrast to the slow and challenging use of the existing practice. Other significant values for the users were **Localization** and **Personalization**. The users were most interested in location-specific content, and also expected the content to be up-to-date and highly integrable with their current context and needs, and were very disappointed when it failed to be so. Another value

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dimension relevant for the users was **Quality and Performance**. The users encountered tags that were not operational, but they expected getting some response from all the tags that were available for touching, and when that did not happen users were very irritated. Users were also annoyed by the inconveniently long download times of some content. **Socialization** value also became visible to the users. In some cases users did present concerns on how easy Internet access might negatively affect social interaction. The nature of current Mobile Internet content typically is most suited to personal use, and consuming it in social contexts was felt to reduce interaction between people.

### *Design implications*

Universal Design recommendations specify that a product should not be specialized for any particular population but should be suitable for most users. Universal design is the design of products and environments to be usable by people of all ages and abilities, to the greatest extent possible, without the need for adaptation or specialized design (Center for Universal Design, 1997). The information acquired from e.g. the aforementioned case study stressed the following value aspects to consider when designing services targeted on everyone.

- *Reliability* – ensure reliable service performance of uniform quality
- *Adaptability* – provide service that can adapt and can be modified to better suit to special characteristics of different users
- *Availability* – provide easy and convenient access to information
- *High quality and relevance* – desire for variation suggests that there is a universal human interest in novelty and attraction for spontaneity, freshness and a certain degree of unpredictability (cf. Brandtzæg et al., 2003); services with a static design and at the same time no novelties or changes will lose the users' interest
- *Social aspects* – service that fosters and encourages social interaction supports an enjoyable user experience (ibid); social contact is rewarding, and interactive technology is not, and should not be, socially isolating.

### **4.3.3 Summary**

This section contributed insights regarding the value in experience design and evaluation implications for different user groups. An analysis of different user groups' perspectives in specific mobile services usage contexts was provided. The most relevant value dimensions revealed in research findings were highlighted and discussed in relation to every user group. Consequently, recommendations for design were proposed based on these identified value priorities.

## 5. Discussion

Walsham (1995) represents four types of generalizations from interpretive case studies: (1) the development of concepts, (2) the generation of theory, (3) the drawing of specific implications, and (4) the contribution of rich insight. In this dissertation the interpretive cross-case study approach was used to develop the “value in experience” *concept*. Furthermore, the author draws on her rich empirical data from a variety of case studies to construct a *theoretical framework* for value design and evaluation. In addition, the author draws *specific implications* in the design of mobile services for different user groups, based on an in-depth understanding gained through a set of mobile service case studies. The final category of generalization, i.e. that of the ‘rich insight’ from interpretive cross-case studies, is also provided, as the author captures *insights* from the findings of a variety of case studies on a range of topics, including the nature of value in experience and its manifestations in case studies with different user groups, and their value priorities in specific service domains.

Capturing and evaluating the user’s value in experience is seen as an essential aspect of developing new mobile services and assessing the existing ones. Information and understanding on value in experience and underlying personal user values provides a good foundation to attract people who share similar value priorities, and generates the necessary information to create a differentiated service offering for targeted user group(s). Value-oriented segmentation is proved to be better than the traditional approaches, such as demographics, in segmenting users (Pura, 2005). By gaining an understanding and acting on users’ personal values we can better comprehend user behaviour and reach potential users (Durgee, 1996). In addition, value in experience provides understanding on how to market services to users and efficiently demonstrate concrete benefits and value in a specific context (Pura, 2005).

The suggested value in experience conceptualization offers insights to help understand the dimensions of value, and serves as a lens to guide interpretive analysis of value in experience. The value framework can be used in the context of designing technology-based services as a tool for analysing the value preferences of future user groups. However, the diverseness of user values and the personal and dynamic nature of value in experience proved the difficulty in revealing an unambiguous explanation of the construct, and the investigation and measurement

of it scientifically. Evidence received from user experience and value is never an objective record of what really happened, i.e. we need to acknowledge that the researcher cannot fully reveal “pure” experience (Helkkula et al., 2012). Experience and value are subjective, and only the individuals themselves can know and feel their own experience, and we others can only analyse and interpret them. Explicit speech and investigation of inner thoughts are an essential part of the sense making of human experiences that illuminate but do not fully reveal lived experience, but rather represent respondents’, researchers’, and readers’ sense making in relation to particular phenomena (ibid). In addition, experience and value may be difficult or even impossible to express to another person (Arhipainen, 2009).

The developed value framework could be helpful when collecting data on users’ value priorities on value in experience, as it structures the discussion and may help the user to verbalize tacit knowledge related to phenomena. There is often a gap between what developers and services providers believe that the users value and what the users actually value. Thus, this framework could be aimed at shrinking this gap. Here, the different user groups were examined more closely through the value dimensions that became clearly visible and were identified most important for the users in the specific service usage context. It was discovered that a number of value dimensions may simultaneously make differential contributions to value in experience in specific usage contexts with different service domains. Thus, in this research widely generalizable conclusions regarding the range of value and their distribution across the case studies and different user groups could not yet be drawn. For individual users the dimensions of value are differentially weighted, and the same service could provide very different value to different user groups. It seems impossible to unambiguously prioritize the values because they appear to work together in such a way that no single value is more important than others so that it would be sufficient on its own; instead, a set of value dimensions contributes accumulatively to value in experience.

However, from the broader purview, not all the services can be evaluated solely from the viewpoint of the users. A successful design must take into account the wide range of stakeholders of the service, people who will be affected in some way by the use of the service or make decisions about its acquisition (Abrams et al., 2004). For example, in the case of public services (as in Publication IV), value must also be investigated from the viewpoint of society and its citizens. The public have values in the same way as individuals; i.e. value can also be collective and created or shared with other people (e.g. Cockton, 2006); and thus, values can serve both individual and collective needs (Schwartz, 1992). In Publications II and IV aspects of collective user experience (Battarbee, 2003) could be seen, as the users created the experiences together and reflected on them together. It appeared that, even though the users individually experience value, they also seem to share a similar type of experiences with other users of the particular service. Worth-centred development must be able to identify collective value within societies and create designs that have an impact beyond the sum of any impact on individual users (Cockton, 2006).

The individual case study findings and the developed value design and evaluation framework may be seen as a valuable tool, as they help to identify and describe the key value dimensions that contribute to users' value in experience. However, even though the research work done here relates only to mobile services, the author would argue that the revealed values also arise in other types of digital services in personal use. The value dimensions suggested here are not only seen as mobile service-specific values, even though some of the values might be emphasized in mobile service contexts (such as 'context-sensitiveness', as it is often important for mobile users to access location-based information on the move; 'flexibility' as the freedom of time and place provided by mobile phones is attractive compared to other alternatives; 'availability' and 'discoverability' as easily and instantly gained information can be very critical and valuable for mobile users). Thus, the author considers the developed value framework to be a good basis for a generally applicable value framework.

Other researchers' work was used to support the description and naming of value parameters. If corresponding, established values were not to be found in the literature, at this point of the research process some of the value names were chosen on an ad-hoc basis. Naming of values will be one area of future research. In future work the value names will be iterated together with the users and designers to ensure the understandability of the value attributes.

## **5.1 Limitations and validity**

In this dissertation the focus is only on those users who are direct users of the service evaluated, and other stakeholders are omitted from the scope of the research. The basis for the formation of in-depth understanding is on user experiences. Value in experience is investigated through user experience which the users themselves interpret and evaluate. The analysis concentrates only on values that are relevant for the users in the context of evaluated service, and leave other value types outside the discussion. Furthermore, this work examines a particular technology in a particular environment, and the research has not addressed the value in experience outside the scope of this particular setting. The evaluation of value in experience through objective measurements regarding the impacts of service adoption was left out of the scope of this research work. In consequence, the value evaluation, i.e. the subjective value in experience, presented in this dissertation does not necessarily correlate with objective measurements of the same parameters.

Furthermore, interpretive researchers report their interpretations of other people's interpretations (Walsham, 1995). Thus, the role of the researcher should not be viewed as that of an objective reporter, since the collection and analysis of data involves the researcher's own subjectivity. The interpretive research process assumes that the researcher can never assume a value-neutral stance and is always involved in the phenomena being studied (Orlikowski and Baroudi, 1991). From a hermeneutic perspective, it is assumed that the researcher's presuppositions

affect the gathering of the data, and the analysis affects the data and the data affects the analysis (Myers, 1997).

In order to collect reliable data on user experience it is necessary to allow the users to use the evaluated service on their own, and preferably for a relatively long period. Findings by Knutsen et al. (2005) indicate dynamism and malleability in user perceptions during the mobile service trial period. The underlying assumption is that first-impressions and alterations can have a decisive effect on the adoption and use of mobile services. Thus, the fact that case studies are limited in time may and probably will have an effect on the user experience, as many aspects of user experiences cannot be reliably studied and evaluated in a matter of hours or even days. However, user studies of shorter duration are also more useful than laboratory studies for demonstrating and reflecting more realistic, real-life usage situations. In addition, as the users knew that the case study was planned to last for a fixed period only, this might have reduced their need to generate strategies for integrating the new service into their everyday lives (Isomursu et al., 2011). In some cases users might have also been quite tolerant towards minor inconveniences, as they knew they would not have to cope with them for long. If the users were to think that they were stuck with the technology, they would need to create strategies to successfully integrate it into their everyday lives.

Furthermore, the users all knew that their behaviour was being observed, and their opinions taken into account during the case study, and therefore the variables suggested as responsible for the Hawthorne effects – such as special attention, change in routine, novelty, enthusiasm related to trying out something new, etc. – probably had some influence on the results (Diaper, 1990).

Users' value in experience may well differ in different countries and cultures, and the presented findings related to the priorities of different value dimensions should therefore be interpreted and applied with caution across different international markets.

The concept of value in experience and the developed value design and evaluation framework have not been tested and validated through empirical studies, but they have been formatted post-hoc based on empirical user experience data achieved from the field with the end-users. Thus, one additional limitation that can be seen is that value in experience was not the original research objective in the case studies, and if it had been, would the findings presented in this dissertation have been different? But the author considers that the selected research approach of cross-case analysis and synthesis has provided insights into solving the research problem of understanding and articulating the value in experience of novel mobile service solutions, taking into account the viewpoint of different user groups and their internal values and motivations. In addition, the author's personal experience and expertise acquired in seven individual case studies increases the validity of the findings.

Furthermore, the author acknowledges the doubt expressed by e.g. Friedman et al. (2006) as to whether any value classification could be comprehensive. Thus, the importance of a value analysis is recognized here that is based on a context-specific description of values. New value manifestations need also to be taken into

account sufficiently when utilizing the value framework in designing for and evaluating value in experience of mobile services. The framework acts as a guide for articulating and understanding user's value in experience, but it cannot be treated blindly as an all-inclusive framework that will capture all the important values across all user groups, services and usage contexts. Therefore, it is proposed that both the pre-conceived values and a context-specific description of values are used and treated as complementary to each other in order to ensure that no important context-specific details are left out.

## 5.2 Ongoing research with the value framework

The value design and evaluation framework is currently being utilized for evaluating the value in experience in the European 'WeCare' research project within Ambient Assisted Living (AAL) joint programme. The project's goal is to encourage older people to participate in their social networks in order to prevent isolation and loneliness. The empirical user studies in the project have already been concluded, and the related user data collected. Now the project work is at the stage of analysis and reporting of the study results. The value design and evaluation framework is being used to evaluate the value manifestations of two user groups, namely 1) older people and their informal caregivers, and 2) other relatives and family. The author herself applied the framework for the value analysis of older people and their spouses, and another project partner utilized the framework for evaluating the value in experience of relatives. This other project partner kept a diary during the value evaluation process, and the following key findings from the use of value framework were revealed:

- Value parameters need descriptions, not sufficient on their own to fully interpret their "meaning".
- Refinements for some individual value parameters' descriptions needed.
- With the framework it is easy to identify both expected and perceived value.
- Value evaluation with the help of the framework leads to a richer analysis and findings than traditional content analysis.
- It is easy to identify both values that 1) came true and also values that 2) did not come true.
- Value parameters can be used as a source when defining a measurement for value in experience (next step in future studies).



## 6. Conclusions

The goal of this dissertation is to better understand and articulate the value in experience of novel mobile service solutions, especially from the viewpoint of different user groups and their internal values and motivations. The empirical basis for this dissertation is the user experience findings from seven individual case studies conducted in the field. The thesis proposes and illustrates an understanding of the term “value in experience” which refers to the user’s iterative (both sub-conscious and conscious) interpretation and evaluation of user experience. An initial value framework was developed as a synthesis from the literature, and by adapting and utilizing this framework to particular mobile service case study contexts, the user experience findings obtained were re-examined from the value point of view by evaluating users’ value in experience from the case studies. Value in experience was a result of active user engagement with a mobile service, not a passive receipt of a pre-defined set of values from developers or researchers. In addition to capturing value in experience, the value framework was used for identifying the expected designer values in order further to examine the interesting congruencies and discrepancies between designer value and value in experience.

Based on this new analysis, value parameters from individual mobile service case studies were interpreted and categorized. The initial value framework was further complemented by relying on the value parameters identified from case studies. All the case studies thus iteratively contributed to the development of the value framework by validating (through making more concrete) and extending (through sub-categories) the values in the initial value framework. Also presented here are an understanding and rich description of value dimensions relevant to specific user groups and service domains in varying usage contexts. Furthermore, guidelines for value in experience design and evaluation were proposed related to different user groups.

Results presented here from each individual case study form the evidence of the research questions of this dissertation. Analysis and interpretation of the value in experience does not aim to produce generalizable findings from large populations, but rather seeks an understanding regarding the value in experience within different user groups and service contexts. The value framework has been referred to in the context of mobile services. Yet, the author believes that the framework proposed here, as well as the concept of value in experience, have potential

applications also in other types of digital services based on personal use. The developed value design and evaluation framework offers not only a means for interpreting and evaluating user's value in experience but also provides a conceptual tool and a language for thinking and talking about value. The author hopes that this thesis will encourage further research, clarification and empirical testing.

However, one needs to accept that there is always a part of user experience and value that will remain a mystery to researchers. This is not only because of the tacit experience that is impossible for the people to express both verbally or non-verbally, but also because of a great number of factors that have an influence on user experience and value in experience at the same time (cf. Arhippainen, 2009). In consequence, a researcher cannot ever be truly certain, why at this moment, in this specific situation, a user was experiencing in this way (ibid).

## **6.1 Theoretical implications**

This dissertation provides new scientific knowledge for researchers as follows. The first theoretical contribution of this thesis is the new focus on value through emphasizing its close interrelationship with user experience. The second contribution is the conceptual model of value in experience and its key elements. The third theoretical contribution concerns the focus on value in experience in the context of novel mobile services. The fourth contribution is the value design and evaluation framework. Even though the framework was constructed based on mobile services, it is seen as a good basis for further improvement towards a more generally applicable framework.

The characterization of value in experience and the proposed value framework complement other pre-defined user-perceived value concepts and measurement scales by other researchers. A value framework can help us to think more concretely about the concept of value in experience in terms of preferred service features and their performances, and valuable outcomes stemming from user experience with service in a specific situation. The empirical case studies analysed here offer a better foundation for taking positions regarding the concepts of user experience and value and the relationship between them.

## **6.2 Practical implications**

As Vargo and Lusch (2004) have stated, the service experience does not exist until the user perceives it, and therefore, the company is not able to offer predetermined value to the user, but only the prerequisites for the service experience and value. Findings from several case studies have revealed that users and developers often have different expectations and value priorities as regards a particular service offering, and thus, user involvement from the start may help developers to better internalize user's value priorities and make better informed design decisions. The insights gained into important value dimensions of different user groups and the value framework can help close the information gap between de-

velopers and users by helping the value the developer intends to provide to the user to coincide with the value desired by the user. Design work should not be based on the users' generic models, since developers often have a vague or contradictory idea of the intended users of the service, and may base scenarios on people similar to themselves (Kujala and Mäntylä, 2000). Also, developers often underestimate the diversity of users (Kujala and Kauppinen, 2004).

The value framework can provide a helpful communication tool for understanding value in experience by the end-users for the purpose of decision-making, as it establishes a vocabulary and conceptualization that can be used to describe the construct. The framework can be harnessed to investigate a more extensive and complete set of the user's desired value dimensions, especially those related to preferred consequences, as the desired service attributes are likely to be more visible and easily communicated. The value framework makes users' inner value priorities more distinct and easier to recognize, and it can thus be used to better predict and understand user behaviour (cf. Madrigal and Kahle, 1994). Interpretive research methods, such as interviews, narratives, diaries and observations are recommended for collecting data about value in experience.

By assessing the value of the potential users, the company can acquire a benchmark for the service's intended value, i.e. 'designer value'. Users may reveal preferences and desires for numerous values, and thus, possibly a large sample of important user values should be able to be screened to a manageable number to retain the practical possibility of steering the strategic choices to only those values that are of most importance. The identified value dimensions and their priorities could then be used for directing design decisions towards delivering value that is highly prioritized by the users. This way the company can guide and improve its service development work before launching the service on the market, using the framework and associated design guidelines to optimize the value provided by the service experience. The value-based approach can also act as a basis for planning effective marketing strategies that are differentiated to user groups that are guided by similar value priorities for using mobile services, and can thus help focus marketing communications on those value areas that are perceived as most important by the users.

### 6.3 Future research

The developed value framework can be used to aid in developing more efficient research methods for identifying relevant value dimensions and utilizing the identified set of values in development work for providing attractive and valuable mobile services to different user groups. Here, the value formation was not fully understood during the design phase, i.e. the designers of the service were not able to envision the values experienced and prioritized by the users. In order to understand what the user values, service providers should strive towards involving users in the innovation process (Woodruff, 1997). In addition, when users have been involved in the design processes, they know from an early stage what to expect

from the service, and they feel that their ideas and suggestions have been taken into account during the process (Abrams et al., 2004). This leads to a sense of ownership for the service that often leads to higher user satisfaction and smoother integration of the service into the environment (Preece et al., 2002). However, interpretation of value propositions of service solutions that incorporate new technology in a fashion that has not been previously available is difficult before the users actually use the particular service offering. People may not be able to articulate (name) what they may value; only what they have found to be worthwhile (Cockton, 2006).

Even though it is practically impossible to predict and understand all the details of how users will experience and perceive value before they actually use the service, as values seem to unfold and become visible through interaction and use (e.g. Isomursu et al., 2008), the next step would be to explore the use of the value framework at the design phase. Thus, the consideration of value in the development processes and the early identification of intended value is another area for interesting future research. If the values are taken into account from the very beginning, how would that influence the design of the service and the success of the final outcome?

Future research should also focus on identifying potential values that have been missed out, despite the literature sources reviewed and synthesized and the iterative cross-case study analysis. One can also argue whether any value classification can be fully comprehensive. Thus, the value design and evaluation framework acts as a guide for examining user's value in experience, but it cannot be treated blindly as an all-inclusive framework that will capture all the relevant values across all user groups, services and usage contexts. Novel context-specific value manifestations need also to be taken sufficiently into account.

Also, an interesting future research question is related to different value dimensions; which dimensions occur at which stages of user experience and do different dimensions dominate at different stages and contexts? Utilitarian values such as convenience might be expected to arise during use as they derive from direct interaction with a service. Furthermore, it would be interesting to study the interdependencies between different value dimensions, such as dynamic relations and possible conflicts among and between values, for the early identification of potential additional key value dimensions for the user. This could make the early design of the service more focused, resulting in better user feedback during the design process and in a service that would better meet the target users' value priorities.

The nature and variations in value in experience should be investigated and compared more closely across different contexts, dimensions, and UX stages. In this research it was not yet possible to draw widely generalizable conclusions regarding the range of values and their distribution across the case studies. But the work done here and these suggestions on future research are seen to pave the way for a more generally applicable value design and evaluation framework.

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## Appendix A: Values in case Mora (Publication I)

	Value parameter	Identified in case Mora
<b>VALUE IN EXPERIENCE</b>	(+) Ease of adoption	Taking the service into use was easy
	(+) Ease of use	Service usage was easy
	(+) Availability	Easily available and accessible service content
	(+) Appropriateness	Convenient to use the service
	(-) Superiority	Did not provide superior value compared to existing/alternative solution
	(+) Technology suitability	Possibility of using mobile phone to access campus intranet
	(+) Flexibility	Service could be used anytime and anywhere
	(-) Adaptation	Desire for personalized content (not yet featured in current service)
	(-) Relevance	Desire for content of high relevance (not yet featured in current service)
	(-) Context- sensitiveness	Desire for context-sensitive content (not yet featured in current service)
	(+) Up-to-dateness	Provides topical information
	(-) Novelty	Not enough novel solution compared to existing practice
	(+) Empowerment	Control over when and where to use the service



## Appendix B: Values in case Amazing NFC (Publication II)

	Value parameter	Identified in case Amazing NFC
<b>VALUE IN EXPERIENCE</b>	<b>Students</b>	
	(+) Ease of adoption	Quickly learned to use NFC technology
	(+) Ease of use	Easy to use NFC technology
	(+) Appropriateness	Service usage was natural and effortless
	(+) Technology suitability	NFC suits the concept well
	(+) Superiority	Preferred over traditional classroom learning
	(+) Discoverability	Easy to find NFC tags at control points
	(+) Context-sensitiveness	Content relevant to usage context
	(+) Integrated usage experience	Provides integrated usage experience at control points
	(-) Social recognition	Desire for competition and benchmarking with other students
	(+) Social comparison	Compared and positioned oneself with others by checking how the others are doing on track
	(-) Play	Does not provide the desired "adventure", feeling of excitement
	(-) Enjoyment	Does not provide intrinsically motivating or thrilling experience
	(-) Learning	Does not provide new, useful knowledge or skills
	(+) Novelty	Provides novel learning experience
	(-) Variety	Does not provide enough variety at the tasks and activities
	(-) Challenge	Need for more challenging tasks, more difficult control point locations, etc.
	(+) Empowerment	Provides the feeling of control over the learning experience
	(+) Independence	Provides independent learning experience
	(+) Social interaction	Working in pairs throughout the lesson
	<b>Teachers</b>	
	(+) Ease of use	Following students' progress during the lesson easy
	(+) Availability	Information on students' progress on the track easily available
	(+) Appropriateness	Monitoring the students realized well with the web interface
	(-) Technology suitability	NFC did not bring added value
	(+) Superiority	Main advantage moving the learning experience outside the traditional classroom
	(+) Reliability	Service was trustworthy and students could be followed on the track
	(+) Learning	Students learned new knowledge and life skills
	(+) Novelty	Provides a novel learning experience
	(+) Variety	Brings variety to traditional teaching
	(+) Self-esteem	Gives students more courage to move around their hometown
	(+) Independence	Encourages students to become more independent
	(+) Social interaction	Supports social collaboration among students
(+) Security	Students' progress could be followed and they could be contacted if needed	
(+) Freedom from fear	Perceived security and trustworthiness leading to peace of mind	
(+) Awareness	Constantly aware on students' performance and progress on the track	



## Appendix C: Values in case InfoTag (Publication III)

	Value parameter	Identified in case InfoTag
<b>VALUE IN EXPERIENCE</b>	(+) Ease of adoption	Easy to learn to use touch-based interaction technique
	(+) Ease of use	Easy to use touch-based interaction technique
	(+) Appropriateness	Touch-based interaction was pleasant
	(+) Availability	Information easily available and accessible through the infotags
	(+) Discoverability	Finding and accessing information tags was easy
	(+) Technology suitability	NFC supports the service concept well
	(+) Superiority	Provides a better access to mobile internet content than the current practice
	(-) Reliability	Encounter of non-operational and broken tags
	(+) Efficiency	Provides fast access to mobile internet content
	(-) Performance	Annoyance due to long download times of content
	(-) Relevance	Content not highly relevant or integrable with one's needs
	(-) Up-to-dateness	Content often static, not updated
	(-) Context-sensitiveness	Content did not take full use of location
	(-) Integrated usage experience	Negative effects on social interaction on public places
	(-) Social approval	Awkwardness caused by consuming loud video content in public places
	(-) Social interaction	Negative effects on social interaction



## Appendix D: Values in case School attendance (Publication IV)

	Value parameter	Identified in case School attendance
<b>VALUE IN EXPERIENCE</b>	<b>Children</b>	
	(+) Ease of adoption	Quick to learn to use touch-based interaction technique
	(+) Ease of use	Very easy to use touch-based interaction technique
	(+) Technology suitability	Service integrates well into everyday routines at school
	(+) Superiority	Children had only positive thoughts about the service
	(+) Achievement	Provides a way to demonstrate competence
	(+) Social recognition	Provided social recognition among school peers
	(+/-) Social comparison	Provides social recognition among school peers; but smart cards compared negatively to NFC phones older students used in the other school
	(+) Status	Provides a means for status differentiation
	(+) Respect	Adults showed respect to children by giving them their very own smart cards, and trusting on their skills and capabilities to carry responsibility
	(+) Enjoyment	Children were very excited to participate in the trial
	(+) Novelty	Provides fresh change to school routines
	(+) Empowerment	Empowering children through participation, independent use, and responsibilities
	(+) Independence	Children operated independently the reader device
	(+) Self-esteem	Service use provides a boost for child's self-esteem
	(+) Participation	Participation in the system design, use and evaluation
	(+) Compatibility	Service usage integrates well into school routines
	(+) Conformity	Children did not resist new practices, but accepted them without questioning
	(+) Value creation	Creating value and useful information for parents
	(+) Responsibility	Taking responsibility of the cards and the login process
	<b>Parents</b>	
	(+) Availability	Provides information on child's attendance details
	(-) Appropriateness	Following child's attendance details not very practically implemented in the system
	(-) Technology suitability	Current implementation of the service created some confusion and insecurity
	(+/-) Superiority	Service created real added value for about half of the parents
	(-) Reliability	Children could lose the card or forget to log in or out; cause for possible concern and worry
	(-) Performance	Current implementation of the service created some confusion and insecurity
	(+) Belonging	Increases the feeling of involvement in the child's life
	(-) Compatibility	Does not integrate well with the daily routines
	(+/-) Security	Increases feeling of child's safety / Possibly cause extra worry and concern
	(+/-) Freedom from fear	Ease the concern and fear of child's safety / Possibly cause extra worry and concern
	(+) Awareness	Parent immediately notified if child absent from school
	(-) Responsibility	Doubt of removing responsibilities from teachers
	<b>Teachers</b>	
	(+) Ease of adoption	Easy to take into use; integrated fast into school routines
	(+) Ease of use	Removes the need for laborious manual roll-calls
	(+) Appropriateness	Simplifies everyday work
	(+) Technology suitability	Integrates well into school routines
	(+) Superiority	Better way for recording the attendance details
	(+) Reliability	Enables more reliable roll-calls by decreasing the chance of human error
(+) Efficiency	Saves effort every school day and simplifies the roll-calls	
(+) Variety	Brings variety to everyday teaching	
(+) Compatibility	Integrates well into school routines	
(+) Conformity	Enables better fulfilling of work role and responsibilities	
(+) Responsibility	Supports in fulfilling the responsibilities	





## Appendix E: Values in case BlindNFC (Publication V)

	Value parameter	Identified in case BlindNFC
<b>VALUE IN EXPERIENCE</b>	(+) Ease of adoption	Quick to learn to use touch-based interaction
	(+) Ease of use	Easy to use touch-based interaction
	(+) Availability	Easily available and identifiable medicine information
	(+) Discoverability	Easier to find correct medicines and important medicine information
	(+) Technology suitability	Positive evaluation of the technological solution
	(-) Superiority	Does not bring real added value compared to established practice
	(+) Achievement	Provides a feeling of pleasure when being able to use the solution contrary to initial doubts
	(-) Social interaction	Fear of possible decrease in social contacts
	(+) Enjoyment	Provides feelings of excitement and pleasure, e.g. by offering means to demonstrate competence
	(-) Compatibility	Conflicts with established practices



## Appendix F: Values in case iShake (Publication VI)

	Value parameter	Identified in case iShake
<b>VALUE IN EXPERIENCE</b>	(+) Ease of use	Easy and straightforward to use
	(+) Availability	Always accessible earthquake notifications on a device that is always at hand
	(+) Appropriateness	Convenient to use
	(+) Technology suitability	Service available on their mobile phone
	(+) Flexibility	Service could be accessed and used on their mobile phone, contrary to similar web-based solutions
	(+) Superiority	Superior way to access and receive earthquake information
	(-) Adaptation	Desire for data personalization based on unique preferences and needs
	(-) Relevance	Desire to be directed with the most relevant earthquake information
	(+) Context-sensitiveness	Provides location-based earthquake notifications
	(-) Social recognition	Desire for competition and comparison with other users
	(-) Social approval	Video content not socially accepted
	(-) Social comparison	Desire for ranking system about users' contributions
	(-) Achievement	Desire to know that own data actually accomplished something
	(+) Novelty	Exciting and novel mobile application
	(+) Learning	Provides useful information to educate oneself regarding earthquake preparedness
	(+) Participation	Participating in creating useful and helpful information
	(+) Security	Provides better feeling of safety
	(-) Freedom from fear	Potential to ease the concern of close ones' safety
	(+) Awareness	Provides useful information to help better prepare oneself for future disasters
	(+) Value creation	Creates valuable and useful information for other users and first response



## Appendix G: Values in case Wayfinding (Publication VII)

	Value parameter	Identified in case Wayfinding
<b>VALUE IN EXPERIENCE</b>	(+) Ease of use	Able to complete wayfinding tasks with the help of service
	(+) Appropriateness	Does not require direct intervention or interaction from the user
	(+) Technology suitability	Places as little physical and cognitive burden on users as possible, modified according to user's limitations
	(+) Adaptation	The combination of modalities chosen according to user's functional capabilities and preferences
	(+) Achievement	Provides feelings of success
	(+) Independence	Potential to increase user's autonomy in carrying out daily activities
	(+) Empowerment	Reduces the need to depend on other people's help, gives control over own life
	(+) Self-esteem	Gives feelings of success and raises thus self-esteem
	(+) Security	Increases the safety during daily activities and wayfinding tasks

PUBLICATION I

**Case study of application-based mobile service acceptance and development in Finland**

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## **Case study of application-based mobile service acceptance and development in Finland**

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**Abstract:** This paper describes the design and development of an application-based mobile service and offers both theoretical and empirical contributions relating to the consumers' motives for and barriers to adopting mobile services. A case study based on a mobile Java-based approach for providing mobile services is introduced to gain insights into mobile service development process and to validate the factors that influence the acceptance of mobile services in Finland. Based on the findings from a survey conducted with a sample of 52 Finnish campus students, the factors that affect consumers' attitudes towards mobile services were discovered. Usefulness was revealed to have the strongest impact on attitude towards a mobile service, with contextual information and attitude acting as significant determinants of the intention to use the service. This study attempts to help mobile service providers choose right development and marketing strategies for mobile services and accelerate the diffusion of services.

**Keywords:** mobile Java; J2ME; mobile service; adoption; acceptance; development; case study; Technology Acceptance Model; TAM; Theory of Planned Behaviour; TPB; Finland.

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## 1 Introduction

The development of mobile technologies has mainly guided the evolution of mobile services and applications instead of customers' needs. Mobile phone visionaries assume that the technological development with a suitable business model will boost the currently modest mobile service usage to new heights (Robins, 2003). The visions are based on the idea that the new supply will create additional value, for which the consumers are ready to pay. However, the high expectations set for mobile services (Kalakota and Robinson, 2002) have not yet been realised and despite the wide variety and availability of services, the adoption of more advanced mobile services has not been as fast as predicted. Mobile services can be said to be at a chasm; the pioneers and early adopters are using the services, but they have not spread to the masses (Moore and McKenna, 1999).

For a long time Finland has been a European pioneer for testing new mobile services. But even in Finland, the adoption of mobile services has been modest and the most popular services are still based on SMS messaging. Many researches have studied the factors that affect the adoption of mobile services in the Finnish context (Hyvönen and Repo, 2005; Bouwman et al., 2007) but there is still a need to evaluate the adoption factors in real-life case studies. Kaasinen (2005) has studied the user acceptance of mobile services in connection with technology research projects related to mobile internet and location-aware information services. Kaasinen has used the Technology Acceptance Model (TAM) (Davis, 1989) to build user acceptance on four factors: perceived value of the service, perceived ease of use, trust and perceived ease of adoption. Bouwman et al. (2007) have researched mobile service adoption from the perspectives of physical, cognitive, security and economic barriers and from the perspectives of the perceived entertainment value and perceived flexibility benefits of mobile services. Bouwman et al. have also examined the role that the functional differences of mobile service bundles play in the process of actual and future use of these bundles. Finnish consumers' usage of mobile services has been studied in a report for National Consumer Research Centre by Hyvönen and Repo (2005). The report focuses on mobile services that Finnish people use, the motives for and obstacles to using the services and the readiness to pay for mobile services.

This paper researches and validates factors that affect the adoption and use of mobile services. The paper overviews characteristics that facilitate and trigger, and respectively hinder, the adoption of mobile services. Furthermore it studies what kinds of services are likely to be adopted; and how businesses can enhance the adoption and diffusion of mobile services. In order to validate the adoption factors in practice, this paper presents a real-life case study of developing and launching the mobile service. The case study evaluated Java-based mobile client that served information for students and personnel in a Finnish campus area. Contents of the service were internal news, events,

announcements and schedules of the study community, as well as a mobile flea market and the personal flea market management. After two months of field trial the feedback about the new service in real use was collected. The factors affecting the service adoption were researched based on a conceptual model that was a modified version of the Theory of Planned Behaviour (TPB) (Ajzen, 1991) and of the TAM (Davis, 1989). Based on the conceptual model, hypotheses for mobile services' adoption were created. The hypotheses were used as a foundation for examining the factors affecting respondents' attitudes towards mobile services, and the relationship between the attitudes to the intention to use the services.

## **2 Success factors and barriers of mobile services**

The success of mobile services not only depends on technological maturity of mobile technology and the penetration of mobile handsets; in the end, the users decide on the success of the services. The predictions are hard to make, but there are certain factors that need to be considered when developing mobile services. Rogers (1995) has developed a set of key innovation characteristics, 'Rogers' basic five', later increased with two more factors (Moore and Benbasat, 1991) that influence the adoption and diffusion of new technologies throughout a social system:

- relative advantage
- compatibility
- complexity
- trialability
- observability
- image
- trust.

Rogers' innovation attributes refer to the notion that mobile services are likely to be adopted if they offer a solution that has some clear advantages over existing products or services. Mobile services are also more likely to be adopted if they are compatible with the existing practices, values and skills of potential adopters, and are relatively easy to understand and use. If it is not possible to experiment with the service before making an adoption or rejection decision, and if the benefits offered by the service are not visible, then adopters are likely to perceive uncertainty and risk in adopting the service. Today the mobile phone is more like a reflection of one's identity, so if the adoption and use of mobile service is perceived to communicate one's personality and enhance one's image and status, it has more potential to be adopted. It is also important that the mobile service adopter perceives the service provider to be trustworthy, since consumers easily have fears, for example about the security of one's credit card number in mobile transactions.

Evidently, there are several factors inhibiting the use of services, since the technology maturity is no longer an obstacle. Development of technology is commonly seen as an important prerequisite, or even as a reason, for people to adopt new mobile services. According to Parasuraman (2000), the technology-readiness construct refers to people's

propensity to embrace and use new technologies for accomplishing goals in home life and at work. The dimensions affecting the technology readiness have been identified as optimism, innovativeness, discomfort and insecurity. The important attributes for innovation adoption set by Rogers (1995) and Parasuraman (2000) have not yet been taken into account to a sufficient extent when designing new mobile services, at least not in Finland. It might be the reason why the adoption and diffusion of mobile services has not proceeded as fast and wide as have been assumed.

According to Gilbert and Han (2005), one key barrier to attracting a critical mass of adopters is the lack of compelling content, and another is the differences among adoption patterns in individual market segments. A UK-based survey (Strong and Old, 2000) found that the convenience of having internet access at any time and place would be the most important incentive for consumers to use mobile internet applications. According to Gillick and Vanderhoof (2000), the new mobility experience, i.e., the anytime and anyplace access to desired products and services, will be the greatest benefit for the consumer. However, Figge (2004) claims that the ubiquity alone is not enough to ensure a general user acceptance and the success of a mobile application: as the user's problems vary with the context in which he or she accesses service, the service based on information of the specific context is likely to become the user's favourite.

### **3 Case study of mobile service adoption**

This paper studies the adoption of mobile services by developing a conceptual model with related hypotheses. The conceptual model is evaluated with the case mobile service in a field trial. The case mobile service focuses on the additional value of mobility, which means the possibility to access, produce and send information, products and services at anytime and from anywhere, regardless of the user's location or the time of day. The case study, called the Mora mobile service, was evaluated in a delimited user group of students and personnel in a Finnish campus area. The case mobile service was based on a downloadable Java mobile application that provided mobile access to the intranet of the campus area. The contents of Mora were internal news, events, announcements and schedules of the study community, as well as a mobile flea market. Mora was launched at the campus, focused on technology and economics education, in Finland in September 2007, in order to research the adoption of mobile services in practice among the campus' students and personnel.

#### *3.1 Conceptual model of mobile service adoption*

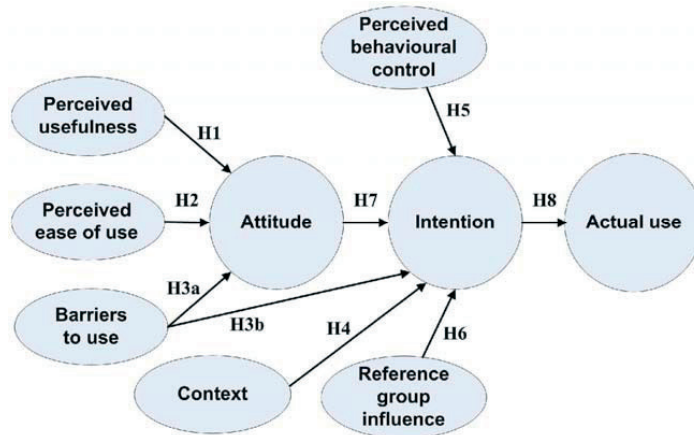
Hyvönen and Repo (2005) have stated that mobile services are not adopted linearly according to the assumptions of diffusion theory. Their studies state that the socio-demographic factors do not essentially affect the adoption of mobile services; instead, the best way to explain the use of mobile services is to research the general attitudes towards new technology, mobile services and devices.

In our study, the adoption of mobile services was researched by using a modified version of the TAM (Davis, 1989) and the TPB (Ajzen, 1991). According to TAM, a consumer's behavioural intention to use a 'system' is determined primarily by its usefulness and ease of use. According to TPB, the intention to use a 'system' is explained by attitudes toward a certain behaviour, subjective norm and perceived behavioural

control. TAM and TPB have both been widely used among researchers and found to be very useful in explaining consumers' attitudes and intentions toward a given behaviour. TPB is a general theory of human behaviour while TAM is specific to information systems. Studies on acceptance of new technology indicate that traditional adoption models need to be extended and modified to better explain the adoption of the innovations. This study modifies TAM by proposing additional acceptance factors associated with mobile services while adopting the attitudinal model from TPB (taking guidance from researches by Karjaluoto and Alatalo, 2007; Merisavo et al., 2007, conducted in the field of mobile marketing).

Figure 1 shows the created conceptual model for case mobile service with causal links between the construct items (Ervasti, 2007).

**Figure 1** Conceptual model for mobile services (see online version for colours)



Perceived usefulness (PU) (Davis, 1989; Davis et al., 1989; Moore and Benbasat, 1991; Venkatesh and Davis, 2000), perceived ease of use (PEOU) (ibid) and barriers to use (BU) (Thompson et al., 1991) are posited as antecedents of attitude toward mobile services (ATT) (Fishbein and Ajzen, 1975; Davis et al., 1989; Thompson et al., 1991; Davis et al., 1992; Taylor and Todd, 1995a, 1995b). Barriers to use are also conceptualised with context (CON) as an antecedent of intention to use mobile services (INT) (Davis et al., 1989; Ajzen, 1991; Taylor and Todd, 1995a). Reference group influence (REF) (Fishbein and Ajzen, 1975; Moschis, 1976; Davis et al., 1989; Ajzen, 1991) and perceived behavioural control (PBC) (Ajzen, 1991; Taylor and Todd, 1995a, 1995b) are also antecedents of intention, which, in turn, affects actual use (USE) (Davis, 1989; Taylor and Todd, 1995b).

Based on the conceptual model in Figure 1, the following hypotheses for mobile services were created:

- H1 Perceived usefulness of mobile services positively affects attitude toward mobile services.
- H2 Perceived ease of use of mobile services positively affects attitude.

- H3a Perceived barriers to use mobile services negatively affect attitude.
- H3b Perceived barriers to use mobile services negatively affect intention to use mobile services.
- H4 Utilisation of context-specific information on mobile services positively affects intention.
- H5 Perceived behavioural control of mobile services positively affects intention.
- H6 Reference group influence positively affects intention.
- H7 Positive attitude toward mobile services positively affects intention to use mobile services.
- H8 Intention to use mobile services is positively associated with actual use of mobile services.

In order to further evaluate and develop the conceptual model with related hypotheses, the use and adoption were tested in a real-life case study of mobile service.

### *3.2 Technical implementation of case mobile service*

The technical implementation of the case mobile service is based on a mobile client approach to providing mobile services. The Java-based mobile client 'Mora' works as an interaction channel between customer and service provider by providing personalised information to the user (Ervasti, 2007). Mora can be classified as a client-server concept. The server-side application carries most of the functionality. It handles an authentication procedure, serves client requests, synchronisation and processing of content, timing and procedure for content updates, and it accepts, stores and processes data in an appropriate form; in general, it implements the main logic of the provided services, including the use of interfaces and software modules.

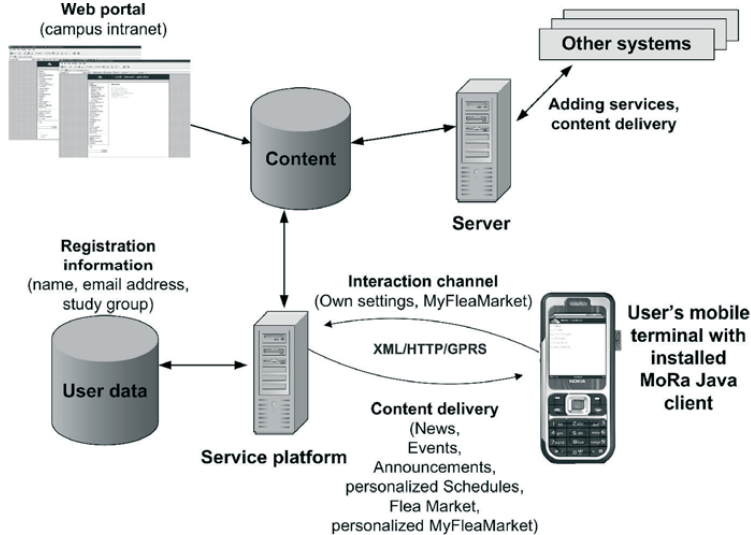
The main technical building blocks to develop a personalised mobile service concept are the service provider's existing information systems, mobile service, customer database and mobile application. The main building blocks (adapted from Alahuhta et al., 2005) of the Mora service concept are introduced in Figure 2.

The major source of information for most of the data and communication processed in the Mora service is the existing information system, the campus' web intranet. This required adaptation of the content from web-based content to mobile content. The Mora service is the link between the customer and the service provider's service platform and between the customers themselves. The user database is utilised in providing personalised services for customers. The existing user database could be used as the basic information source for user-related information; besides the basic personal data (name, e-mail address, study group) the database could be expanded to consist of information on the customer's special preferences. This information could be used to provide better and more personalised services and marketing messages.

The mobile end of the concept utilised mobile Java technology. The concept approach of using mobile application has several benefits both for the end user and the service provider. For example, unlike SMS-based solutions, the application provides more versatile content delivery and an interaction channel; a service provider can create a fully-branded mobile service concept and the application is unobtrusive and convenient

to use, avoiding the spam effect. When compared to browsing, the application-based approach offers better possibilities for improving usability in mobile services. In addition, the optimisation of data traffic between the terminal and servers is easier to implement in mobile applications. The small size of the displays also favours application-type services.

**Figure 2** Overview of the Mora mobile service



Nowadays, especially, Java compatibility is in every new mobile phone and Java technology can be implemented across all kinds of mobile devices ranging from basic mass market to high-end devices. As a programming language, Java is also easy to master and its environment is secure and portable with access to dynamic content and a huge developer community. Its 'easy-to-go' approach advanced developments in a very fast and productive manner. With clever software design and a powerful API, mobile Java (J2ME) can give a very qualified product in a very short amount of time, compared to some other mobile technologies, like Python and Symbian C++ (Helaakoski and Smirnov, 2006). The only critical part which is missing from the standard J2ME is the ability to create deeply-customisable GUI components and user interfaces. The lack of customisable GUI components may become very harmful to a mobile solution (ibid).

## 4 Testing the mobile service in the field trial

### 4.1 Promoting Mora service

The case mobile service started with an information and marketing campaign that advertised Mora web pages and gave presentations about the field trial to various student groups and personnel in the campus area. The purpose was to make the test-users feel

they were privileged to have the mobile service like Mora exclusively on their campus, and have the opportunity to participate in the service testing and development. These initial Mora users were even encouraged to compete for the best development ideas.

In the adoption of application-based mobile services, the key barrier to overcome has been identified by Nokia (2003) as to get the users to begin the first download. Therefore, Mora instructions presented simple steps for starting the use of Mora as follows:

- 1 registration via web page
- 2 downloading the Mora mobile application via SMS or web page
- 3 setting up the required connection settings
- 4 setting up the mobile client preferences.

The test-users were given an opportunity to post questions to a dedicated e-mail address in problem situations, and separate events for getting help in downloading and installing the application were arranged to further ease the adoption process. Other events were also arranged, in which was offered an opportunity to test the Mora service with separate test phones in case a user's own mobile phone didn't support the application.

#### *4.2 Evaluating Mora with conceptual model*

The feedback from the case study was collected after two months' field trial. The feedback questionnaire was created based on the hypotheses in the conceptual model (Ervasti, 2007). All of the questionnaire's items consist of multiple variables, and unless stated otherwise, a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with 3 (cannot determine) as a neutral anchor point was used to measure the variables. In Table 1, the feedback questionnaire for the case study is presented (adapted from Venkatesh et al., 2003). The feedback about the Mora service was gathered through online and paper questionnaires.

## **5 Results and analysis of the case mobile service**

During the field trial, the Mora mobile service gathered 67 registered users and the survey resulted in 52 completed feedback forms. The results were treated and analysed anonymously (Ervasti, 2007). The analysis of the research data was done by using SPSS 14.0 software. The rather small amount of sample data restricted the number of feasible analysis methods. The analysis was conducted using the basic frequency and descriptive calculations. The regression analysis was utilised by first examining the effect of the independent variables on the dependent variables according to the set hypotheses, and then testing the combined effect of the explanatory variables as stated in the conceptual model.

### *5.1 Demographics and mobile phone usage*

Of the respondents, 11.5% were female and 88.5% male. The sample comprised of relatively young consumers, as the majority of the respondents were less than 25 years old. By nationality, 69.2% of the sample were Finnish and 30.8% foreign, the foreign



respondents' nationalities mostly representing Nigeria, Russia and Hungary. Most of the respondents were single and had a monthly income of less than 1,000 euros. Most of the survey respondents had a relatively new mobile phone in use, the handset's age being under two years for the majority. The sample's monthly mobile phone expenditure was mainly under 30 euros, and most used their phone more for private than business purposes.

5.2 Attitudes towards mobile service

The survey respondents' attitudinal valuations of the Mora mobile service are presented in Table 1 with mean values and standard deviations.

**Table 1** Questionnaire items and attitudinal dimensions of test-user responses to Mora mobile service

<i>Construct</i>	<i>Variable</i>	<i>Mean</i>	<i>s.d.</i>
Perceived usefulness			
PU1	Using Mora gives me topical information.	4.29	0.610
PU2	Using Mora saves me time/helps me accomplish things more quickly.	3.77	1.022
PU3	Using Mora gives me personal information.	3.39	1.150
PU4	Using Mora gives me information that is of interest to me.	3.81	0.817
PU5	I find Mora useful in my daily life.	3.90	1.053
Perceived ease of use			
PEOU1	I know what kind of mobile services I can use with my phone.	4.14	1.167
PEOU2	It was easy for me to download and install Mora in my mobile phone.	3.88	1.211
PEOU3	I quickly learned to use Mora.	4.62	0.718
PEOU4	I find Mora easy to use.	4.33	0.964
PEOU5	My interaction with Mora is clear and understandable.	4.00	1.085
PEOU6	I find it easy to get Mora to do what I want to do.	3.92	1.100
Barriers to use			
BU1	Fear of technical features is an obstacle to me adopting mobile services.	1.63	1.085
BU2	Difficulty and effort caused by the downloading and installation of the application in a mobile phone is an obstacle to me adopting mobile services.	1.76	1.205
BU3	Knowledge of data transmission billing is an obstacle to me adopting mobile services.	2.51	1.528
Context			
CON1	I would view the content of Mora related to a specific time or date (e.g., exam day, weekend) as useful.	4.39	0.750
CON2	I would view the content of Mora related to me being in a specific location (e.g., campus restaurant, library) as useful.	4.10	0.953

**Table 1** Questionnaire items and attitudinal dimensions of test-user responses to Mora mobile service (continued)

<i>Construct</i>	<i>Variable</i>	<i>Mean</i>	<i>s.d.</i>
Context			
CON3	I would be prepared to spend time providing my personal details (a user profile) to make the content of Mora more relevant to my needs.	3.78	1.112
Perceived behavioural control			
PBC1	I find it important that I can choose between different styles in Mora.	3.17	1.354
PBC2	I find it important that I can easily control the use of Mora (that I can decide when and where I use Mora).	4.50	0.828
PBC3	I find it important that I can easily stop using Mora.	4.44	0.978
PBC4	It would be important for me to be in control in terms of the ability to filter the content of Mora related to my interests/needs.	4.19	0.793
Reference group influence			
REF1	I started to use Mora because it was recommended to me by someone I know.	2.71	1.576
REF2	I started to use Mora because my friends are using it.	2.12	1.199
REF3	I would have been more likely to start to use Mora if the message containing a link for downloading the application was forwarded to me by someone I know.	2.83	1.424
REF4	I recommended Mora to people I know.	3.49	1.271
Attitude			
ATT1	Using mobile services (downloadable applications) is pleasant.	3.90	1.159
ATT2	Using Mora is pleasant.	4.08	0.710
ATT3	Using mobile services (SMS-based) is pleasant.	3.38	1.223
ATT4	Using mobile technology to access a variety of services is interesting.	4.31	0.707
ATT5	Using the mobile phone as a channel to access the content of the university intranet is a good idea.	4.73	0.528
Intention			
INT1	I feel positively about Mora.	4.54	0.503
INT2	I am willing to use Mora in the future, if possible.	4.48	0.641
INT3	I would use Mora regularly in the future.	4.02	1.038
Actual use			
USE1	I am using Mora every day.	2.58	1.226
USE2	I am using Mora every week.	3.71	1.226
USE3	I regularly check what's new with Mora.	3.40	1.302

In perceived usefulness, the respondents mostly agreed with the statement ‘Using Mora gives me topical information’. In perceived ease of use, most agreed with the statement ‘I quickly learned to use Mora’, and the respondents were also aware of the kinds of mobile services they can use with their mobile phones and they mostly agreed with the statement that downloading and installing Mora was easy. The respondents disagreed with the statements concerning perceived barriers to use. Fear of technical features, required effort in downloading and installing the application, or even the data transmission billing weren’t seen as obstacles in adopting mobile services.

The utilisation of time- and date-related contextual information in Mora services was seen as more useful than the utilisation of location-specific information. The respondents weren’t especially eager to spend time providing their personal details to make the content in Mora more relevant to their needs. When examining the perceived behavioural control, the respondents found it important that they could control the use of Mora by deciding when and where to use the service, and by being able to stop the use of the service. The reference group influence was perceived as rather irrelevant.

The attitudinal construct showed that the respondents had a more preferable attitude toward downloadable applications than toward SMS-based mobile services. Most agreed with the statement ‘Using the mobile phone as a channel to access the content of the university intranet is a good idea’. The respondents reported that they were willing to use Mora in the future. However, the actual use of Mora wasn’t that regular since it happened more on a weekly than a daily basis.

71.2% of respondents reported having used other mobile services in addition to Mora and 67.3% of them had used downloadable applications, whereas only 38.5% had used SMS-based services. Besides Mora, 73.1% of respondents had tried out other mobile services and 21.2% of them had experience of downloadable applications, whereas SMS-based services were familiar to only 7.7%. The respondents’ previous experience of mobile services mainly consisted of entertainment, information and news and e-mail: 57.7% of respondents reported having used entertainment services and 55.8% had used both the information and news services and e-mail: 38.5% had used instant messaging and 23% banking and financial services.

Table 2 shows the standardised coefficients and t-values of the tested hypotheses regarding mobile services (t-statistics indicating the significance of individual variables when the t-value is > 2, Schwager, 1995).

**Table 2** Hypotheses examination

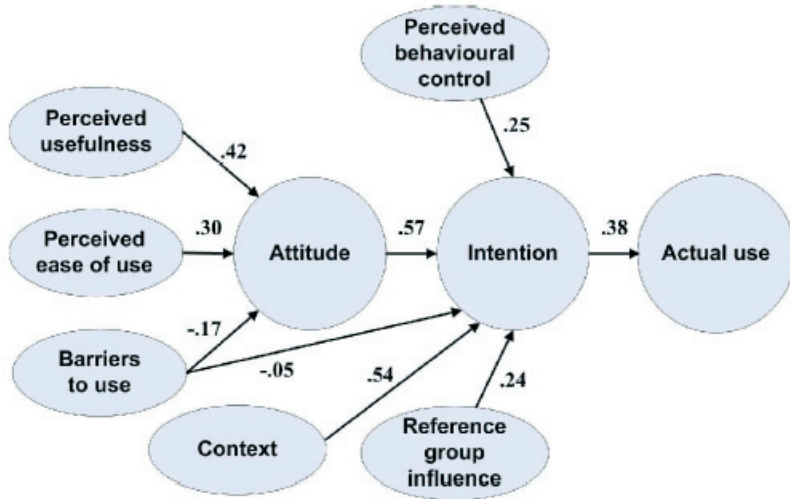
<i>Hypothesis</i>	<i>Standardised coefficient β</i>	<i>t-value</i>	<i>Sig.</i>
H1 PU to ATT	.419	3.164	.003
H2 PEOU to ATT	.303	2.182	.034
H3a BU to ATT	-.173	-1.205	.234
H3b BU to INT	-.050	-0.345	.731
H4 CON to INT	.539	4.430	.000
H5 PBC to INT	.250	1.828	.073
H6 REF to INT	.237	1.707	.094
H7 ATT to INT	.572	4.882	.000
H8 INT to USE	.381	2.913	.005

The strong coefficient ( $\beta = .419, t = 3.164$ ) of H1 shows that there is a positive and direct relationship between PU and ATT. Thus, the perceived usefulness of mobile services is a strong predictor of attitude and H1 was supported. It can also be seen that the PEOU of mobile services was directly and positively associated with ATT, providing support for H2. H3a and H3b address the role of BU, and the findings point out that barriers to use affect attitude more strongly ( $\beta = -.173, t = -1.205$ ) than intention ( $\beta = -.050, t = -0.345$ ). The coefficients were negative, but very low, which indicates that barriers to use have no significant influence on either attitude or intention, thus H3a and H3b were not supported.

Next, the strong coefficient ( $\beta = .539, t = 4.430$ ) of H4 indicates that context-related information acts as a strong and positive predictor of intention to use mobile services, so H4 was supported. H5 and H6 hypothesise that PBC and REF have a positive and direct relationship with INT. Both coefficients are similar with low magnitudes, therefore neither H5 nor H6 were supported by the data. H7 states that the more favourable attitude a person forms toward mobile services, the higher his or her intention to use those services. The relationship was found to be positive and statistically significant ( $\beta = .572, t = 4.882$ ). The final hypothesis, H8, argues that INT is directly associated with USE and the coefficient is strong and positive. Thus both H7 and H8 were supported.

Figure 3 illustrates the standardised coefficients for the conceptual model.

**Figure 3** Conceptual model results (see online version for colours)



Other numerical tests for regression diagnostics of the conceptual model were also conducted (Table 3).

**Table 3** Validation of the conceptual model

<i>Hypothesis</i>	<i>Adjusted R square</i>	<i>Durbin-Watson</i>	<i>Tolerance</i>	<i>VIF</i>
H1 PU to ATT	.445	1.865	.900	1.111
H2 PEOU to ATT			.765	1.307
H3a BU to ATT			.829	1.207
H3b BU to INT	.430	2.387	.829	1.206
H4 CON to INT			.772	1.295
H5 PBC to INT			.884	1.131
H6 REF to INT			.911	1.098
H7 ATT to INT			.687	1.456
H8 INT to USE	.128	1.963	1.000	1.000

R square represents the goodness of fit of the model. The R square value .445 indicates that 44.5% of the variance in the dependent variable ATT can be predicted from the independent variables PU, PEOU and BU. BU, CON, PBC, REF and ATT explain 43.0% of the variance in INT, whereas INT only explains 12.8% of the variance in USE. The Durbin-Watson test statistics were used to detect the presence of autocorrelation in the residuals. The Durbin-Watson statistic should be between 1.5 and 2.5, indicating that the values are independent (Weil et al., 2001), and from the table it can be seen that all the Durbin-Watson values fall within that range. Multi-collinearity was assessed by examining two collinearity diagnostic factors, tolerance and the variance inflation factor (VIF) (Research Consultation, 2008). A small tolerance value indicates that the variable under consideration is almost a perfect linear combination of the independent variables already in the equation and that it should not be added to the regression equation. A tolerance value of less than 0.1 should be investigated further. The VIF measures the impact of collinearity among the variables in a regression model. Values of VIF that exceed ten are often regarded as indicating multi-collinearity, but in weaker models values above 2.5 may be a cause for concern. As can be seen from the Table 3, both the tolerance and VIF values were acceptable.

## 6 Experiences of Mora mobile service development and introduction

The technology is not just playing a role of enabler for the solution, but also becomes a key factor for successful extensions and improvements on the developed system in the future. The limitations and benefits of the technologies used seamlessly turn into the limitations and benefits of the solution itself. J2ME enabled fast and efficient development of the portable mobile application. A truly challenging task was development of the new mobile solution on the top of the service provider's complicated infrastructures (Helaakoski and Smirnov, 2006). While the project team had met many challenges on its way to a successful mobile concept, the resulting example application had a customised GUI, supported different look-and-feel styles and had easy integration with the service provider's infrastructure.

Even though the challenges represented by marketing the Mora service and establishing test-users' interest were recognised and actions were taken to overcome them, one reason for the somewhat modest use of the Mora service was that many students didn't know the service well enough or didn't understand its advantages. Thus, the benefits of the service weren't visible enough to potential adopters. Another significant obstacle was the effort required in downloading and installing the application. To deal with this problem, several separate events were arranged where guidance and support in service adoption was offered to users. Test-users reported that the best source for getting information about the downloading, installation and use of the Mora service was the Mora website. However, the events organised by the field trial organisers proved to be even more efficient in reaching the test-users.

Generally speaking, it was noted that mobility does not provide enough added value for the users with the Mora service in its current form. Consumers were not attracted to the service because they already had an easy and familiar way to access almost the same content via the web, so they felt that the Mora is just a mobile substitute for the campus' web intranet. Rogers (1995) has emphasised the significance of relative advantage in the diffusion of new ideas and the survey results supported the fact that a new innovation should be better than the current one. For Mora service users, the easiness and flexibility of the service should have been stressed even more, i.e., that the service can be used at any time and in any place, freeing the users from the traditional time and place constraints even more efficiently than internet services.

## **7 Conclusions**

There have already been conducted numerous researches on adoption factors in Finnish context (Hyvönen and Repo, 2005; Kaasinen, 2005; Bouwman et al., 2007) but there is still a lack of studies that would combine adoption theories with real-life case studies. This paper introduces a conceptual model for mobile service adoption that is a modified version of established adoption models. The developed conceptual model was evaluated and validated in the real-life case study of mobile service, through which we have gained practical insights into application-based mobile service development and promotion, as well as having identified the factors affecting the adoption of mobile services in Finland.

The findings from the survey suggest that the perceived usefulness of mobile services is the strongest predictor of attitude toward mobile services. That is also supported by previous studies (e.g., Rogers, 1995) on consumer acceptance of new technologies. People will adopt a technology when the added value offered by technology fulfils their needs. Hence, compatibility with users' needs (*ibid*) is a critical variable for predicting technology adoption. Ease of use wasn't perceived as having a strong relationship with acceptance of mobile services, contrary to Rogers (1995), so it can be reasoned that usefulness is a stronger determinant of attitude toward mobile services than perceived ease of use. Utilisation of contextual information was found to have a strong impact on intention to use mobile services, which is also consistent with the reviewed literature (Figge, 2004; Kaasinen, 2005), and proves the point that consumers desire relevant and personalised services.

The respondents did not perceive the technical features of mobile services, the downloading and installation process or data transmission billing as significant barriers to adopting mobile services as prior researches suggest (Parasuraman, 2000; Eriksson et al.,

2001; Aarnio et al., 2002; Nokia, 2003). When examining the impact of control and social norms, the results of the survey were not congruent with the theoretical background (Ajzen, 1991; Rogers, 1995; Parasuraman, 2000) either, since perceived behavioural control and reference group influence weren't stated as important determinants of service adoption. A preferable attitude toward mobile services was, however, proven to have a strong impact on intention to adopt services, whereas the intention in the end didn't act as a good predictor of actual use.

However, in interpreting the results of the case study it has to be notified that the sample size is small, focusing on the students and personnel of one specific campus in one country and the survey analysis did not include socio-demographic variables. What also needs to be taken into account is that the respondents are probably more experienced mobile users and might regard mobile services in a different way than other, larger-scale and more widespread samples. This means that the opinions and experiences of active, critical and participative consumers are likely to be emphasised in the research. There are, also, many other variables that were not included in our analysis and which can be considered relevant in predicting the adoption and diffusion of mobile services.

The reason for the somewhat modest sample size is the fact that it wasn't possible to participate in this survey in a merely written form: the respondents had to be real test-users that had truly experimented with Mora mobile service. The aim of the research was to gain real user experiences based on personal and active use of Mora service and due to this the field trial lasted two months. Another fact that may have decreased the amount of users is that the Mora service was short-term and continuation of the service was not expected.

Future work could utilise Rogers' (1995) diffusion of innovations model consisting of four critical technology diffusion elements of innovation, communication channels, time and social system, to explain 'the process by which an innovation is communicated through certain channels over time among the members of a social system'. Therefore, similar research need to be conducted in other countries as well in order to obtain benchmarks for comparing the differences in adoption characteristics in different countries, and to further validate the developed conceptual model. The conceptual model should also be extended further to include more factors that reflect the unique characteristics of the usage intentions of mobile services. Further attention should be devoted to the comparison of rival models in explaining consumer attitudes and intentions. Empirical research on the adoption processes of different types of mobile services would be interesting to conduct as well in order to see how the factors affecting the mobile services adoption vary between entertainment and pure utilitarian-type services.

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# LEARNING THROUGH NFC-ENABLED URBAN ADVENTURE

## *User Experience Findings*

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**Keywords:** Near Field Communication (NFC), Mobile learning, Urban adventure track, Context-sensitiveness, Teenagers.

**Abstract:** This paper presents a mobile context-sensitive learning concept called the Amazing NFC, and reports the findings and results of a field study where 228 students experienced the Amazing NFC urban adventure during spring 2008. The Amazing NFC concept is an Amazing Race -style survival game for teenagers for learning skills and knowledge essential to everyday life and familiarising them with their hometown. During the Amazing NFC lessons, students were guided through an urban adventure track with the help of NFC mobile phone, site-specific NFC tags located at eleven control points and related mobile internet content. Trial aimed to analyze touch-based interaction paradigm directed to specific users in a defined context as an implementation technique for mobile learning. User experiences and added value evoked by the service concept were investigated via a variety of data collection methods. Findings revealed that students experienced the NFC technology as easy and effortless to use. However, users hoped to see more challenges and activity in the track in the future. Our analysis indicates that one main benefit of the urban adventure concept was moving the learning experience from the traditional classroom to a novel context-sensitive learning environment that includes social interaction between students.

## 1 INTRODUCTION

Traditional classroom learning is what we are all most familiar with. It usually awards credits based on student performance, which is measured through assignments, tests and exams. Traditional learning typically takes place in an identifiable classroom space during pre-defined hours. A classroom usually has a number of specific features, including a teacher who delivers information to students and a number of students who all are physically present in the classroom and regularly meet at a specific time. Many learners favour traditional learning while others find that it is more restrictive and lacks flexibility. (Learn-Source, 2008)

However, new ways of learning are emerging. New learning approaches suggest that imaginative and innovative approaches are needed to bring about improvements in learning new skills and adopting new information (Espoir Technologies, 2007). The best learning occurs in a stimulating, active, challenging, interesting and engaging environment when you move at least some part of your body and when you learn things by doing and by experience

(ibid). The best learning occurs when you are actively involved in co-constructing knowledge in your own head, not passively reading or listening or taking notes. Forcing people to sit in a chair and listen (or read) dry, formal words (with perhaps only a few token images thrown in) is often considered to be the slowest, least effective, and most painful path to learning (ibid). Yet it is the approach you see replicated in everything from K-12 to universities.

Mobile phones have now evolved into pocket-sized computers and as such have the ability to deliver learning object and provide access to online systems and services. Mobile learning is unique in that it allows truly everywhere, anytime, personalized learning, and offers opportunities to integrate learning technology into student's daily activities (Laroussi, 2004). Mobile devices belong to a learner's personal sphere, which means that the learner can take learning opportunities directly in the situation where they occur, because the learner has his learning environment always at hand (ibid). Mobile learning can also be used to enrich, enliven or add variety to conventional lessons or courses (Attewell, 2005). Thus, the educational potential of

mobile learning contents, both as learning and teaching tool, is widely acknowledged, and various initiatives have been undertaken to encourage the integration of educational mobile resources in school practice (Avellis et al., 1999).

Portable technologies have been explored in the context of m-learning to provide literacy and numeric learning experiences for young adults (aged 16-24) who are not in a full-time education environment (Attewell, 2005). The m-learning project running 2001-2004 intended to develop some of its learning materials using a gaming philosophy to make their use attractive to young adults. In the project 62% of learners reported they felt keener to take part in future learning after trying mobile learning. 82% of respondents felt the mobile learning games could help them to improve their spelling and reading, and 78% felt these could help them improve their maths. Study's evidence suggests that mobile learning can make a useful contribution to attracting young people to learning, maintaining their interest and supporting their learning and development. It was also observed that loaning equipment to young adults has resulted in other benefits not directly related to the learning experience. In particular, some of the learners were surprised and proud to be trusted with such expensive and sophisticated technology.

Wyeth et al. (2008) have used mobile technology as a mediator within science learning activities in a trial where 11-year-old children completed in pairs an outdoor treasure hunt activity using a combination of two mobile phones and a video camera. During the trial was discovered that all the children treated the treasure hunt as a competitive activity and were highly motivated to make discoveries based on the clues. However, the side effect of the racing nature of the treasure hunt was that it detracted from more focused learning and considered reflections on what had been observed. Study findings also revealed the importance of context in learning: new understanding emerged as children moved through the treasure hunt environment. Productive and creative aspects included in the trial appeared also to provide an intrinsically motivating platform for learning.

Chang et al. (2006), in turn, have introduced the treasure hunting learning model that extends Computer-Aided Learning systems from web-based learning to mobile learning. In their model the system will provide students suitable instructions or quests according to students' learning results on web, students can use the mobile phone to get the guidance messages or quiz when they are moving around in the field, and what concepts students

obtained and did not understand during the mobile learning phase will be posted on the website in order to let teacher and students do further discussions.

The effective use of mobile learning resource depends to a large extent on how enjoyable students find the learning experience. Some students may be motivated by an element of competition (Becta, 2006). Also to cater the academic needs of students, the service needs to be at the appropriate intellectual level. Avellis et al. (2003) state that the effectiveness and pedagogical soundness are very important to evaluate in mobile contents. Some of the factors that encourage a positive response from students to mobile learning have been identified as (Becta, 2006):

- Attractive presentation
- Interactivity
- Feedback
- Appropriate skill level(s)
- A 'fun' element
- Clear focus
- Use of different types of media
- Versatility
- Non-threatening environment
- A feeling of progression and achievement
- Intuitive design and interface
- Challenge.

In the Amazing NFC trial, an Amazing Race - style game was created for teenagers for learning skills needed in everyday life and learning facts about the city of Oulu in Finland. An objective was to trial a context-sensitive educational service for the target group by utilising NFC technology. Our urban adventure concept acknowledged the importance of context within the learning experience by focusing on situated learning (Brown et al., 1989): enabling learning in real-life contexts, outside the confines of a conventional classroom (Tétard et al., 2008).

The aim of the trial was also to investigate user experiences evoked by the touch-based interaction paradigm and the mobile learning concept itself. In addition, the educational aspects concerning the new learning environment and the suitability of the touch-based user interface and the related interaction technique for the target group, i.e. the teenagers was explored. In the trial was also examined the added value the concept brings to learning.

## 2 NFC TECHNOLOGY

Touching with a mobile terminal has been found to be an intuitive, natural and non-ambiguous

interaction technique that does not incur much cognitive load for users (Rukzio et al., 2006). Väikkynen et al. (2006) state that touching is an effortless way to select objects in the environment and it is easy to learn and use.

NFC (Near Field Communication) technology is designed to make communication between two devices very intuitive, and NFC suits the requirements for physical mobile interactions very well. Objects can be augmented with NFC tags and mobile devices can be equipped with NFC readers. Tags in the environment may be used to provide fast, zero-configuration service discovery (Isomursu et al., 2008), and they can be attached to virtually any object or surface. When a tag is touched, the tag reader integrated into the mobile phone reads the information embedded by the tag and is then able to perform predefined actions. Tags are also small and inexpensive, which makes tags suitable for embedding the user interface into the everyday living environment of the user.

The main advantages of NFC are the simple and quick way of using it and the speed of connection establishment, and even though people may have to learn how to use touch-based interaction, it still offers possibilities to be much simpler and quicker than classical screen-based user interfaces on mobile devices (Falke et al., 2007; O'Neill et al., 2007). In our concept an URL to the web content was transferred from the tag to the mobile phone when the user touched the tag. The browser available in the mobile phone could then directly access the URL.

### 3 RESEARCH SETTING

Amazing NFC field trial was implemented in the city of Oulu in May 2008. The total of 228 students between the ages of 14 and 15 from the schools located in the Oulu district participated in the trial. The mobile learning concept used in the trial was called "Amazing NFC" after the well-known TV series called "Amazing Race". During the Amazing NFC lessons that took place in downtown Oulu, the students were guided through an urban adventure track with the help of mobile phone and related mobile internet content. Eleven locations, that we called "control points", around Oulu were marked with NFC tags.

In the beginning of the Amazing NFC lesson, the students were grouped into small groups of two. Each student was provided with Nokia 6131 NFC-enabled mobile phone for the duration of the lesson

and each student pair received an individual route with a designated departure point. Upon arrival at a control point, the student touched the NFC tag and a web-page concerning information about the place where the control point was located (e.g. a museum) was sent to the student's phone. First the student read the text relating to the control point, watched a video or listened to an audio file, and then answered to a question related to the site. In some locations, the question required the user to do some tasks to acquire the information needed to answer the question. After completing the assignment, students received instructions and a map guiding them to the next NFC control point. The control points, with the exception of zoological museum, were located in the city centre within a couple of kilometres distance, and the students were expected to travel from one control point to another with bikes (although some used mopeds against instructions).

During the lesson, the teachers were able to follow in real time via a web-based user interface how the pairs of students proceeded through the adventure track. Also, the students were advised to use the mobile phone to call the teacher in case of problems or questions. In Figure 1 is described the overall view of the urban adventure concept.

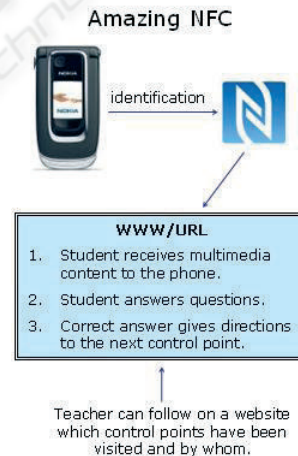


Figure 1: Overall view of the trial.

The educational goals of the Amazing NFC lesson were to provide the students with knowledge related to landmarks, public buildings and offices in their hometown, and practical skills related to dealing with public authorities in mundane everyday tasks. The locations chosen as control points were city information centre, fire station, swimming hall,

police station, museum, city hall, youth and culture centre, zoological museum at University of Oulu (requiring a bus journey to the museum and back, and ticketing was done with an NFC phone), city library, theatre and the social insurance institution. During the bus journey to zoological museum, the students became familiar with, among other items, the "Initiative for Oulu" service, i.e. sending an electronic initiative to city authorities by touching information tags in the bus. In Figure 2 the student is touching the Amazing NFC tag at the control point inside the social insurance institution.



Figure 2: Student visiting the Amazing NFC control point located at the social insurance institution.

The Amazing NFC lesson was planned and designed in close cooperation of teachers, service and technology providers, and researchers. During the design phase was especially emphasised the ultimate goal of integrating the concept into the normal practices of the schools, so that the trial would not to remain as a single occasion related to the research project. The aim was to create a viable concept that could be adopted as a learning instrument to be used also after the research trial. This required tight involvement of teachers and school administration in planning and implementing the applications, and organizing and supervising the trials. During the trial, the researchers were only involved in the data collection activities; teachers took full responsibility for organizing and supervising the actual Amazing NFC lessons.

#### 4 DATA COLLECTION

Dutton and Aron (1974) have stated that humans are not very good at analysing what actually caused an experience, so it can be difficult for users to identify if the experience was caused by the technology under evaluation or the user experience evaluation

method (or any other event in the life of the user). Human memory about experiences is also unreliable thus affecting our ability to recall past experiences so that we could compare them with other experiences (Schooler and Engstler-Schooler, 1990), or to describe them reliably after time has passed. Also, our ability to predict our own experiences in a hypothetical or future setting is very limited (Wilson et al., 2000; Gilbert and Wilson, 2000). Therefore, in order to achieve the most reliable understanding of user experience, the data during the Amazing NFC lessons was collected in three phases: before use, during use and after the use.

Since describing and understanding user experience are complex as user experience is always multifaceted and difficult to verbalise and describe, the combining of different data collection methods increases the reliability and validity of the results (Isomursu et al., 2007). Therefore, we decided to utilise a variety of data collection methods that were highly complementary (Yin, 2003). The methods used and data collected in different phases of the experiment were as follows.

Before the start of the trial, two teachers were interviewed in order to investigate their expectations, doubts, thoughts and attitudes towards the evaluated technology and learning concept. Before the Amazing NFC lesson we also observed how the students learned to use NFC technology, and what kind of spontaneous reactions and discussion took place in introduction of the concept. A mobile questionnaire was used to capture information about the expectations and attitudes towards the mobile learning experience before the lesson. Unfortunately, there were some technical problems with the mobile questionnaire during the very first trial lessons. Additionally, some teachers forgot to provide the NFC tag used for accessing the mobile questionnaire for their students. Therefore, not all students were able to report their experiences through the mobile questionnaire (we received 133 valid responses from 228 participants).

User experiences during the Amazing NFC lesson were collected through video recordings, and through automatic creation of log data about how the pairs of students progressed on the track. Video recordings were made by placing video cameras at fixed spots to record students while they were visiting the NFC control points, and by providing students video cameras that they could use to record their experiences during the lesson.

After use, the students filled out a second mobile questionnaire collecting data about the user experience immediately after use. The data received



from both mobile questionnaires was used to survey how students' expectations and attitudes changed during the trial; whether their expectations were met and attitudes altered. The students and teachers were also requested to fill out a web questionnaire within two weeks after the trial. For this purpose we created two separate questionnaires (resulting in a total of 81 responses from students and 8 from teachers). In addition, we arranged a workshop with twelve students to explore the experiences with the Amazing NFC. The workshop included participatory features, i.e. the students participated in designing how to iterate the concept for future use.

## 5 FINDINGS

### 5.1 Before Use

Evaluation before use was done for gaining insights into the attitudes, expectations and doubts of the user groups regarding the upcoming Amazing NFC lesson. Technology training situation was observed to see how the students coped with learning to use new touch-based interaction technique.

#### 5.1.1 Interviews with Teachers

In general, teachers had a positive attitude toward the learning concept. They found the trial trustworthy; students could not get lost or get into trouble as the teachers could follow their progress on the track in real time through a web interface and contact them if needed. Teachers felt it was good that learning could be taken out from the traditional classroom and 45-minute teaching style. They saw the concept as an excellent way to familiarise the students with their hometown and for students to learn life-skills and to gain more courage to visit different public buildings and offices in the city. However, teachers thought that urban adventure track needs to provide students a sufficient amount of challenge in order to maintain their interest and motivation during the Amazing NFC lesson. Thus, in order to make a concept to succeed and to create real experiences students must be offered more activities, such as competitions and tasks. Teachers expressed a doubt of NFC technology having the taint of decoration; that in practice NFC would not bring any added value for the learning concept. Teachers' stressed that the technology itself is not enough to surprise and amaze students; it is the content and activities that need to generate real experiences.

### 5.1.2 Observation of the Training

Before the Amazing NFC lesson, students were given an introduction to NFC technology and they had their first visual and physical encounter with the learning concept and their first hands-on experience on using the novel interaction paradigm. Therefore, it is not surprising that learning touch-based interaction required some practicing. Students needed some practice to find the comfortable personal reading distance between the tag and the phone. Also, finding the right touching spot both from the phone and from the tag, and learning the response times required some practice. However, as teenagers are nowadays very technological-savvy and familiar with mobile technology, they adopted the new technology and touch-based interaction fast: all students were able to learn to use touch-based interaction with a few repetitions.

#### 5.1.3 Mobile Questionnaire

Students' preliminary feelings were explored with a mobile questionnaire just before the Amazing NFC lesson: general attitudes toward the lesson, the biggest expectations of and the major doubts about the lesson. We received 133 responses from 74 boys and 59 girls. A three-point Likert scale ranging from 1 (positive) to 3 (negative) was used to measure the question concerning the attitude. 54.1% of students had positive feelings about participating in the lesson, and only 10.5% of students expressed negative attitudes towards the lesson (see Figure 4).

In order to investigate the correlations that stemmed from the student's gender, data was also analysed by doing the dependency tests between the questionnaire parameters. Between the student's gender and attitude towards the Amazing NFC concept was found a direct correlation (see Figure 4). 16.2% of boys had negative attitudes towards the lesson, whereas only 3.4% of girls expressed the same opinion. In contrast, 72.9% of girls thought it was nice to attend the lesson, the corresponding proportion of boys counting only to 39.2%.

Students were expecting most eagerly (see Figure 3) to spend time with their friend (21.8%), to try out new technology (21.8%) and to get out of the school (19.5%). They were least expecting to learn new information at the control points (9.8%) and to get to know new places (8.3%). Correlation was also discovered between the gender and expectations (Figure 3). 32.2% of girls were most expecting spending time with their friend while only 13.5% of boys were expecting that. Whereas 29.7% of boys and only 6.8% of girls were expecting getting away

from school the most. Quite surprisingly, more boys (13.5%) than girls (5.1%) were waiting “learning new information”, whereas girls (15.3%) were more waiting “getting to know new places” when compared to boys (2.7%).



Figure 3: Students' expectations of the Amazing NFC before the lesson (n=133; 74 boys and 59 girls).

Over half of the students (66.2%) reported having no doubts regarding the Amazing NFC lesson. Of those 33.8% students that reported having some doubts, 16.5% identified the most important reason to be the anticipated problems with new technology, 7.5% considered it to be the difficulty of finding the control points and moving around the city and 3.8% feared bad weather during the day. Student's gender had also effect on whether or not something daunted him or her before the lesson: 41.9% of boys had some doubts whereas the figure with girls was lower (23.7%).

## 5.2 During Use

Collecting information about user experiences at the time they happen requires in situ data collection methods which can be applied during the use of technology (Consolvo et al., 2007). This means that the tools and methods used for collecting user experience data need to be integrated into the everyday practices of the trial users, just as the technology under evaluation. Experiences show that the user experience evaluation method may actually “steal the show” (Isomursu et al., 2007) if it is more visible and needs more attention and cognitive processing from the user than the actual technology under evaluation.

### 5.2.1 Video Recording

Video cameras were set at fixed spots to record students while they visited NFC control points. This solution was chosen in order to minimise the interruption of the videotaping, and to prevent it from having an influence on the user's behaviour

and user experience formation (Yin, 2003). However, when the student's head was down while he was watching the mobile device, it was difficult to see all the facial expressions. Students also often turned their backs to the camera or even moved out of the reach. Thus, videos recorded by students themselves proved to be a better information source. Videos showed, for example, that students commonly asked for help from passers-by if they had trouble finding the control points. During the lesson they also called and send text-messages to their classmates to find out how they were doing and how many control points they still had to go.

### 5.2.2 Log Data

User experiences were also collected by monitoring the log data that was automatically recorded from the control points by the Amazing NFC backend system. For example, from the log data could be seen that some pairs coincided with each other at some control point and continued their way from then on together, which resulted in some students going through part of the track in bigger groups.

## 5.3 After Use

After-use evaluation was utilised to investigate user experiences after the lesson and to identify possible changes in students' attitudes by comparing situations before and after use. Also the future use of the concept was inquired of students and teachers.

### 5.3.1 Mobile Questionnaire

Students' experiences were explored with a mobile questionnaire immediately after they had finished the Amazing NFC lesson. The questionnaire explored the general feelings after the lesson as well as the best things and the downsides experienced during the lesson. A three-point Likert scale ranging from 1 (positive) to 3 (negative) was used to measure the question concerning the emotions. 51.9% of the students reported that they had enjoyed participating in the lesson, whereas 13.5% described their feelings as negative (see Figure 4). A direct correlation between student's gender and feelings after the lesson was revealed: 20.3% of boys had negative feelings when only 5.1% of girls were in the same opinion. As much as 66.1% of girls but only 40.5% of boys had enjoyed the lesson.

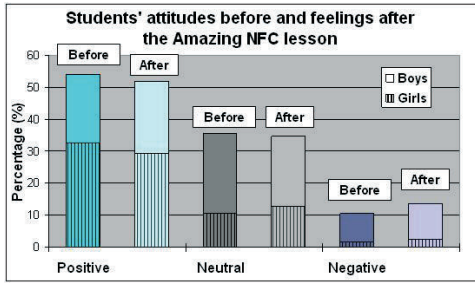


Figure 4: Students' attitudes towards Amazing NFC before the lesson and their feelings towards Amazing NFC after the lesson (n=133; 74 boys and 59 girls).

There was also discovered correlation between students' attitudes before and feelings after the lesson. 60% of the respondents who reported having negative feelings after the lesson had also had an unfavourable attitude towards the lesson. Correspondingly, as much as 72.9% of those having positive feelings after the lesson had also had a favourable, positive attitude before the lesson.

The best things in the lesson were considered to be spending time with a friend (30.8%), wandering on the town (22.6%) and trying out new technology (19.5%). Over half of the students (64.7%) stated that in their opinion there were no downsides in the Amazing NFC lesson. Those 35.3% that had experienced some negative things felt that the most important reason was related with finding the control points and moving around the city (12.8%).

### 5.3.2 Web Questionnaires

After the trial, students and teachers answered to the web questionnaire that aimed for evaluating their experiences about the lesson and finding improvement ideas for Amazing NFC. Unless stated otherwise, a four-point Likert scale ranging from 1 (strongly agree) to 4 (strongly disagree) was used to measure the questionnaire variables.

The total of 81 students (42 girls and 39 boys) answered to the web questionnaire. The majority of the respondents reported that they liked the urban adventure track (av. 3.741, where the scale was from 1 (boring) to 5 (nice)). Students mostly agreed that it was easy (av. 1.691) to discover the tags located at the NFC control points. The navigation from one control point to other by using the map and instructions received on the mobile phone was considered easy (av. 1.838). The usage of NFC phone and touching the tags was also experienced as effortless and natural (av. 1.457).

However, the students somewhat disagreed (av. 2.432) that the information provided at the control points was interesting. Students did not think they had learned lot of useful information during the lesson (av. 2.346) nor considered the questions presented at the control points having been challenging (av. 2.951). Nevertheless, they preferred (av. 1.704) the learning through Amazing NFC to learning in the classroom, but did not think (av. 2.346) that participating in the trial had given them more courage to visit the public buildings and offices in their hometown.

Students found it nice (av. 1.469) that they could go from one control point to other on their own and at their own pace. In the trial, the learning experience was rather social, as the students were instructed to work in pairs. Working in pairs was preferred by almost all (97.5%). In addition, many participants (59.5%) reported that they had formed bigger groups during the Amazing NFC lesson. The time it took from the students to go through the adventure track and the distances between the control points were perceived as suitable by 76.5%.

In the web questionnaire were also explored students' preferences between the eleven control points. Students had most liked about the control point that was situated inside the zoological museum (32.1%), next best was the bus journey to the museum (25.9%), the third best being the police station (9.9%). So, clearly the most interesting control point for Amazing NFC participants was the visit to zoological museum. The visit started with a bus journey, where the students were able to use their NFC phones for ticketing. Inside the bus the students were able to use informational NFC tags offering e.g. news from the local newspaper. For other transitions, students used bikes in all weathers. During some lessons, weather was cold, rainy and windy. Also, as the lesson lasted approximately three hours, some students started to get tired. Therefore, the bus ride was experienced as a welcome change. At the zoological museum, the students were instructed to see the animals on display, and consume content about the animals through tags attached to the displays. When compared to other control points, there was clearly required more activity and offered more interaction with the environment.

Students reported that they would be willing to participate in the Amazing NFC lesson also in the future (av. 2.123), but were not especially eager to go through the adventure track on their own outside the school (av. 2.716). In students' opinion NFC technology suited the learning concept well (av.

1.605) and they would be glad (av. 1.815) to use NFC technology also in other situations and environments. The average grade students gave to the concept was 8, on a scale from 4 to 10.

The total of eight teachers answered to the web questionnaire after the Amazing NFC lesson. Teachers experienced that the new learning concept exceeded their expectations (av. 1.5) and somewhat agreed that students had learned and received new information to expected extent (av. 1.75). All the teachers thought that the adventure track served well getting to know ones hometown, and 75% of the teachers were in the opinion that the lesson had also served students becoming independent and learning life-skills, whereas only 25% thought that the lesson had served informational learning. They also agreed that the monitoring of students' progress on the track was easy (av. 1.375) through the web-based interface and had received all the necessary information through it (av. 1.625). All the teachers were ready to exploit the learning concept in the future. The average grade the teachers gave to the concept was 8.9 on the scale from 4 to 10.

Teachers gave also many ideas for the future utilisation of Amazing NFC concept. For example, different kinds of adventure tracks could be planned based on art works, nature, history or different theme days such as Easter and Christmas, and in those occasions tags could be placed in locations that suit the theme. Teachers also hoped to see the concept to be used for teaching of different school subjects, e.g. in language learning clues and tasks at the control points could be given in English. NFC tracks could also be created for new students starting the secondary school in autumn. On their first day at new school students could go through the adventure track located on the school premises and would thus have an opportunity to familiarise themselves with the new school and its surroundings. Getting to know unfamiliar cities with the help of NFC technology would also be useful for example during school trips. Teachers were in the opinion that the adventure track should be mainly directed for a bit younger students, because students around the age of 15 already have so advanced knowledge and skill levels that they comprise a difficult target group when you want to dazzle them with new information.

### 5.3.3 Workshop

In the workshop twelve students were asked to give ideas on how the Amazing NFC concept could be improved and developed further. In their opinion,

tags at the control points should be hidden and located in more difficult places. Students also thought that the tasks should be longer, and more effort should be required to find answers to questions, because now all just guessed the answers. There should be someone supervising at the control points to check that all tasks would be performed correctly. Students hoped to see more physical and problem-solving tasks and activities at the control points and if they could also compete with each other on the adventure track it would bring along more motivation and excitement.

## 6 DISCUSSION AND CONCLUSION

The Amazing NFC learning concept provides a learning experience on a mobile phone – which many young people are comfortable using and enthusiastic about. Mobile technology was used to encourage both independence and collaborative learning experiences, to help to battle against reluctance to use ICT in learning, to help to remove some of the formality from the learning experience, to engage reluctant learners, to aid learners to remain more focused for longer periods and to help to raise learners' independence and self-esteem. In our concept an objective was to have learning content, pedagogical methods and technological tools all functioning in a harmony (Tétard et al., 2008).

Teenagers are a tough target group for designing mobile services. The experience and high knowledge in using mobile devices means that this user group is hard to amaze or even satisfy. NFC promises a novel and intuitive user interface to mobile devices but the novelty of the technology is not enough to ensure the success and interest of the concept. The teenagers who attended the trial had high expectations concerning the new technology and the content and quality of the service. One factor contributing to negative attitude towards the content provided and related tasks may be the association made by naming Amazing NFC after the popular TV show "Amazing Race". The naming might have set expectations and mental impressions that were not fulfilled. For example, searching and finding the tag at the control points was part of the excitement of the urban adventure. This is illustrated in the following improvement idea expressed by one of the students: "*Tags should be somehow hidden so it would be more interesting to search for them.*" The

excitement and challenge level of the TV show was not obviously reached during the lesson.

Observation of students showed that none of them had problems in learning to use touching as an interaction technique within a couple of minutes of hands-on training. Intuitiveness and naturalness of this interaction technique made adopting effortless. In NFC technology survey (O'Neill et al., 2007) was discovered that users were concerned with how the use of NFC readers in public spaces made them appear to other people around them. Many participants of that survey noted that they felt awkward at first using NFC due to the very explicit public act of reaching out and touching a tag embedded in the environment. However, many participants lost their reservations about using NFC over the course of the trial. In Amazing NFC trial, none of the students reported that touching tags would make them feel uncomfortable.

Even though the students attending the Amazing NFC lessons mostly reported that context-based mobile learning experience was better than classroom learning and they enjoyed participating in the lesson, they criticized the provided content strongly. Majority of students reported that the tasks and the information provided were not interesting and challenging enough to make the urban adventure truly motivating and thrilling. Students expressed their need for getting more challenging tasks, for example by including physical and competitive activity and increasing the variety of tasks. For example, the following student comment reveals the need for improvement: *"There should be more challenge at control points. Now the maps were not actually needed and the questions were too easy."*

Clearly the most interesting control point for Amazing NFC participants was the visit to the zoological museum. When compared to other control points, there was more activity required from the students and more interaction offered with the environment. The average time used for the visit was the longest during the lesson, and the content and related questions integrated seamlessly with the physical activities required and the context of use. In most control points, the students just quickly visited the entrance hall of a public building for reading the content and to answer the question. In these cases, the physical experience and social context of the location did not successfully integrate with the content provided, as the students did not really interact and experience the space and environment they visited.

Thus, in future development the Amazing NFC urban adventure needs to be more carefully

combined with intrinsically motivating attributes (Malone and Lepper, 1987) such as challenge, curiosity and competition. However, when adding the element of competition in learning, one has to be aware of the possible pitfalls associated with racing (Wyeth et al., 2008).

Teachers brought up an idea that in the future the students themselves could act as content creators and providers by offering them a possibility to create their very own tags and to place these tags at the control points. In general, teachers identified that the main benefit of the Amazing NFC lesson was moving the teaching situation and learning experience from the traditional classroom to real-life contexts that also included social interaction between students.

Within this mobile learning concept the threats mostly concern to ensure the safety of students while they are independently going through the urban adventure track. However, students participating in the trial were already older and more independent and used to move around the city by themselves. Also, students could not get lost in the city because teachers were able to follow in real time their progress on the track through a web interface, and the students were advised to use the NFC phone to call the teacher in case of problems or questions. Throughout the pilot, the students coped very well on their own. However, the city of Oulu is relatively small (130 000 inhabitants). In bigger cities safety could be more of a problem.

Also, in this kind of concept a password protection is a necessary requirement to gain access to the web interface that contains status information of the students (which control points have been visited, at what time and by whom) while they are on the urban adventure track. Tags at the control points need also be protected against rewriting.

After this Amazing NFC trial, the project arranged a cultural/historical track where students became familiar with the city of Oulu's culture and history. The route consisted of seven NFC control points located at the local cultural and historical sites in the Oulu, such as statues, monuments and historically meaningful buildings.

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**Touch-based access to  
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User experience findings**

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# Touch-Based Access to Mobile Internet: User Experience Findings

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## ABSTRACT

*This article reports user experience findings from two field trials where Mobile Internet access was supported through Near Field Communication (NFC)-based tag infrastructure. The authors' results show that touch-based interaction can provide enhancement to the Mobile Internet user experience in: (1) content and service discovery, (2) Mobile Internet access, and (3) integrated situated and embodied experience. The problems related to service discovery can be solved by providing location-based access, and by using visual cues embedded into the environment for discovering content and services. Mobile Internet access through touch solves the problem of memorizing complicated URLs and the challenge of typing with a mobile device keypad. As touch-based access builds a semantic bridge between the physical context of use and the Mobile Internet experience, the user experience converges seamlessly into one where both the physical and digital worlds play a role.*

*Keywords: Mobile Internet, Near Field Communication (NFC), Physical Interaction, Tags, Touch-Based Interaction, User Experience*

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## INTRODUCTION

Internet content and services are becoming increasingly versatile and soon will integrate with practically all the imaginable and yet unimagined areas of our lives. It seems likely that internet use will not be limited to the boundaries set by desktop use, but rather will be needed and sought after also in mobile situations. The fast technological development of wireless networks and wireless communication devices seems to offer solutions that can make that hap-

pen. Modern urban environments are evolving towards Mark Weiser's (Weiser, 1991) vision of Ubiquitous Computing, where all objects are computerized and networked.

The Mobile Internet has shown that technological advances and service availability alone do not result in widespread adoption and use (Constantiou et al., 2007). There are still challenges in the Mobile Internet hindering usage and slowing down adoption rates. An example of such a challenge is our limited understanding of how the Mobile Internet differs from the traditional internet experienced through a fixed desktop environment (Isomursu et al., 2007).

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Research on mixed reality user interfaces (Milgram et al., 1994) has explored how our physical environment could be enhanced with digital content and services by mixing digital information and affordances with our physical world. NFC (Near Field Communication) technology provides one alternative for adding a link between an object in the physical world and digital content and services associated with that object. This link can be used by direct physical manipulation to provide digital services through a physical interface. These kinds of physical mobile interactions make it possible to bridge the gap between the physical and virtual world in an intuitive way (Falke et al., 2007).

### Touch to Access Mobile Internet

Accessing internet content through objects in the physical world is called physical browsing (Ailisto et al., 2006). In physical browsing, the links are embedded in physical objects, and the user can select and use them to access internet content and services.

The technology used in the research presented in this article, NFC, is one technology for implementing physical browsing user interfaces. Other possible solutions include, for example, visual codes that are read through the camera of a mobile device (Rekimoto & Ayatsuka, 2000; Hansen & Grønbaek, 2008), infrared transceivers and tags (Swindells et al., 2002) or infrared beacons (Debaty et al., 2005; Want et al., 1999), and various other RFID variations (Want et al., 1999).

The user experience of NFC-supported service and content access has been studied in controlled settings. Touch-based service and content access have been found to be easy to learn and use, and users value the simplicity of the technology (Isomursu et al., 2008; Riekkilä et al., 2006; Välikkynen et al., 2006a). The research presented in this article contributes to the prevailing knowledge by exploring the user experience related especially to Mobile Internet access and providing results from the use of technology in field settings in various contexts.

### NFC Technology

The field trials reported in this article have been implemented within the constraints of a research project that has evaluated applications and services based on Near Field Communication (NFC) technology. NFC is a short-range wireless technology that allows electronic devices to exchange data upon touching. NFC standards have been built over existing radio frequency communication standards (e.g. RFID and smart card standards), so it is a special case of RFID implementation technology.

The most common scenario for NFC use is to integrate the NFC reader into a mobile device, such as a mobile phone. This has already been done by some mobile phone manufacturers, and low quantities of NFC-enabled mobile phones have been available in the market for some years now. The mobile device can then be used to read NFC tags, or to communicate with other NFC-enabled devices upon touch. NFC tags are small and cheap, and they can be attached to virtually any object or surface. The tag can then act as a link between the physical and digital worlds.

Using an NFC tag as a Mobile Internet access point is very simple. The tag can directly store the URL to the web content. When the user touches the tag, the URL is transferred to the mobile phone using short-range radio frequency. No resolution services are needed, as the browser available in the mobile phone can directly access the URL transferred from the tag. In this article, we explore the usage scenario where a URL is transferred from the tag to the mobile phone. It is important to note, however, that the tag can store other formats of data too, such as phone numbers.

### Mobile Internet Access Challenges

The expected main benefit of touch-based Mobile Internet access is that the user does not need to type or remember the URL needed to access the Mobile Internet content. Other solutions to this problem explored by previous studies include, for example, context-sensitive

search (Church & Smyth, 2008) and adaptive content push (Beaver et al., 2006).

Reducing the number of key presses required to access and use Mobile Internet content has been found to be a one of the key principles in making the Mobile Internet more usable (Buchanan et al., 2001; Kamvar & Baluja 2006). The effort needed to enter a word on a cell phone keypad is more than double that required to enter the same word on a full QWERTY keyboard (Kamvar & Baluja 2006). With touch-based Mobile Internet access, the user does not necessarily need to use the keypad at all. This makes Mobile Internet access easier and faster for all users, and is especially valuable for those who cannot use the small keypad of a mobile phone because of limited vision or poor hand-eye coordination (for example, the visually impaired or elderly), or for reasons of illiteracy (for example, very small children). NFC technology can be used to implement Mobile Internet access requiring no keypad use, or reading of the display. This has proved especially valuable with elderly users (Häikiö et al., 2007).

In a research paper by Rukzio et al., (2004) it was established that finding services in a given context is one of the central issues that needs to be addressed in order to create useful mobile services. A significant problem is that the discovery process of location-based and context-aware services is left to the user alone. In order to solve this problem, the user needs to be made aware of the availability of these services, for example by means of different kinds of visual codes (Rukzio et al., 2004).

## RESEARCH METHODS

The research question explored in this article deals with existing technology (touch-based interaction enabled by NFC technology) that is commercially available, but not yet widely used in the market. Therefore, to get access to user experiences evoked in normal everyday use, we chose to use field trials. In the trials, selected users were introduced to and provided with the

technology and related applications. They then made a commitment to use the technology as a tool in their everyday life, and using selected methods, report their subjective experiences to the researchers.

The two field trials presented are part of a larger three-year (2006-2008) technology research project, SmartTouch, which explores the use of NFC technology in various domains. The field trials were planned and implemented in co-operation with the city authorities, service and technology providers, and research parties. The goal was to achieve as high an experimental reality (Aronson, 2004) as possible, i.e. the trial aimed at providing conditions where users would be able to integrate the evaluated technology and related applications into their everyday life and practices.

In both field trials, the research focus was on the subjective user experience of the trial users. We define the subjective user experience to cover both the sensory experience evoked by the use of Mobile Internet, and the subjective interpretation of the experience. This can be called, for example, "qualia" (Ramachandran & Blakeslee, 1998); which is to say the raw feeling of subjective sensations. Therefore, the approach for understanding the user experience is phenomenological, i.e. the user experience is seen as a subjective, first-person phenomenon (Greenfield, 2000). Methodologically, the problem is how to capture objective research data about a subjective experience. In our trials, the methods for capturing an objective account describing the subjective user experience were tailored individually for each field trial. The primary sources of data were the humans subjectively experiencing the user experience, i.e. the trial users. Research on psychology and experience design shows that describing subjective experiences has its challenges, for example, through recall problems (Robinson & Clover, 2002), or difficulty in verbalising one's emotions (Desmet, 2002; Reijnveld, 2003). However, our hypothesis is that a subjective, first-person description of an experience is still the most reliable source available for understanding and characterizing the subjective

user experience, as it is impossible for another person to experience the subjective experience of another person (Greenfield, 2000). Subjective descriptions of user experiences were collected primarily through questionnaires and semi-structured interviews. These descriptions were complemented with observations which provided an external interpretation of the subjective experiences. Observation included both direct observation of behaviour triggered by the user experience, and observation of the use and usage patterns through automatically compiled log data.

In this article, we focus purely on analyzing the user experience related to consuming Mobile Internet content and services, and exclude analysis of the socio-economic impacts of the applications used, or how the applications were able to fulfil their goals (e.g. learning goals in the case of the mobile learning trial).

## FIELD TRIALS

The results presented in this article are based on the findings from two field trials. In the first field trial, NFC tags providing access to selected Mobile Internet content were distributed in public places in the city of Oulu to be used by anyone passing by. In this trial, the vision of ubiquitous Mobile Internet access in an urban environment was explored. The access tags were called "Information tags". In the second trial, a mobile learning environment with an urban adventure realized by the means of an NFC track was investigated. This trial aimed to analyze touch-based Mobile Internet access directed to specific users in a defined context as an implementation technique for mobile learning.

Both field trials were organized in the city of Oulu, Finland. Oulu is the sixth largest city in Finland with 130,000 residents and with a population density of 357 people per km<sup>2</sup>. Today, there are some 850 high-tech companies based in the Oulu area, employing some 18,500 people. (Ministry for Foreign Affairs of Finland, 2009)

## Information Tag Trial

In the information tag trial, 2650 NFC tags providing access points to selected Mobile Internet content were distributed in public places in the city of Oulu. The vision of this trial was that tags placed in our everyday environment can provide location-aware access to Mobile Internet content and services for visitors or people passing by. Service and content access could be provided by commercial players, public authorities, communities and even private persons, as NFC tags are cheap and easy to program. In our trial, the tags providing a mixed-reality user interface to access the Mobile Internet were called "information tags" to depict the specific nature of information access.

Information tags were placed in different contexts:

- **On parking meters:** The parking meters were placed outside on the pavements. People parking their cars used the parking meters, and also people walking by passed the parking meters within touching distance.
- **Theatre:** In a theatre, information tags were placed on large posters on walls, and on stands placed on the tables of cafeterias and halls.
- **Restaurant:** In a restaurant, information tags were placed on stands placed on the tables.
- **Pub:** In a pub, information tags were placed on the bar and tables for clients.
- **In a bus and at bus stops:** In the bus, information tags were attached within reach of the passengers (see Figure 1).

In all contexts, a selected set of tags providing Mobile Internet content access was provided. This generic set of content contained the following:

- access to news through a Mobile Internet version of local newspaper
- the menu of a local restaurant

*Figure 1. A passenger accessing Mobile Internet content through information tags available in a bus. Note that the symbol indicating the area to be touched is different in this version of information tags. It was later changed into an N-like symbol visible in the other figures.*



- the menu of a local pub
- the program of local theatre
- an operator portal for city-specific information

In addition to generic content, theatre, bus stops and pub-provided content specific to those environments was given. In the theatre, information about plays including, for example, trailers and the director's comments, could be accessed through tags placed in posters (as seen in Figure 2). At bus stops, the users could access real-time bus schedule information through an information tag. In the pub, the clients could use the information tags to access Mobile Internet content describing the special selection of beers available (see Figure 3). The total number of tags distributed in the city was 2,650.

The goal of the information tags was to provide a generic service for people visiting the places in which the tags were placed. However, for research purposes, we needed to recruit users in order to provide them with the NFC-enabled mobile phones. Information tags were available for use for the total of 238 trial users, who were

recruited to use other NFC-based applications, namely NFC-enabled parking payment, ticketing in a theatre, ordering lunch and pub customer services. The users were recruited primarily for testing these application concepts, not the information tags. Information tags provided an add-on service that all recruited users (or any other user with an NFC-enabled phone) were able to use during the trial period. The parking pilot users were recruited from companies operating in the city area, as their employees needed and used parking services regularly. Theatre users were also recruited through local companies, who wanted to provide a theatre experience for their employees. Restaurant and pub users were recruited from the regular customers of both places. The individual pilots were active at different times (see summary in Table 1).

Two main sources of data were used for analyzing and interpreting the use and user experience evoked through the information tags. The first data source was the automatically generated logs about use. The logs provided information about who used the tags, which

Figure 2. Theatre visitors consuming Mobile Internet content about the play



tags were used, and when the tags were used. The second data source was a questionnaire and related interviews. They were used for collecting subjective experiences related to the use of the information tags.

The user's subjective experience was collected immediately after the trial with questionnaires. In some contexts, a web-based questionnaire was used (e.g. for the theatre visitors), and for some, a paper-based questionnaire

Figure 3. Pub customer accessing Mobile Internet content describing special beers available at the pub



*Table 1. Timing of information tag pilots and duration of use for individual users*

	<b>Period</b>	<b>Duration</b>	<b>Duration of use for individual user</b>
Parking pilot	3 Sep – 1 Nov 2007	approx. 8 weeks	Whole pilot period
Theatre pilot	8 Nov – 19 Dec 2007	approx. 6 weeks	One evening
Pub pilot	12 Nov – 31 Dec 2007	approx. 7 weeks	Whole pilot period
Restaurant pilot	19 Nov – 31 Dec 2007	approx. 6 weeks	Whole pilot period

was applied (e.g. for the parking application users). The choice was made on the basis of practical arrangements: in the theatre, each user used the NFC-enabled mobile phone to access theatre specific Mobile Internet content only once, and they did not meet the researchers face-to-face. Using a web-based questionnaire, the user experience data could be collected immediately after each theatre visit, thus minimizing recall problems. All users returned their online questionnaires within a couple of days after the theatre visit. On the other hand, the parking application users met the researchers in a feedback seminar right after the trial, when they returned their phones to the research team. This provided a perfect opportunity to give the users the paper questionnaires which they could return when they left the seminar. However, not everyone had time to fill out the paper questionnaire, and they were subsequently requested to fill the questionnaire through a web interface. 43 users filled the paper questionnaire in the seminar, and five users filled the web question-

naire right after the trial period. In the restaurant and pub trials the request to fill out a feedback questionnaire was sent to the users by email immediately after the trial ended, and the majority of the users replied within one week (only four out of 39 used more than a week), and more than half responded on the same day that the request was sent (20 out of 39). A summary of the number of test users in each context and the data available through final questionnaires is presented in Table 2.

All the users were adults, the youngest being 22 years and the oldest 72 years. The average age was around 40 years. The gender balance was equal for parking and restaurant application users, but for the theatre, females outnumbered males (76% of the users were females), whereas in the pub context males outnumbered females (88% male users).

Even though the log data and questionnaires provide the primary source of data used in the analysis, we also did some additional, context specific data collection especially for capturing

*Table 2. Number of users for each trial and reply rates for the final feedback questionnaire*

	<b>Total # users</b>	<b># of returned questionnaires</b>	<b>Questionnaire return %</b>	<b>Questionnaire type</b>	<b>Time of returning the questionnaire</b>
Parking	51	48	94%	paper combined with web	when users returned the phones
Theatre	141	101	72%	web	within a couple of days after the visit
Restaurant	27	23	85%	web	mainly within one week after the trial
Pub	19	16	84%	web	mainly within one week after the trial

data that could help in understanding the subjective user experience. The users of the parking application were interviewed after the trial in a feedback seminar. Eleven users volunteered for the interview. The interviews were recorded. The average duration of the interview was around ten minutes, the majority of which was used for exploring issues related to the parking application, not to information tags. Also, the users of the parking application were able to send feedback during the trial using a feedback form in the Web. The total number of feedback forms received during the parking trial was 26 – most dealing with the parking application itself. The theatre visitors were observed in actual use situations by attending the theatre visits with the users. Observation was done during one selected evening, when the researchers visited the theatre and at the same time, trial used the services themselves to get a first-person experience in addition to observing other users and the responses of bystanders. After visiting the theatre, the researchers verbalized their own experiences and observations through an open-ended questionnaire. Usability testing was performed in the restaurant pilot. A total of five users used the service in the restaurant, and the testing session was videotaped. In the usability test, the users followed a predefined test script, i.e. they all performed the same activities in the same order. Also, personnel of each establishment were interviewed for their interpretation of user experiences evoked, as they had received feedback from the users during the trial, and had observed the users on a day-to-day basis.

The log and questionnaire data was analysed with basic statistical methods, and used for producing charts and other visualizations of data for interpretation. Observation, interviews and feedback were analysed with content-based qualitative methods, where the main goal was to interpret and analyze descriptions of the subjective user experience, and find relationships and explanations with findings based on quantitative data.

## Mobile Learning Trial

Our second field trial was implemented in the school environment. The users were 14 to 15 year old pupils of schools located in the Oulu district. A total of 228 pupils attended the trial during May 2008. Participating pupils were from multiple classes of four different schools. The mobile learning concept used in the trial was called “Amazing NFC” after the well known TV series called “The Amazing Race”.

Over the course of the field trial, each pupil participated in one Amazing NFC lesson, during which the pupils were guided through an urban adventure track with the help of mobile phone and related Mobile Internet content. On each trial day only one lesson was organized, in which two classes participated at a time. Eleven locations around the city of Oulu were each marked with an NFC-marker, and pupils were to visit all the eleven locations during the lesson. Here, we call these locations “control points”. The pupils were grouped into small groups of two, and all were provided with NFC-enabled mobile phones for the duration of the lesson, which lasted an average of three hours. By touching the NFC tag at each control point, the pupils received information about the place where the control point was located (e.g. a fire station), and given a related question that required an answer. In some locations, the question required the user to perform some tasks to acquire the information needed to answer the question. For example, at the social insurance institution, the pupils had to browse the web service of the institution to access information required to answer the question correctly. During the lesson, the teachers were able to follow in real time via a web-based interface how the pairs of pupils proceeded through the adventure track. Also, the pupils were advised to use the mobile phone to call the teacher in case of problems or questions.

In Figure 4, the pupils try Amazing NFC at the city hall of Oulu. This situation was photographed in the design phase to get feedback from the pupils. In the actual trial, the visual outlook of the tag was richer and more colourful, the



*Figure 4. Pupils trying out Amazing NFC at the city hall of Oulu*



tag was located in the entrance hall instead of auditorium, and the pupils were wearing their outdoor clothing.

The educational goals of the lesson were to provide the pupils with skills related to landmarks, public buildings and offices in their hometown, and practical skills related to dealing with public authorities in the course of mundane everyday tasks. The locations chosen as control points were the city information centre, fire station, swimming hall, police station, museum, city hall, youth and culture centre, zoological museum (requiring a bus journey to the museum and back), city library, theatre and the social insurance institution. The control points, with the exception of the zoological museum, were located in the city centre within a couple of kilometres distance of each other, and the pupils were expected to travel from one control point to another with bikes (although some used mopeds against instructions).

The Amazing NFC lesson was planned and designed in close cooperation with teachers, service and technology providers, and researchers. Special emphasis was put into integrating

the concept into the normal practices of the schools, as the goal was to create a concept that could be adopted as a learning instrument to be used also after the research trial. This required the close involvement of teachers and school administration in planning and implementing the applications, and organizing and supervising the trials. During the trial, the researchers were only involved in the data collection activities; teachers took full responsibility for organizing and supervising the actual Amazing NFC lessons.

User experience data was collected in three phases: before use, during use, and after use. Before use, our researchers observed how the pupils learned to use the evaluated technology, and what kind of spontaneous reactions and discussion took place at the introduction of the concept. A mobile questionnaire, comprising of short multiple-choice questions, was used to capture information about the expectations and attitudes towards the technology-supported learning experience just before the Amazing NFC lesson. Unfortunately, there were some technical problems with the mobile question-

*Table 3. Summary of data collection methods and number of valid cases for each method*

Data collection method	Number of valid cases
Mobile questionnaire before use	133
Observation of learning before use	30
Video on selected control points	50
Video shot by pupils during the lesson	4
Log data about lesson	228
Mobile questionnaire after use	133
Web questionnaire after use	81

naire during the very first trial lessons. Additionally, some teachers forgot to provide the NFC tag used for accessing the mobile questionnaire for their pupils. Therefore, not all pupils were able to report their experiences through the mobile questionnaire (we received 133 valid responses from 228 participants).

User experiences during the Amazing NFC lesson were collected through video recordings, and the automatic creation of log data about how the pairs of pupils progressed. Video recordings were made by placing video cameras at fixed spots where the camera recorded the pupils visiting that specific location on the track, and by providing two pupil pairs (i.e. altogether four pupils) video cameras that they could use to record their experiences during the lesson.

After use, the pupils filled out a multiple-choice mobile questionnaire collecting data about the user experience immediately after the lesson. The data received from both mobile questionnaires was used to survey how pupils' expectations and attitudes changed during the trial; whether their expectations were met and attitudes altered. The pupils were also requested to fill out a web questionnaire within two weeks after the trial. Pupils mainly answered the web questionnaire at school, as their teachers took the initiative to offer pupils time and facilities to fill in the questionnaire in the midst of the school work. A web questionnaire aimed for evaluating in more detail the pupils' experiences about the lesson, and pupils were also asked for generating ideas for improving the mobile

learning concept. In addition, we arranged a workshop with twelve pupils exploring their experiences with the Amazing NFC. The workshop included participatory features, i.e. the pupils participated in designing how to iterate the concept for future use. The data collection methods and numbers of users for each method are listed in Table 3.

## USER EXPERIENCE FINDINGS

We offer here a combined presentation of the findings related to the Mobile Internet user experience revealed through the analysis of user experience data collected in the field trials described above. The findings are grouped into five groups discussing user experience findings related to (1) ease of use, (2) social acceptance, (3) discoverability, (4) content and (5) technical problems.

### Ease of Use

The trials provided all users with their first experience of using NFC technology. Therefore, it is not surprising that learning touch-based interaction required some practice. As NFC technology is based on short-range radio technology, the NFC reader reads a tag not only upon physical touch, but also from a distance of a couple of centimetres. Therefore, the users needed some practice to find the comfortable personal reading distance: some users preferred to physically touch the tag, while others pre-

ferred a short reading distance. Also, finding the right contact point both from the phone and from the tag, and learning the response times required some practice. However, all users were able to learn to use touch-based interaction with a few repetitions. Our observations indicate that learning NFC-enabled touch-based interaction requires hands-on practice, but can be adopted within a few minutes. In the information tag trial, over 90% of the users stated that learning touch-based interaction to access Mobile Internet content was easy. Observation of pupils in the mobile learning trial showed that none of the pupils had problems in learning to access Mobile Internet content through touch within a couple of minutes of hands-on training.

The use of tags for accessing Mobile Internet content was perceived as extremely easy in both trials. Users reported that accessing Mobile Internet by touching tags was very easy (92,6% of Amazing NFC web survey respondents stated that using NFC phones and touching tags was easy and natural). Participants also described the experience of touching a tag to access Internet content to be pleasant (depending on context, 70-80% of information tag users said that touching was a pleasant interaction technique). The only inconvenience reported by the users was related to using two phones during the trial. Even when the trial users were allowed to use the trial mobile phone for their personal phone calls, they usually preferred to carry both their own and trial phones with them most of the times. This caused extra worry, as the users were required to keep track of and find space for two devices. Also, this fact probably affected the user experience, as the full possibilities of mobile convergence (i.e. combining internet access with normal functionality of a mobile phone) were not realized. This is well illustrated by the following user comment from an interview concerning an information tag user participating in the parking payment trial:

*I would definitely use this service if it would be made available. However, the prerequisite would be that I would not be required to carry*

*two mobile phones with me. (translated by the authors)*

## Social Acceptance

In none of the trials did the users report that touching tags would feel socially unacceptable, as has been indicated by some user studies on similar user interfaces conducted earlier (Riekkilä et al., 2006). However, in some cases users did present concerns on how easy Internet access might negatively affect social interaction. For example, in the pub, users expressed concerns that consuming Mobile Internet content through a mobile device in a pub would decrease social interaction between the pub clients, and the clients and personnel. Pub visitors seemed to value the social interaction provided by the pub environment. For example, the information tags provided information about the special products available but some users said that they would prefer getting that information directly from the pub personnel.

The nature of current Mobile Internet content typically is most suited for personal use, and consuming it could reduce the interaction between people. However, with good contextual design of the services and content, it is posited that social interaction can also be fostered and encouraged. For example, in the pub context, the service content could be designed to evoke discussion or interaction amongst pub clients and between clients and personnel, for example, in the format of quizzes. In the mobile learning trial, the learning experience was social, as the pupils were instructed to work in pairs. Working in pairs was preferred by almost all (97.5% of respondents of the web questionnaire). In addition, most participants (59.5% of respondents of the web questionnaire) reported that they had formed bigger groups during the Amazing NFC lesson.

In the theatre context, two concerns related to social interaction were identified. First, the placement of the tags had an influence on how people located themselves in the space, and therefore placement seemed to negatively affect

group formation, and draw people away from each other into solitary units. When designing NFC-based systems, special attention must be given to these kinds of social and behavioural concerns. The optimal placement of tags supports the natural paths and flow of people in the space by allowing people to form groups and engage in social interaction, but at the same time, does not block pathways.

Second, as some of the content that was made accessible by the tags was video with sound, some users seemed embarrassed or startled by the loudness of the suddenly appearing sound. This might also partly explain why the preferred media format in Amazing NFC was text (see Figure 10). As the user usually does not know for sure what kind of content the tag links to, these kinds of embarrassing moments may form a formidable hindrance to the adoption of Mobile Internet usage. As a possible solution, a tag could indicate the media types it links to through its graphical design. Use of symbols has been suggested previously for indicating the type of the service provided through the tag (Välkkynen et al., 2006b) but, according to our knowledge, not for the purpose of indicating media type.

## Discoverability

The tags can provide support for service discovery only when the user is able to discover the tags embedded in things and the environment. Therefore, the tags must be marked somehow, or the user must know where the tag is. In small, specific purpose applications, it can be reasonable or even desirable to have hidden tags that are known only by the users to whom they are targeted (e.g. service described in Häikiö et al., 2007). However, for services that are targeted for larger audiences or random users, marking the tag somehow is crucial.

In small-scale prototypes of information tags, we have used special-purpose visual design for each tag. For example, to access bus time schedules we used an icon representing a bus to mark the tag. However, we quickly found out that when there were many services available,

the users had trouble discovering tags that did not share common visual characteristics. In the trials presented here, we used a special icon to mark the tag, and then explained the content provided on the space around the tag. In the first trials, we used the icon illustrated in Figure 1 (similar to work presented by Arnall (2006)). The users learned quickly that the round icon was always used to mark a tag. However, soon after, the NFC Forum (<http://www.nfc-forum.org>) introduced their own standardized visual icon that is illustrated in Figures 2 and 3. We decided to adopt the standardized icon, as standardization seemed to be a good way for introducing a common language to large audiences globally. Amazing NFC trial users reported having experienced no difficulties in locating the NFC tags at the control points: 92.6% of the pupils stated that finding tags was easy.

As the markings we used were based on visual icons, for the visually impaired, discovering tags can be problematic. With NFC technology, it is, however, possible to implement an audio application that can aid in locating a tag. When the visually impaired user brushes a surface with a mobile phone, the phone gives an audio cue when the tag is detected. However, the user should already know that the tag would be available for use somewhere.

In the information tag trial, users discovered tags that did not respond to touch. For example, the tags used for parking payment could be used only by subscribers who had the parking payment Java application installed in their mobile phone. The users found these situations very annoying. Therefore, it could be recommended that standardized markings would not be used on tags that are not targeted for all users. In these cases, the users of a special-purpose application should learn to find the service tags by other means.

We used the same sizing in each trial, i.e. the size of the visual marking was always the same as the size of the tag (c. four centimetres). This seemed to be adequate when the tags were located near the user, i.e. within reach. However, several users complained that the visual markers were too small when the tags were located

further away. This was especially noted in the theatre pilot, where the smart posters were placed on the walls of the theatre building. The size of the visual icon was obviously too small to be properly seen from a distance, as is illustrated by the following comments made by the theatre visitors:

*The target marks used in the posters should be printed larger so that one could see it over a distance.*

*The tags were too small. (translated by the authors)*

On the other hand, if the visual icon used to mark the placement of the tag is larger than the tag itself, the users might face difficulties in finding the correct spot to touch within the visual icon. This could be solved, for example, by having additional visual signals inside the visual icon to indicate the optimum spot to touch.

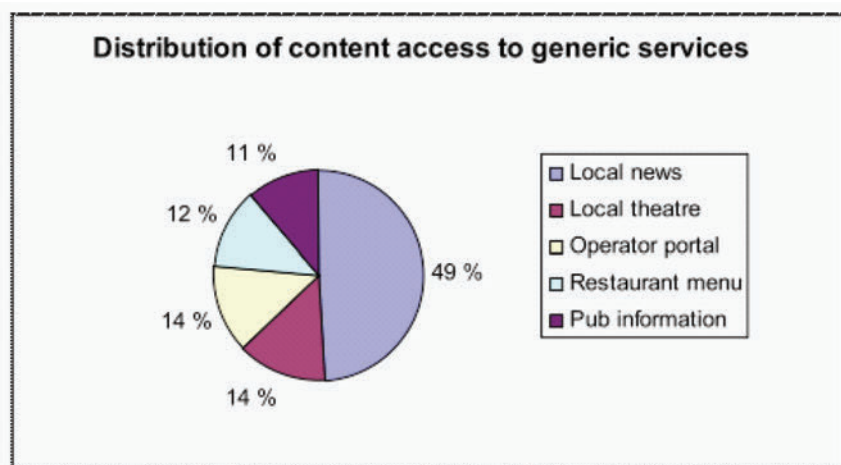
## Content

The most accessed Internet content during the information tag trial was the news service of the local newspaper. It was the most used when measured by the logs (see Figure 5), and rated subjectively as the most interesting and valuable service provided in the trials.

The program of the local theatre was also rated as interesting in subjective ratings. However, many users were disappointed that the content of the theatre program was static, which meant that it was not updated during the trial, and therefore contained old information. This observation was repeated in several comments; the users expected digital content to be up-to-date, and they wished that it would be frequently updated.

The information tag users expressed hopes of better utilizing the possibilities of the digital platform by, for example, providing location aware services. The users rated content describing local events and information as most interesting (i.e. local news and the program of local theatre). Some content available through the tags did not take full use of the location

*Figure 5. Distribution of access to Mobile Internet content through information tags during a nine-day period estimated not to contain artificial accesses caused, for example, by usability testing or research demonstrations*



information. For example, a tag that provided access to a tourism information service provided information about another city as the default. The users were puzzled why they were provided information about events in the city of Helsinki, when they were located 600 kilometres away in Oulu. Of course, they could access information about events in Oulu by selecting the correct city from a pull-down menu, but the users expected the knowledge about their location to be automatically processed by the service.

The pilot specific tags were used more than generic tags in all pilots (see Figure 6). In the restaurant pilot, the pilot specific tags were used for making an order, and the user had to touch multiple tags to finish an order. This explains the high volume of tag usage in the restaurant pilot.

Even though the pupils attending Amazing NFC lessons mostly reported that the mobile learning experience was better than classroom learning (93,8% of web survey respondents) and that they enjoyed participating in the lesson (see Figure 7), they strongly criticized the Mobile Internet content provided. The majority of pupils reported that the tasks were not challenging enough (70,4% of respondents of the web survey) and 40,7% stated that the information provided was not interesting. Most improvement ideas suggested the provision of more challenging tasks, for example by includ-

ing physical activity and increasing the variety of tasks. The following user excerpts illustrate ideas for improvement related to the content expressed by the pupils after the lesson:

*I would like to have more interesting content and more difficult questions at the control points.*

*There should be more challenge at control points. Now the maps were not actually needed and the questions were too easy.*

*The tasks should have been longer, and more effort should have been required to find answers to questions, because now all just guessed the answers. There should have been someone supervising the control points to check that all the tasks would be performed correctly. (translated by the authors)*

One factor contributing to negative attitude towards the Mobile Internet content provided and related tasks may be the association made by naming Amazing NFC after the popular TV show The Amazing Race. The naming might have set expectations and mental impressions that were not fulfilled. The excitement and challenge level of the TV show was not obviously reached during the lesson.

Figure 6. Distribution of tag usage across pilots. Data from the parking pilot was not available for analysis due to technical problem with logs

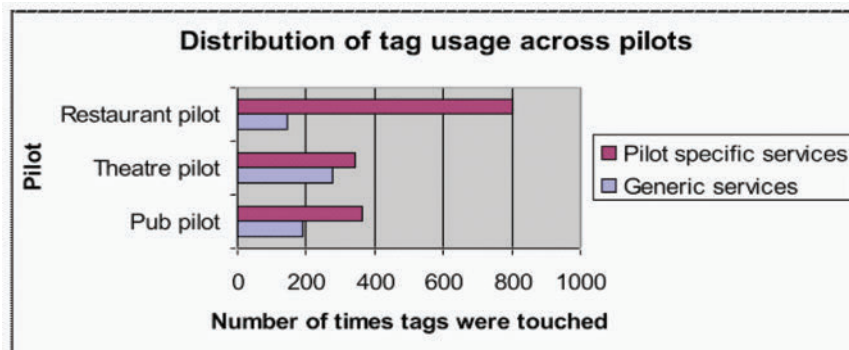
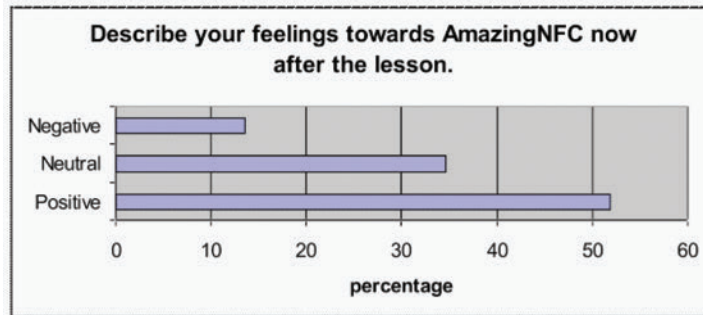


Figure 7. Feelings towards Amazing NFC according to the mobile survey made right after the lesson ( $n=133$ )



Clearly the most interesting control point for Amazing NFC participants was the visit to the Zoological museum (see Figure 8).

The visit started with a bus journey, where the pupils were able to use their mobile phones for ticketing and touching information tags available inside the bus. For other transitions, pupils used bikes in all weathers. During some lessons, the weather was cold, rainy and windy. Also, as the lesson lasted approximately three hours, some pupils started to get tired. Therefore, the bus ride was experienced as a welcome change. At the Zoological museum, the pupils were instructed to see the animals on display, and consume Mobile Internet content about the animals through tags attached to the displays (see Figure 9). When compared to other control points, there was clearly more activity required and interaction with the environment. The average time used for the visit was the longest during the lesson, and the Mobile Internet content and related questions integrated seamlessly with the physical activities required and the context of use. Our findings indicate that the Mobile Internet user experience successfully supported and enhanced the museum visit user experience. At most control points, the pupils were only required to quickly visit the entrance hall of a public building for reading the Mobile Internet content to answer the question. In these cases, the physical experience and social context of the location did not successfully integrate with the

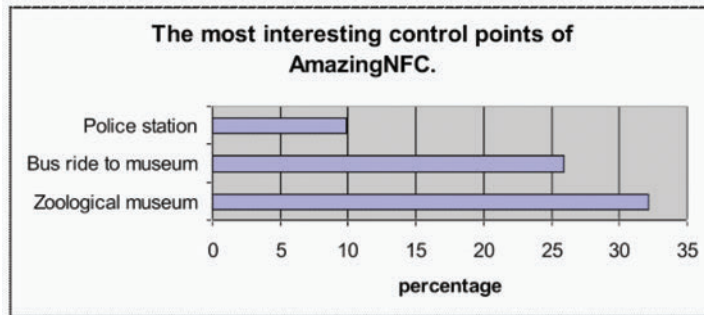
Mobile Internet content provided, as the pupils did not really interact and experience the space and environment they visited.

In the information tag trial, which lasted for a longer period, the usage was clearly most frequent at the beginning of the trial, and rather quickly faded with time. The users explained this phenomenon most often by highlighting the static nature of the content. When they had seen the content once, it did not interest them anymore. This may also explain the popularity of the news service since it was frequently updated.

### Technical Problems

Some users were annoyed by the long download times of the content. Especially, at the theatre the download times could be inconveniently long, as the structure of the building impaired the capacity of the wireless network available, and the video content provided needed more network capacity than most commonly used Mobile Internet pages containing primarily text and small pictures. Perhaps because of the long download times of video and pictures, text was the preferred format over other content formats in the Amazing NFC trial (see Figure 10). Pupils also reported that they occasionally became frustrated with the long download times:

Figure 8. The three most interesting control points of Amazing NFC according to the web survey (n=81)



*You had to wait for a long time for a web site to download. (translated by the authors)*

In the information tag trial, tags were ubiquitous and could be placed virtually anywhere in a public space. Some of the tags that the users found were visible and available for touching but not operational because they were broken or set up to work only with certain devices for

specific users. The users found these situations very annoying. They expected that they would get some response from all the tags that were available for touching, and when that did not happen, they were irritated.

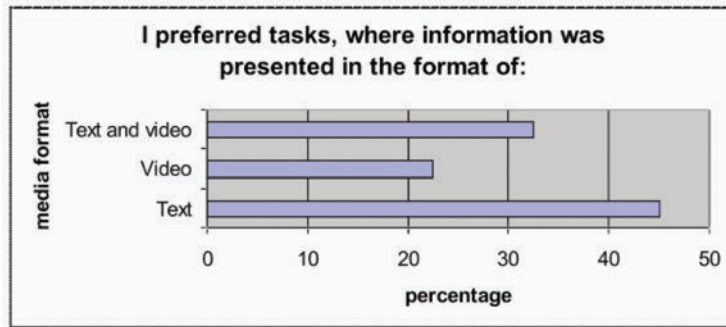
As tags are cheap and easy to attach almost anywhere, there is a danger of “tag litter” that can destroy the user experience and especially trust towards tags in general. As tags are not

Figure 9. A pupil touching an Amazing NFC tag at the Zoological museum





Figure 10. Preferred media formats of Amazing NFC participants according to the web survey (n=81)



continuously connected to a network, it is difficult for service providers to notice when a tag becomes inoperable. As tags can be distributed by virtually anybody, it might not be reasonable to assume all service providers even care to maintain tags after distributing them.

In the Amazing NFC trial, the tags were made available only in selected places, so the pupils did not run into or pay attention towards tags that were not specifically targeted for their use, and they reported no problems with non-functional tags. Maintaining the integrity and functionality of a specific set of tags is of course easier, than maintaining a ubiquitous assembly of tags distributed around the urban environment. Also, reporting malfunctioning tags could be easily done by calling the teacher in charge during the Amazing NFC lesson, whereas error reporting would be considerably more difficult for generic Mobile Internet services available through information tags. However, no problems in the technical functionality of the tags were observed during the Amazing NFC lessons.

## CONCLUSION

Our findings both confirm previous findings and the expected benefits of NFC-enabled touch-based Mobile Internet access, and provide some insights that can be used by Mobile

Internet content designers for aspiring to provide a successful user experience for Mobile Internet users. Here, we conclude our findings into three categories: (1) Mobile Internet content and service discovery, (2) Mobile Internet access, and (3) situated and embodied internet experience.

## Mobile Internet Content and Service Discovery

The mixed-reality user interfaces realized through tagging the environment to allow direct access to the Mobile Internet through the physical interaction of touch can relieve the service discovery problem by bringing the service access points physically to the mobile usage situations the user might face, and visualizing services in our everyday environment. The visual cues embedded into our environment can be used as indicators of services available through the Mobile Internet, and therefore increase user awareness about its content and services. In addition, Mobile Internet services and content can be made available at the locations they are most needed, as NFC tags can be attached virtually anywhere.

Two alternative visions can be seen in embedding visual cues into our environment. In the first scenario, the visual elements naturally available in our environment can be used to provide cues about Mobile Internet content

and services available. For example, a medicine package could provide a cue that by touching the package, Mobile Internet content describing the medicine can be accessed. In the second scenario, service and content providers can bring new visual elements into our environment advertising all available Mobile Internet content and services. Information tags described in this article represent the second scenario, as they are visual objects that are not directly linked to any physical object in our natural environment, but rather create new visual objects. Both visions require that users have learned the language and signs needed for service discovery, i.e. the new digital literacy skills of mixed reality user interfaces. The users need skills to identify the digital affordances in a mixed-reality environment to be able to discover the digital services and content available. The examples presented in this article have suggested one alternative for creating mixed reality interfaces with NFC technology.

In the trials described here, the users quickly learned the visual cues indicating the presence of digital content and services. However, this was not too difficult because of the limited availability of resources, and the limited variations in the visual design used.

### Mobile Internet Access

Touch-based Mobile Internet access provides one possible solution to the Mobile Internet access problem caused by the slow and challenging use of the keypad of the mobile device in a mobile usage context. Typing while on the move can be dangerous and sometimes impossible. Even remembering URLs required to access internet content while on the move can be challenging. Our observations from various contexts described in this article confirm that touch-based Mobile Internet access was perceived as very easy and convenient. This is perhaps not too surprising. However, we feel that providing the user experience findings from a large user base in different contexts provides new material, even if it only confirms expectations concerning this technology. Also,

this finding is important, as it confirms that touch-based user interaction implemented with NFC tags can provide a solution to one of the most difficult usability problems of the Mobile Internet today.

As tags are always located in a specific place, they can be used for implementing location specific Mobile Internet application concepts. In the Amazing NFC mobile learning concept, the principle idea was that the pupils had to visit the control points providing Mobile Internet access at specific locations. Searching and finding the tag for access was part of the excitement of the adventure. This is illustrated in the following improvement idea expressed by one of the pupils:

*Tags should be somehow hidden so it would be more interesting to search for them. (translated by the authors)*

### Situated and Embodied Internet Experience

Our observations and analysis indicate that one of the strengths and opportunities of the Mobile Internet user experience can be found in its potential to combine the internet experience with the situated and embodied experience evoked by physical surroundings, social context and physical sensations. When the user accesses internet content through the static desktop environment, the digital internet experience is often more immersive than in the mobile context, and almost alone responsible for creating sensory stimulation contributing towards the user experience. For a desktop user, the physical surroundings and social context remain rather static and therefore not highly stimulating. In a desktop setting, the user is unlikely to experience the warmth of sunshine on her skin, the smell of fresh bread or the pleasure of walking slowly down a street or beside a river. And even if she were able to do so, this experience would unlikely be semantically linked with the digital experience evoked by internet use. With Mobile Internet, the internet

content and services are more often consumed in the context, where the situated and embodied sensory experiences strongly contribute to the total user experience. The Mobile Internet user experience can seamlessly integrate with the sensory experience and interpretation of the physical environment and social context, and thus create opportunities for flow of experience where digital and physical experiences intertwine and support each other.

Research on psychology suggests that humans are not particularly good at analyzing what actually caused an experience (Dutton & Aron, 1974). Therefore, the Mobile Internet content consumed with good company in pleasant surroundings can evoke a more positive user experience, than the same content consumed in a hurry and in bad weather. We believe, that the successful combination of the interesting and stimulating environment of the Zoological museum, bus journey and very context specific Mobile Internet content integrating seamlessly with interaction with the physical environment resulted in the user experience, that was clearly preferred by the pupils (see Figure 8). The video recordings and average time spent at each control point show, that in other places the pupils only quickly touched the tag and left, and did not really experience the environment. Therefore, the Zoological museum seemed to be the only place that provided a successful combination of the experience of a physical space and the Mobile Internet experience.

Also, in the information tags trial, the implications of Mobile Internet use to the social context and interaction were found to strongly affect the user experience of Mobile Internet content. The users expected the content to be highly relevant and integrable with their current context and needs, and were very disappointed when it failed to do so, as illustrated by the following comment from a theatre visitor:

*If I download restaurant information in Oulu, I certainly do not want to receive information about restaurants in Helsinki! I immediately*

*stopped using information tags when I realized this. (translated by the authors)*

## LIMITATIONS AND VALIDITY

Even though the goal of the field trials was to provide as high an experimental reality (Aronson, 2004) as possible, there are issues in the trial settings that may have affected the results and probably did so.

Perhaps the most severe limitation of our research setting was the availability, selection and content available through the tags. If information tags were to become popular and tags would be used by commercial service and content providers, there would be considerably more tags available for use. This would mean that the selection of Mobile Internet content and services would be wider, and with experience, commercial content providers would learn to provide more usable, meaningful and valuable content. As the tags were evaluated in a research project, there were no actual goals for business or the public good that would have needed to be met. Tag placement, design and accessed information content were not rigorously designed to meet any specific goals, such as, for example, optimal coverage of a certain user group.

However, in the information tag trial, the content accessed presented the state-of-the-practice in Mobile Internet content design, as it was actual, pre-existing Mobile Internet content provided by commercial actors. The content was not specifically produced for research purposes, but it was provided by the content providers for Mobile Internet users in general. This was not the case in the mobile learning trial. For the mobile learning trial, the content was created for the purpose of the trial, as the learning concept was new and no pre-existing Mobile Internet content was available. Since there is little design knowledge available on how to design engaging and motivating learning material for Mobile Internet, it is understandable that the first versions of such content may be not optimal. However, in the mobile learning

trial there were well-formulated learning goals that were used for designing the content.

Another issue that may have an effect on the results is that none of the users were able to use their own mobile phone to access the Mobile Internet through tags, but rather had to use a special NFC-enabled trial phone. This meant that the users usually carried two mobile phones with them, and used their own mobile for voice calls, and the trial phone only for the NFC-enabled features. This might have had an effect on the usage frequency, perceived accessibility and ease of use especially in the information tag trial. In the mobile learning trial, this might have an effect on perceived ease of use, as the pupils had to learn to use a new mobile phone for the duration of the lesson. However, this effect was probably not too strong, as none of the technical problems reported by the pupils were related to the phone model used.

## SUMMARY

This article explored the Mobile Internet user experience through two field trials where touch-based mixed reality user interaction was used to provide end users with Mobile Internet access points. Our findings confirm that touch-based Mobile Internet access was perceived as easy and fast to use. The users expected to get direct access to location-specific information, and were most interested about location specific and location aware content. One of the keys for achieving a good user experience was successful seamless integration of the Mobile Internet user experience with the experience evoked by the situational and embodied experience resulting from interaction with the physical and social surroundings of the user.

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## User Experiences with Mobile Supervision of School Attendance

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**Abstract**—This article presents a field study arranged at a Finnish primary school where two classes and a total of 23 pupils between the ages of 6 and 8 trialed an attendance supervision system supported by Near Field Communication (NFC) technology. In the trial the pupils marked their arrival at and departure from school by touching a reader device or a NFC-enabled mobile phone with a contactless smart card. Parents were able to get their children's attendance details via an online 'citizen's portal' and through text-messages sent to their mobile phones. The system was designed to simplify attendance monitoring and to replace teachers' manual roll calls. Information about user experience was obtained by using a variety of data collection methods. We evaluate how various aspects identified in new technology adoption affect the design processes of home-school interaction systems by examining the findings from the viewpoint of three end-user groups (children, parents and teachers). Our analysis also shows that a technology supported attendance supervision system can bring value for all end-user groups but it seems that the system will serve primarily the teachers and the parents.

**Keywords**-Near Field Communication; attendance supervision; school; children; technology adoption; user experience; value-based design

### I. INTRODUCTION

This paper introduces a Near Field Communication (NFC) supported school attendance supervision system for school children. Traditionally, teachers conduct pupils' attendance monitoring every morning with manual roll calls, and mark absences and delays in the backend system. This requires time and effort on every school day, which is taken away from teaching. In addition, children beginning school in Finland travel to school largely independently, either on foot, by bicycle, or by bus. Therefore, parents of young pupils regularly call to their child's or teachers' cell phones to ensure that the child has made his/her way to school safely. Answering parents' calls takes up teachers' time that could be used for teaching. The NFC-enabled school attendance supervision system has been designed to simplify attendance monitoring. The system replaces manual roll calls and gives parents information of their children's attendance in real-time.

Related work is described in the next section. Then the research setting is outlined, describing the NFC technology and the developed attendance supervision system. This is

followed by the procedures used in the system design with a description of research objectives. The paper continues by introducing methodology used in user experience data collection, and represents and analyzes the field study results. The paper finishes with a discussion and conclusion.

### II. RELATED WORK

Developments in networked and mobile technologies now provide us with more methods than ever for supporting children in their transition between home and school [3]. For example, locational systems can be used to make sure that children are safe on their way to school [4]. Jernström [4] introduces a solution called The Smart-its child Surveillance System, SiSSy, that is an approach to tag children and parents with Smart-Its devices which can sense the environment and determine whether a situation is dangerous or if the child is engaged in something hazardous.

In a study by Fraser et al. [3], family members saw journeys between home and school as an important transition and a big issue for parents in managing their children's time. Information transfer between home and school was also raised as an important matter. Families' reactions to home-school technologies were enthusiastic; they saw benefits in the increased availability of information that can be gained through these technologies. While parents were worried about their children, they suggested that technologies that monitored children's activities, such as the mobile phone tracker and sensors, moved from expressing concern to expressing distrust as children aged. In consequence, Fraser et al. identified as one core issue for future research the discussion of children's privacy in technological design. Not only are there safety concerns about the protection of data collected about children, but also ethical concerns about the rights of children in gathering it. For example, how do we justify increasing links between home and school, when children are often active in resisting such information transfer [5]?

Denmark is traditionally presented as a country where children are able to freely move around and have independent mobility to schools and leisure facilities [11], and Finland can be considered similar to Denmark when it comes to children's mobility. Children beginning school in Finland travel to school largely independently, either on foot, by bicycle, or by bus. A Danish survey by Fotel and

Thomsen [11] states that parents' supervision of children's mobility is bound up with different aspects of their travel conditions, such as the choice of mode of transport. Driving a child, for instance, clearly supports the physical supervision of children's mobility, whereas bicycling or walking can be performed by the child on his/her own and thus leaves room for unmonitored movement.

While statistics show a reduction in the number of road accidents involving children during the past decades, Danish parents report an increase in their concerns about their children's road safety [12]. On top of monitoring children's mobility through escorting them by car or other traffic modes, some Danish parents also monitor their children's mobility from a distance [11]. New technology has made it possible to monitor children by e.g., their cellular phones, and some parents use that deliberately in situations where the children are testing the boundaries of where they can go independently. Monitoring children's movements from a distance seems to provide some parents with a feeling of control and thus seems to ease their risk worries, even though parents' opportunities to save the child from any danger are limited [11]. Fotel and Thomsen [11] state that even though monitoring the mobility of children is often done with a caring rationality, it can transform into a control, which in some cases, the child does not benefit from.

In a small town in the United States a public school children's whereabouts on campus were monitored by a system that used RFID (Radio Frequency Identification) technology. Children wore badges around their necks that contained a photo, grade level and name of the pupil. Within the badge was a chip with an antenna attached. As the chip passed underneath a reader mounted above the classroom door, it transmitted a 15-digit number, which was then translated into the pupil's name by software contained in a handheld device used by teachers to check attendance. Several parents complained that their children's privacy rights were being violated; while the school board defended the system by saying it would keep children in school, free up more time for teachers to teach and increase security for pupils and teachers. The proposal died after protests by parents and privacy and civil-liberties advocates, including the American Civil Liberties Union (ACLU). [6]

Also a Rhode Island school district has announced a pilot program to monitor pupil movements by means of RFID chips implanted into the schoolbags of 80 children. Each chip would be programmed with a pupil identification number, and would be read by an external device installed in two school buses. The buses would also be fitted with GPS (Global Positioning System) devices. Parents or school officials could log onto a school Web site to see whether and when specific children had entered or exited which bus, and to look up the bus's current location as provided by the GPS device. The RFID tag would contain only an ID number, not a name, address, or other personal information, so unauthorized individuals are prevented from gaining an access to pupils' private information. The ACLU has criticized the plan as an invasion of children's privacy and a potential risk to their safety. [7][8]

Qvortrup [9] and Rasmussen [10] argue that the increased protection of children by monitoring them is a central characteristic of modern childhood and we do not yet know all the consequences. According to Rasmussen [10], the possibility of impersonal supervision performed from a distance reduces children's privacy even more, and while some parents approve of it, the majority oppose its prevalence. Williams et al. [13] have presented that society could now perhaps openly question whether (urban) parents are good parents if they don't know where their children are and what they are doing at all times and don't have control over them. Aitken [14] shows how some parents employ a policy of constant supervision of children even up to early teenage years while in any outdoor space. Furedi [15] and Rayner [16] both point out the damage to children and childhood this 'paranoid parenting' might be doing and call for parents to allow children to take more risks.

### III. RESEARCH SETTING

The attendance supervision trial supported by Near Field Communication (NFC) technology began in Oulu, Finland on September 2008, continuing until December 2008. The trialing phase lasted 14 weeks. The trial was conducted at a local primary school, where two classes with a total of 23 pupils between the ages of 6 and 8 (the majority just starting at school), participated in the trial. Parents' permission for their children to participate in the trial and to the adjacent research had been asked in advance. One of the participating classes represented a first grade class (16 children out of 19 participated in the trial; 9 girls and 7 boys) and the other one was a special-needs class consisting of special-needs school children (all 7 boys, 4 first-graders and 3 second-graders, took part in the trial) who were diagnosed with minor special-needs, such as dyslexia, difficulties with concentration or troubles with perceptive skills. At the same time, a similar kind of study was done at a local secondary school with more advanced technology and more complicated application features.

Curtis et al. [28] have argued that disabled children, children excluded from school, and children for whom the discursive nature of conventional interview-based research is less accessible have been less well represented in participatory research than children who are easier to interview. For a range of methodological and practical reasons, children who communicate well, or who are regular school attendees, are more likely to be given a voice in the research literature [28]. Therefore, the class with special-needs children was chosen to participate in the trial along with the 'normal' first grade class.

#### A. NFC Technology

Touching with a mobile terminal has been found to be an intuitive, natural and non-ambiguous interaction technique that does not incur much cognitive load for users [17]. Väikkynen et al. [18] state that touching is an effortless way to select objects in the environment and easy to learn and use. Near Field Communication (NFC) technology is designed to make communication between two devices very intuitive. NFC is a very short-range wireless technology that

allows electronic devices to interact with other devices simply by touch. The main advantages of NFC are the simple and quick way of using it and the speed of connection establishment

NFC is based on existing radio frequency communication standards, so it is a special case of implementation of RFID technology. The touch-paradigm prevents reading from a distance because a short physical proximity (a couple of centimeters) is needed to transfer information. Even though NFC technology uses a touch-paradigm, it is technologically possible to read information through NFC from a distance with special powerful reader devices. However, in this paper, we assume that NFC is used through a touch-based interaction paradigm. In our attendance supervision field study, we explore a usage scenario where NFC-enabled mobile phones and smart reader devices located in the classrooms are used to read information stored on pupils' contactless smart cards.

**B. System Description**

Designed to simplify attendance monitoring and replace manual roll calls, the NFC attendance supervision system does not require teachers to mark absences in the backend system thus leaving more time for teaching. In Figure 1 an overview of the attendance supervision system at school and in extended day care programs is shown.

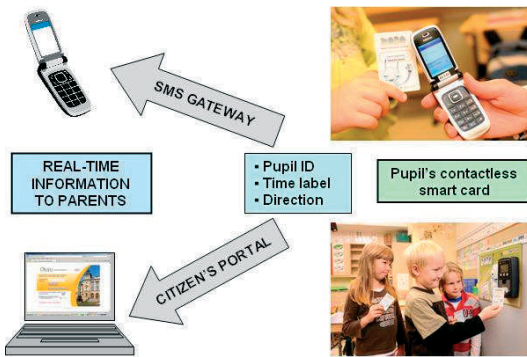


Figure 1. Overview of the NFC school attendance supervision system.

In the attendance supervision trial pupils were given contactless smart cards named “Robo” containing the pupil’s ID. Upon arriving at school pupils in the first grade class ‘logged in’ by touching an NFC smart card to an active card reader device and pupils in the special-needs class logged in by touching an NFC-enabled mobile phone. The reader devices recorded the card ID (the child’s name), the direction (arrival at school) and a time stamp in the backend system. The active reader device was chosen for the first grade class because it works faster than an NFC-enabled mobile phone for large groups. The application in both the reader device and the mobile phone recorded the time of the login; it was possible to choose the ‘direction’ of the pupil registration (in or out) through both devices. At the end of the school day

pupils touched the reader devices again to mark their departure.

The attendance supervision system (through NFC phone) was also used in extended day care programs where some children went after school. The day care is held in another building outside the school, so with the help of the supervision system parents were also able to follow how much time it takes for their child to walk to the day care from the school (the time between logging out at school and logging in at day care) and to ensure that their child has safely made his/her way from school to day care.

Figure 2 explains the functionality of the school attendance supervision scenario.

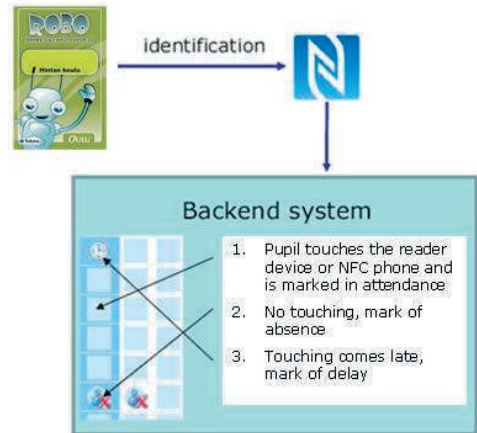


Figure 2. Functionality of the attendance supervision scenario.

The log of arrivals and departures was automatically compiled by a backend system, and could be read by a teacher in a classroom in real time. If a login did not occur, the pupil was marked absent by default. If a pupil logged in late, the backend system recorded the lateness. Parents were able to get information of their children’s attendance details via an online ‘citizen’s portal’ and through text-messages sent to their mobile phones. The system prevented truancy in real time, enabling instant intervention.

**C. Design Procedure and Research Goals**

The attendance supervision concept was planned and designed in close cooperation with teachers, service and technology providers, and researchers. During the design phase the ultimate goal of integrating the concept into normal school practices was especially emphasized, so that the trial would not be an extra effort related to the research project. The aim was to create a viable concept that could also be adopted in the school as a routine to be used after the research trial. This required close involvement of teachers and school administration in planning and implementing the applications, and in organizing and supervising the trial. It was also seen very important that children were given a possibility to participate in the system design to empower

them and get them committed to the use of the system. For example, children participated in the visual design of the system. Information security and privacy issues were also considered in the system design, and precautions were taken to minimize the associated risks. The contactless smart cards only contained a pupil's ID number, not any personal information other than the printed name on the card surface. In addition, in order to handle the pupils' attendance data as confidentially as possible, access to this data online was put under password protection and text-messages about the pupils' attendance details were sent only to parents' authenticated mobile phone numbers. These measures were taken to prevent unauthorized individuals from gaining access to pupils' private information.

During the trial, the researchers were only involved in the data collection activities; teachers took full responsibility for organizing and supervising the actual attendance supervision trial. Participating teachers volunteered for the trial, and it was their responsibility to adopt the attendance supervision system for everyday use in their class. The teachers explored new working practices introduced by the system and were expected to report their experiences and observations regarding the system.

The goal of the concept was to (1) enhance and secure children's independent mobility in home-school transition and (2) to increase the rationalization of home-school communication. The objectives of the field study were to test the attendance supervision system for school children and their parents and teachers, and to examine the value the attendance supervision concept brings to these stakeholders, as well as the attitudes of each user group concerning the use of the system (regarding e.g., privacy issues). The extent to which the service supports the enhancement of school routines and practices and improves information sharing between school and home was also examined in the study.

#### IV. USER EXPERIENCE DATA COLLECTION

Druin et al. [21] have argued that design work in a school is subject to difficulty due to the school setting and the embedded power relations between adults and children. Children have so few experiences in their lives where they can contribute their opinions and see that adults take them seriously [21]. When respect is fostered, it changes how children see themselves [24]. Williams et al. [22] implemented an exploratory workshop with ten 11-12 year old children for exploring and developing the interface between children and new mobile 'wearable' ICTs, and found that the children are valuable, adaptive and creative users in the participative design of ubiquitous computing experiences and devices that might enable them.

Druin [23] has developed a typology of roles that children may have in the design of new technologies: a user, a tester, an informant and a design partner. For each role she also presents three underlying dimensions: the relationship to adults, the relationship to the technology and the goals for inquiry. The role we sought from the children was essentially that of an informant. As the trial objective was concerned with the potential of the attendance supervision system, the actual usage of the technology was an essential prerequisite

to the children's articulation of potential use and for the informant role as well. Therefore in the case of this trial the children's role was both that of a user and an informant.

TABLE I. SUMMARY OF DATA COLLECTION METHODS AND NUMBER OF VALID CASES FOR EACH METHOD

Data collection method	Number of valid cases
First classroom observation and interviews with first grade class	16 pupils 1 teacher
Second classroom observation and interviews with first grade class	16 pupils 1 teacher
Classroom observation and interviews with special-needs class	7 pupils 1 teacher 1 special needs assistant
Phone interviews with the parents of the special-needs class	6 parents
Paper questionnaires for 16 first-graders' parents whose children participated in the trial	14 parents
Paper questionnaires for three first-graders' parents whose children did not participate in the trial	3 parents

Given difficulties that need to be overcome for describing and understanding user experience, we decided to collect data during the actual use of the system and to combine a variety of complementary data collection methods [19] in order to increase the reliability and validity of the results [20]. The user experience data collection methods and the number of stakeholders for each method are listed in Table 1. In the next sections we will present the data collection methods in greater detail.

##### A. Classroom Observations

Classroom observations were made to collect information about how the pupils learned to use NFC technology, what kind of routines they had established after using the system for some time, and what kind of spontaneous reactions and discussion took place in using the attendance supervision system. Children in the first grade class were observed twice over the course of the research. The first visit happened in a very early phase of the trial: the attendance supervision system had been taken into use only a day before the visit. At the time of the second observation the attendance supervision system had been in use for two weeks. The special-needs class was observed when they had used the attendance supervision system for two weeks. Observations with both classes were conducted during a normal school day by attending the first lesson in the morning. The login process was observed from the back of the classroom to minimize the disturbance caused by the researchers' presence. During the observation the children's behavior and actions were videotaped and photographed. The children seemed not to be disturbed or bothered about the researchers' presence.

##### B. Interviews with Children and Teachers

All the children participating in the trial as well as their teachers were interviewed in order to investigate their thoughts and experiences about the technology and service concept under evaluation. The interviews took place on the

same days as the classroom observations. After login was done and children started their school work, interviews were conducted very informally by chatting with a few pupils at a time either in the classroom or in a separate place. Children in the first grade class were interviewed twice over the course of the research. The teachers were interviewed informally partly in the midst of teaching, partly during breaks between classes.

The following aspects related to the attendance supervision were discussed with the children and the teachers:

- Where the children keep their “Robo” cards
- Do the children remember to bring the card with them every morning to school
- Have the children somehow personalized their cards
- How the children understand the technical details and functionality of the attendance supervision system
- How the children understand the reason behind the use of the system: why do they need to log in and out of the school
- Do the children think that their privacy is violated; that they are being stalked
- Do the children remember to log in when arriving to school and respectively log out when leaving school: does the teacher need to remind them
- How the children manage to use the smart card
- What is the children’s general attitude towards the service
- Do the children know if their parents actively follow their attendance information via the system

The children seemed to be proud and excited that adults outside their school had come to their class just to chat with them and ask about their thoughts. The children were very happy with answering the questions and spoke freely and frankly about their own thoughts and opinions.

*C. Phone Interviews with Parents*

Since it is feasible to conduct one-to-one interviews with a small user group, the parents of six (out of seven) participating children (two fathers and four mothers) in the special-needs class were chosen to be interviewed via telephone. The parents of one child did not give their contact information for the interview. Interviews lasted from fifteen minutes to half an hour. In order to gain real hands-on experiences by the parents, interviews were conducted one and half months after the beginning of the field study when the parents had had time to experiment for a longer period of time with the attendance supervision system. The aim of the phone interviews was to investigate parents’ thoughts on the service concept, opinions about possible added value the attendance supervision service brings to the families, and whether the service could be developed further to have a positive impact on their lives.

*D. Feedback Questionnaires for Parents*

As the parents of the first grade class formed a bigger user group and interviewing them via telephone would have

been more cumbersome, we decided to create two separate short paper questionnaires, one for the first-graders’ parents whose children participated in the trial and the other for the parents who chose not to allow their children to participate in the trial. Questionnaires were delivered to the parents one and half months after the beginning of the trial in order to assure that the parents had already gained real experiences with the attendance supervision system. A total of 17 parents (out of 19) answered the questionnaire. The same things were explored in the questionnaires as in the phone interviews (see Table 2).

TABLE II. QUESTIONS ASKED IN PHONE INTERVIEWS AND FEEDBACK QUESTIONNAIRES

	Question
Phone interviews with the parents of special-needs class children and questionnaires for participating first-graders’ parents	Have you experienced the attendance supervision service as useful? What kind of benefits have you derived from the service?
	If in your opinion the service has not benefited you enough or it would still need more improvement, please tell us your suggestions for service development and improvement.
	Would you be ready to pay 30EUR a year for the SMS service?
	Have you experienced any problems with the service? If you have, what kind of problems?
	By your own estimate, how often have you used the service, i.e. followed your child’s logins? (daily, weekly, not so often)
	Do you use the service in some specific situations? If so, in what kind of situations?
	In your opinion, how has your child experienced the attendance supervision and how has she/he remembered to carry the ‘Robo’ card with her/him?
	In your opinion, has the supervision system had any influence on your family’s daily routines?
	Other ideas and thoughts regarding the service
	Feedback questionnaires for non-participating first-graders’ parents
	If in your opinion the service in its current form would not benefit you enough or it would still need more improvement, please tell us your suggestions for the service development and improvement.
	Other ideas and thoughts regarding the service.

V. IMPACT FOR THE SYSTEM DESIGN PROCESS

We evaluated the obtained research data from the point of view of how various aspects identified in relation to this study affect the design processes of home-school interaction systems. We present in the following sections experiences and analysis from these findings. Some of these results have been presented earlier in [1] and [2].

A. Participation

Children, teachers and parents were able to participate in the system design process as well as the adoption process,

and we analyzed our data from the viewpoint of each user group:

1) *Participation of Children:* Three kinds of participatory aspects were identified: (1) Children were able to participate in the visual design of the smart card used for attendance control, (2) children participated in daily use by operating the reader devices and being responsible for logging in and out of school, and (3) children were able to express their opinions throughout the research process through various data collection methods.

Before the beginning of the field trial, one of the pupils in the special-needs class had invented the name “Robo” for the contactless smart card. His idea was used in designing the visual outlook of the card (see Figure 3). Receiving the card had been especially important for the boy who came up with the “Robo” name: the boy had been very pleased that his own idea had been implemented. According to the teacher, for the same boy the start of the school had been especially difficult and for him the opportunity to influence the smart card design had been a very important boost to his self-esteem. Even though the children’s role in designing the card was not very big, the other children clearly valued as well that one of them was behind the idea for the smart card name and appearance.



Figure 3. The visual outlook of the “Robo” card and the reader device.

The teacher of the first grade class had shown and taught two pupils how to operate the reader device and what to do when the pupils needed to log out of school at the end of the school day (how to turn the device on etc.) when the teacher was not present. Every Wednesday, operating the reader device was their responsibility. This was also valued by the children, as they saw this as a sign of trust in their skills, and a source of special pride for the whole class, not just for those two children in question. Other children commented on this by saying that, “...they were chosen because they use the computer also for other things than just playing,” so the two pupils were regarded to be knowledgeable and skilled in the use of computers.

Interaction systems for children are usually designed by adults who often have very little idea of children’s needs and desires [29]. Several authors [24, 29] have identified that

involving children in product development is beneficial. Our findings revealed that children valued that they were able to participate and be active in the design, use and evaluation processes. By participating, they could have their voices heard and influence the decisions that affected their school days. Also, our experiences indicate that by participating in the design and use processes the children became aware and internalized the functionalities and goals of the system, which can lower the barriers for adoption and use.

2) *Participation of Teachers:* Participation of teachers was seen to be especially valuable in integrating the application and processes into the daily routines of a school day. The teachers took the responsibility of integrating and supervising the adoption of the new practice. Our experiences indicate that this is essential for the success of adoption.

The teachers were able to observe the use and the user experiences evoked in the children daily. This knowledge was very valuable for interpreting the data collected by interviews and observations.

3) *Participation of Parents:* Parents gave many ideas for the system development and improvement in the phone interviews and questionnaires, and they were identified as important partners for the design and evaluation processes, which is also supported by previous studies [3].

Parents reported that following the children’s logins and logouts was not very practical and did not integrate well with their daily routines. Parents needed to separately log in to an online ‘citizen’s portal’ and that took way too much time during a busy workday, in their opinion. The information of children’s logins and logouts should be received on the device that is nearly always at hand. Therefore, the text-message service appeared to be a more usable solution in monitoring children’s attendance: “We do not always have an opportunity to be by the computer, so a message to a mobile phone would bring lots of additional value.”

One parent stated that she would preferably receive the attendance data in an email, while another parent did the majority of his work on a PC so he was able to follow his child’s attendance information regularly during his work days. He found the text-message service more harmful than useful because a parent could “be bombarded with text-messages” during the work days, which could disturb and interrupt working.

In the parents’ opinion it would be much better if the children could log in to school immediately when they arrive on the school grounds, for example at the school gate or by the school’s front door, as opposed to the login done inside the classroom. Then the parents could get the attendance information as soon as the child arrives to the school area. One parent reported that for their family it would be much more useful to get a message indicating whether or not their child has locked the front door when leaving for school. A desire was expressed that it were possible to send a message from home when the child leaves for school and the device would then react if the child does not log in to school within a time limitation. Also, a child’s timetable could be added in the system and a message could be sent to parents if the child did not arrive at school in time.

Several parents mentioned that they hoped to see the attendance supervision service developed further to include more features. For example, in one parent's opinion the paper notebook for home-school communication was already outdated and behind the times, so a web-based counterpart would be much better. An idea was raised that more services could be added to the card (the card functioning also as a library card, for example) as well as important daily information about school. That information could also be checked from the web portal. Parents also stated that they would like to be able to see longer-term statistics about their child's logins and logouts instead of only day-specific data.

### B. Adoption and Use

At the time of the first visit to the first grade class, a routine for the login had not yet had time to develop and the login had not yet been integrated into the children's everyday school routines. As the pupils arrived to the classroom, the teacher had to remind most of them about the login. The children had quite different ways of doing the login procedure; some merely touched the reader device with their card while some carefully placed the card on an exact position on top of the device.

Using the system seemed to be easy according to the children: "You just put the card there like this," "You can put it either way," "You don't need to wave it, just flash it there quickly," "When it [the device] says OK, login has succeeded." In Figure 4 there are pupils logging into the school.



Figure 4. Pupils log into the school by touching the reader device with their contactless smart cards.

All the pupils had already allocated some specific place for their card where they always put the card so that it remained safe. Most of the pupils said they kept their cards in their backpacks, and many even had one particular pocket in the bag where they put their cards. Some pupils said that they kept their card in a pen case.

The pupils seemed to remember well to carry the card with them every day, with only a few exceptions. One child said that her Mom took care that the card is with her by putting it into her bag in the morning. On the first

observation day one boy had not brought the card with him to school since, "the card is on the table at home, Mom did not remember to put it with me."

At the time of the second observation, the attendance supervision system had been in use for two weeks and the login had now become a natural part of the children's school routines. As the children arrived in a classroom, they remembered without a separate notification to take their cards from their backpacks and to log into school. According to the teacher a small line usually emerged behind the reader device and then the latest children remembered the login.

The teacher of the special-needs class said that before the experiment had started pupils had eagerly been asking, "When do we get the cards? When will the device arrive?" Similar to the first grade class, the login process appeared to have integrated well in to the school routines after only two weeks use. The teacher did not need to separately remind the children to log in as the children remembered it themselves. The login happened by touching the card with the NFC phone.

In the special-needs class the login seemed to happen quite smoothly, only with some slight bustling and elbowing: "It's my turn now!" "Wait for your turn!" Similar to the first-graders, all the pupils said they kept their cards in their backpacks, and most had one specific pocket in their bag in which they always put their card after login.

The classroom observations revealed that the login with the smart card reader device was faster when compared to the NFC phone as children did not need to queue for the reader device. In addition, with the reader device, the children practically did not need the teacher at all for the login. They were able to handle it independently instead, contrary to the login done with the NFC phone. According to the first-graders, login with the reader device at the classroom was easier than login with NFC phone in the day care: "The cell phone needs to be moved back and forth in a way," "It takes more time." the children explained. Also the teacher of the first grade class said: "It worked like an assembly line," with the reader device.

The teachers said that the children had been extremely excited when they had heard they could participate in the experiment. The pupils had waited intently to receive their own cards, and after a few weeks' use had only positive thoughts about the attendance supervision: "This is easy to use, login has worked well." Teachers reported that the children had easily learned how to use the card, and the login had soon become an integral part of their school day.

### C. Children's Understanding of the Whys and Wherefores

The first-graders' seemed to understand pretty well why they had received their "Robo" cards and what the purpose behind the use of the attendance supervision system was, which is shown in the following excerpts gained from first-graders' interviews: "Mom and Dad will know that I have arrived at school and at home." "The reason for doing the login in the morning is that the thing starts to transmit information to somewhere, and in the afternoon when leaving school you need to log out so that the thing won't

send any more information and so that the information would not proceed anymore.”

The first-graders also had noticed some benefits the attendance supervision system had brought to their lives: *“It’s also nice that you don’t need to phone when you have arrived at school.” “Once when I came to school by bike and Mom tried to call me, my Mom had put my phone in that kind of place in my backpack where I couldn’t find it. At that time we did not have this card thing yet, but it’s good that we have it now.”*

Children in the special-needs class understood also the reason behind the use of the system, and seemed to understand how the system created value for parents and school. However, it is possible that the children’s answers partly repeated the same words the teacher and their parents had told them about the attendance monitoring: *“Mom and Dad know at what time you have arrived at school and left home, and if you have stayed in detention.” “You need this at your new school, so that they know whether you are late or not.” “You do the login because you need to touch the phone.” “Parents check at their work place that you have arrived at school.”*

When the children were asked whether they knew if their parents had been checking their attendance information, about half of the pupils were aware that their parents had been monitoring their attendance information: *“My parent watches the logins through the Internet.” “Mom said that she hasn’t checked yet.” “Mom sometimes looks, but not every day.” “Mom does not check the logins until at home in the evening.”*

#### D. Children’s Understanding of the Technology

Children of the first grade class did not really understand the technical details behind the system, and they did not seem to have thought about it that much. When we asked them what they thought about how the system worked they were rather baffled at first and then some of them were able to give us answers: *“It puts the information on the computer.”, “There is some little thing in the cell phone, a kind of strange looking tiny card inside the phone, a plastic one with nothing inside, which takes the information.”, “I wonder what does my Mom see? Does some explanation mark like appear, that your son has left home from the day care, that it is a safe journey?” “The cell phone is a bit like a living thing, it reads that information and then it happens.”*

Specifics of the technical details and operation of the system were not very clear for the special-needs class children either, even though they had a reasonable understanding about how the technical components involved together and some basic conception of how the system functions: *“It writes names on the Internet, are you at school or where?” “It sends an e-mail or a message and Dad opens his phone and sees a text message.” “A message leaves when the card and the phone touch.” “A light appears in the machine telling that you are late. Green flashes when you have arrived at the right time.”*

#### E. Attitudes towards Privacy

When planning and designing the system for children’s attendance supervision we were aware of the potential of such technology to increase the debate on the issue of surveillance and privacy invasion. Concerns were expressed even before the actual system was taken into use when the Finnish media published the plans for implementing and testing the NFC-enabled school attendance supervision concept in the city of Oulu. On the web site of the local newspaper many readers expressed their biases and opinions about the system. The following excerpts are from the discussion on the web site (translated from Finnish): *“For real, big brother will also monitor in this case [27].” “Personally, I would certainly not accept stalking through access control at our school, the old, traditional control of non-attendance made by the teacher is enough...we need to really take care that the high technology of the future will be used to help people, not to stalk them [27].” “The next phase is a microchip planted on the back of the hand, the mark of the beast from the Apocalypse of John...[26]”*

However, during the study itself the privacy concerns and negative aspects of surveillance did not play a big role, contrary to the previous studies [3, 5, 10]. The benefits of monitoring were seen as greater than the costs by all the interest groups. For example, one parent stated in the phone interview that in her opinion it is good that you can monitor your children, since, *“...life is changing all the time, it is becoming more fierce.”* One family reported that because of the attendance supervision system, they did not need to provide their child with a mobile phone which they would have otherwise done to monitor how the child travels between home and school.

In their interviews, children themselves did not bring up any comments regarding stalking, losing their privacy or being under surveillance. Quite to the contrary, and also according to the parents, the children regarded the attendance supervision as a natural part of the school routines, and did not wonder why they were given the cards and why they had to do the login every day, because, as one of the parents said: *“For a child it is just part of his life.”*

NFC technology is a very short-distance technology requiring a close touch to activate reading. Based on our observations, we expect that this increases the feeling of control, and does not trigger the feeling of being under surveillance. Other types of RFID technologies that can be read automatically from a distance without any explicit action from the user side can create a stronger feeling of being under surveillance by “an invisible eye”, therefore triggering negative experiences towards the loss of privacy and being monitored. This has become very apparent in earlier surveillance initiatives conducted in school environments [6, 7, 8].

The contactless smart cards used in our study contained only an ID number, not any personal information (other than the printed name on the card surface), pupils’ online attendance data was put under password protection and text-messages were sent only to authenticated mobile phone



numbers, and so unauthorized individuals were prevented from gaining access to pupils' private information.

#### F. Trust and Respect

The parents reported that the contactless smart cards and the attendance supervision concept had been received very well by the children. Parents said that their children felt the supervision was important and took a big responsibility for keeping the card safe and carrying it to school every day. One of the parents commented, "A proud and eager pupil has remembered it well." For example, one child had gotten really excited when he received the card that was similar to the card his father used at work. The parents said that the children had taken care that they always had their cards with them, and for some of them it seemed to be very important that they had their cards with them all the time. Figure 5 shows some pupils logging into school.



Figure 5. Pupils log in by touching the teacher's NFC-enabled mobile phone with their "Robo" cards.

For many children the possibility to participate in this trial seemed to be a boost for their self-esteem, which is also consistent with previous research [25]. The children were very proud and excited that they were shown trust by giving them their very own contactless smart cards that were their own responsibility, and that adults trusted the children to take care of the cards and the login. This is well illustrated in the following teacher's comment: "For the children this has been an important and big thing, since not all the classes have these cards in use, so in that way children now have a chance to stand out and they have something that others do not have."

We had expected that the children would have taken some actions to personalize their cards but the interviews and observations revealed that children had not modified their cards' outlooks in any ways. It seemed that the children placed a high value on the card and showed respect by not modifying the card. The children seemed to appreciate their cards so much that they did not even think of the possibility of e.g. adding any stickers or drawing on them. One girl commented that, "I wouldn't dare to put a sticker on without asking." The children also seemed to have developed some misconceptions about the system, which can be partly

interpreted as an outcome of the fact that they had not internalized the technical details and functionality of the system: "When there is a sticker on the card and you log in, the cell phone accidentally takes the sticker and some picture of Winnie the Pooh or something appears there," one child said.

However, many of the pupils knew that secondary school students had received NFC mobile phones for attendance supervision and the pupils seemed to be a bit jealous about it. One of the children said, "Smart cards could have been given to the secondary school students and we could have had the touch mobile phones." Clearly, mobile phones were valued as devices and status symbols more than smart cards.

The children evidently valued the trust they were given, but they also used this new power to mutiny against teachers and parents. One child had thrown his card away in a burst of anger towards his parents. In general, however, children accepted parents' and teachers' authority in protecting them [30] through attendance control without question. The children could have chosen not to mark their arrival to and/or departure from school as a sign of rebellion, or could have given their card to a classmate to handle the login and logout on their behalf. However, this type of behavior to manipulate the system did not come out in our trial group. We assume that this might be different with older children and teenagers.

#### G. Adults' World

On the web site of the local newspaper many readers commented on the attendance supervision system also in the following way (translated from Finnish): "A child is not allowed to grow up at her own pace anymore; she will be raised in a real 'Orwellian' spirit [27]," "Here the monitoring, caring and presence of a grown-up is trying to be replaced with a ridiculous mobile phone [27]."

The children themselves did not wonder why they had to do the login and did not resist new practices; they simply regarded it as a natural part of school routines. This is well illustrated in the following excerpt from one of the teachers: "Nowadays children have seen so many kinds of things that they don't marvel at things like this." The children had only positive thoughts about the attendance supervision, it had been "nice" and "easy," even "awfully nice, giant-sized!" and "really great!"

However, those parents, whose children did not participate in the field study, explained that they had considered that, "The safety of the child is created through the genuine presence of an adult and not through a supervision system." These parents thought that what children really need is the time of trusted adults, and also considered the trial to be a technology-led project "Where the effect of the project on a child's everyday life had hardly been thoroughly considered," which is also argued in previous research [9, 10]. Parents stated: "Children of this age should not need to be rushed into the world of cards and codes. They can do that later. The amount of new things in the first-graders' world is already large enough."

#### H. Responsibilities

The teachers said that the parents had expressed their interest towards the system for practical reasons; to be able

to know where their children were. It often happened that a child had forgotten to phone Mom or Dad, and consequently the parent made a 'check call' to the teacher in order to make sure that the child had safely made his/her way to school. For example, one child had once promised to call his father as soon as he arrives at school but the batteries had died out from his cell phone so he was not able to make the promised call. So, the attendance supervision system facilitated the teacher's work by eliminating the need for a teacher to answer parents' calls during the school day.

However, some parents chose not to participate in the trial, as they thought that the teacher should have full responsibility over the whereabouts of the children, and felt that a computerized system would remove this responsibility from the teachers. One of the parents said, "*If parents cannot trust that the teacher knows where the children are (ill, at school, on vacation etc.) something is really wrong.*" One parent argued that in the case that a child does not arrive at school and there has not been any notice about the absence, it is teacher's duty to contact the parents, so, "*What kind of additional value does the service bring to parents?*"

In addition, the parents commented that the system can sometimes cause extra worry, as the child might lose the card or forget to log in upon arrival: "*The login is based on memory, so parents cannot be sure that the child is at school if the child has forgotten to log in or if the child has lost his card.*"

In one parent's opinion all the resources should be directed to preventive work in regard to safety, such as traffic, school environment and social support: "*What does it help to get the information that something has happened, if something could have been done to prevent that from happening!*"

#### I. Added Value

About half of the parents who participated in the trial answered in phone interviews and feedback questionnaires that they were satisfied with the system and thought that the system adds value for them. The system was seen as especially useful when both the parents are working and are able to follow through the system that their child has arrived at school and check at what time the child has left for home. The system was also found valuable in that it would notify the parents immediately in situations where the child for some reason does not arrive at school or in day care.

However, the interviews and questionnaires revealed a fact that for some families the attendance supervision system did not bring real added value. In these families one of the parents was always at home when the child left for and arrived from school, enabling the parent to follow the child's comings and goings, or a family lived so near the school that the child had only a short way to school.

Some parents also thought that the service only brings the same feeling of safety as calling with a cell phone when ensuring the child's arrival at school, so the system does not bring real value when compared to an already established practice. In one parent's opinion the attendance supervision for older pupils would bring more benefits, since she

considered that a small pupil is already quite well controlled by the school and day care.

One interesting finding was related to situations where the parents were separated. The system could provide a parent not living with the child (at the moment) with a way to know more about the daily activities of the child. This could provide a better feeling of involvement in the life of a child. In our trial, one father not living with her daughter would have liked her to participate in the trial so that he could get more information about his child, but the mother who lived with the child refused the child's participation.

#### J. Downsides

Most parents wondered why their child's login always happened so late in the morning, for example the child might have left home to go to school at 7:30 am, but the login however, did not happen until around 8:30 am. As the parents knew that the journey to school should not take this long, it easily caused concern and worry. The delay was caused because the reader devices were located in the classrooms, and some mornings it took some time before the children got inside or remembered to log in. In the parents' opinion it would be much better if the children could log into school immediately when they arrive on the school grounds, for example at the school gate or by the school's front door, as opposed to the login done inside the classroom. Then the parents could get the attendance information as soon as the child arrives on school grounds.

A few parents also expressed concerns about increasing the amount of information they needed to follow: "*In this insecure world it is good to know where the child is, but the information flood and reading of messages is already now fully employing the parents and therefore it feels that the 'traditional' way should be enough. But naturally, if there is a fear that the child is skipping classes or thinks of leaving on his/her own way from school, the attendance supervision service is good.*"

In the first grade class three children did not participate in the trial. The parents of those children justified their decision by saying that the attendance supervision system could cause parents extra worry instead of increasing the feeling of safety and peace of mind, as the child might lose the card or forget to log into or log out of school.

#### K. Economic Feasibility

The administrative units of the city of Oulu estimated that if the system with the SMS notification service were adopted at schools for permanent use, it would cost each family using the system approximately 30 EUR per year. Parents' willingness to pay the suggested amount of money for the service was inquired in the phone interviews and feedback questionnaires.

Altogether 11 parents who participated in the trial stated in phone interviews and feedback questionnaires that they would be ready to pay the suggested amount of 30 EUR per year for the SMS service: "*I could also pay for security.*" Five parents said that they were not willing to pay for the service, one parent wasn't sure, and three did not give their answer to the question.

The expenses of the system would include at least hardware and software costs for the backend system and the hardware units (smart card reader devices and NFC-enabled mobile phones) needed in schools, data transfer costs between the backend system and the reader devices, contactless smart cards for the pupils, the price of sending SMSs to parents, deployment costs, and the maintenance costs of the system. However, teachers would need less time for administrative work and could use that time for teaching instead. Parents would also save time since they would not need to make check calls to their children. In this context the time savings is difficult to convert into direct financial savings. Rather, here the time savings means for the teachers the prospect of increasing the quality of education and for the parents the possibility to concentrate better on their work when they do not need to worry for their children's safety.

However, there is a possibility that this kind of fee-based attendance supervision service creates inequality among the pupils, as not all the parents would be willing to pay for the service. The quite low percentage of parents ready to pay for the service (55%) in this study might be partly explained by the fact that Finnish people are accustomed to thinking that school attendance is free and therefore they do not easily, maybe just out of principle, accept the idea that a purely school-related service would be subject to a charge. Also, in a situation where only some of the families were using the attendance supervision service provided by the authorities the teachers would in any case need to also do the manual roll calls thus reducing the time savings for teachers and possibly even causing extra work for them.

In Finland the school system is based on public schools, and basic education is free for citizens. Therefore, public authorities play an important role in adopting new technologies in the school environment. This means that investments are covered with public funding and decisions for adopting new technologies are done through public decision making processes. In the case of public services, goals and criteria for adopting may differ significantly from the private business environment, where the goals usually deal with maximizing profits and can be justified with economic reasons. With public services it can be difficult or meaningless to show the created value only through economic measures.

Evaluating the value of adopting new technology in an environment that is fully financed by public authorities and serves various user groups with different needs is challenging. It would be possible to calculate the actual costs of deployment and continual use of the attendance supervision system in order to make an educated decision on whether or not it is economically feasible to take the system into use. However, the schools do not operate in a business environment, trying to generate revenues and operate at minimum cost level. Instead, schools create value for the society and the families using their services. Benefits of adopting new technology in such a setting must include other value parameters in addition to traditional cost or time savings.

## VI. CONCLUSIONS

In our trial, information about user experience was obtained by combining different data collection methods. The findings were analyzed from the viewpoint of three end-user groups, namely, children, parents and teachers.

The attendance supervision system can reduce unnecessary doubt by allowing parents to receive real-time information on non-attendance or if a pupil is late from school. The main benefits for the home are that parents can follow their children's attendance status in school and day care in real time, thus eliminating the need for calling the child or the teacher to inquire about the child's whereabouts. The service also facilitates teachers' work by offering technology and a system for gathering the information about children's attendance and keeping a log about their possible tardiness at school.

The importance of the role of children in the research process was emphasized throughout the research project to overcome the problems associated with children as research subjects [21]. The children were respected as users of new technology and their contributions and ideas were sought out and valued. All communication was planned to convey a message that the children could trust that adults will listen to their thoughts and ideas, and respectively the adults aspired to learn to elaborate on the children's ideas, rather than merely listen passively or not listen at all [24].

For many children the possibility to participate in this trial was a boost to their self-esteem. The children were very proud and excited that they were shown trust by the adults by giving them their very own contactless smart cards that were their own responsibility and that adults trusted them to take care of. Also, the children valued the responsibility they were given for logging in and out of school and even operating the reader devices by themselves. Similar results have also been discovered in research by Attewell [25].

User research revealed that for the children at this age as well as for their parents, the concept of being monitored by the technology is not something they reject, but possibly welcome. Interviews and questionnaires with parents and children revealed that mobile phone ownership among this age group is closely tied to parental purchases, and motivated by parental and child desires for parents to be able to contact their children when they have to go to school alone. With this new attendance supervision system children would be able to go to school alone even if they did not have their own mobile phone, since the attendance monitoring would enable parents to check that their children had arrived at school safely, thus making check calls between parents and their children (or between parents and teachers) unnecessary.

Main concerns with the attendance supervision system relate to privacy and security issues concerning the collection of pupils' real-time attendance details and the possibility that unauthorized individuals could gain access to children's movements and location and personal data. In this study privacy concerns were not raised, which seems unique when compared to previous research [3, 5, 10]. We expect that one reason for this is the nature of the NFC technology, which enables reading the ID only upon touch.

It also needs to be noted that security at school is improved via an attendance supervision system: it is easy to see which pupils are in which classrooms. Real-time attendance logs are also important for a pupil and for his or her legal protection.

#### A. Implications for practice

This study has some concrete implications for practice and research related to technology adoption in a school setting. First, our findings revealed that children valued that they were able to participate and be active in the design, use and evaluation processes. By participating, they could have their voices heard and influence the decisions that affected their school days. Also, our experiences indicate that by participating in the design and use processes the children became aware and internalized the functionalities and goals of the system, which can lower the barriers for adoption and use. In addition, the fact that the teachers took the responsibility of integrating and supervising the adoption of the new practice appears to be essential to the success of adoption.

Also, the children, as well as their teachers, became familiar with the login process very quickly, and the attendance supervision was soon integrated into their everyday school routines, mainly due to the intuitiveness and effortlessness of the NFC touch-based interaction technique [17][18]. However, the interviews showed that the children did not fully understand the technical details or functionality of the attendance supervision system even though they seemed to have a good comprehension of the reasons behind the use of the system, and they knew how the system created value for their parents. For the children to get full value of the technology it is important to give them enough information about the system and how it works.

Comments by the parents clearly showed that when a new technology is brought into a school environment, it needs to be clear for everyone how the adoption of the system affects the responsibilities of school personnel, parents and children. In this case, the responsibilities of the teacher remained the same, and the technology was used only to support and enhance communication. However, many parents felt that the technology would remove responsibilities from the teachers.

If this kind of system were taken into wider use economic feasibility of the system needs to be considered. 55% of the participating parents in this study were willing to pay a small amount of money per year for the use of the system. It is likely that not all the expenses would be covered by the money received from the parents, which means that the rest of the expenses need to be paid using tax money. A fee-based attendance supervision service might also create inequality among the families, as not all the parents would be willing to pay for the service. We think that this is part of the bigger discussion of using tax money to pay for some services versus citizens paying for the services partly themselves in addition to paying taxes.

Even though the children themselves did not get direct benefit from using the system, they valued the fact that they could actively help teachers and parents by creating useful

and valuable information. Perhaps surprisingly, the children seemed to be the group most pleased with the system. When describing their experiences with the system, the children's descriptions were positive and enthusiastic. Our analysis shows that a technology supported attendance supervision system can bring value for all end-user groups but it seems that the system will, however, primarily serve the teachers and the parents.

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# Touch- and Audio-based Medication Management Service Concept for Vision Impaired Older People

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**Abstract**—A novel Near Field Communication (NFC) based solution to support medication management of vision impaired older users is presented in this paper. The service concept allows older users with vision impairments to manage their daily medications autonomously by providing them means to identify medicines and retrieve personal medication information. In order to demonstrate the feasibility of the concept, an early prototype called BlindNFC was implemented. It is a NFC-enabled PDA with a basic functionality of reading the medicine name and dosage information aloud by touching the medicine package. The service concept was tested and evaluated with user studies in Finland and Spain, where altogether 39 older people with varying level of problems with their sight and other functional abilities participated in the studies. Findings revealed that older users learned and used the basic functionality of touch- and audio-based system quite easily. A set of design issues to be taken into account was identified. Users showed a high degree of satisfaction in the use of the BlindNFC device, together with the solution it offers. They found potential value in the technology also in tagging and identifying other everyday physical objects than medicine packages and using their own self-recorded audio messages for marking objects. However, users were not currently willing to adopt the system for continuous use, as many of them had established over time methods for managing the medications, and were therefore observed reluctant to change these ways.

**Keywords**—User study; RFID; NFC; medication management; older users; vision impairment; touch-based interaction; audio interface; usability test; Finland; Spain.

## I. INTRODUCTION

As people age, they experience declines in many abilities that impact on various aspects of their everyday lives, resulting in a growing need for more support in carrying out their daily tasks and activities. Different degrees of vision impairments are inevitable results of growing old, as the physiology of our eyes changes with time when the eye tissues lose their flexibility and suffer from damages caused by everyday life, different health conditions and gravity. Our possibilities to prevent vision impairment with technology are very limited, but there are promising possibilities to support the visually impaired older people in better managing their everyday lives with the help of modern information and communication technology. Older people desire independence [1], and successful independent living involves the ability to carry out daily living activities [2].

The ageing is often associated with a growing amount of troubles with health, which appear as symptoms and diseases that also require medical treatment. As a consequence, older people use a substantial amount of drugs; between four and six medications on a daily basis [3][4]. A subgroup of the older people (frail elderly with multiple co-morbidities) takes an average of nine medications [5]. An important aspect of medication use is the medication management (MM). MM has been defined for example in a following way: “managing medications is an instrumental self-care activity that requires cognitive and functional capabilities to coordinate and carry out the associated tasks” [6]. Beckman Gyllenstrand [7] describes the process of MM to include the following five steps: 1) receiving a prescription, 2) filling the prescription, 3) storing the drug, 4) preparing a dose for administration, and 5) administering a dose. In a Swedish population aged 77+, a large proportion (66%) of the elderly people was unable to perform rather simple tests related to medication management [7]. In addition, a substantial proportion (60.5%) of the elderly who reported that they could manage their medication was not able to perform all the tests of MM.

The technology used in our research, Near Field Communication (NFC), is a very short-range wireless technology that allows electronic devices to exchange data upon touching. NFC standards have been built over existing radio frequency communication standards, so it is a special case of implementation of Radio Frequency Identification (RFID) technology. Touching with a mobile terminal has been found to be an intuitive, natural and non-ambiguous interaction technique that does not incur much cognitive load for users [8]. Touching is an effortless way to select objects in the environment and it is easy to learn and use, and users value the simplicity of the technology [9][10][11].

The work discussed in this paper describes the experiences and possibilities of using modern mobile communication technology in supporting the older users with varying levels of vision impairment in medication management.

## II. BACKGROUND

As people get older, the risk factors associated with medication non-adherence (caused by unintentional or intentional reasons) become more common [12]. Unintentional non-adherence can happen because of forgetfulness or other cognitive reasons, or physical problems, such as difficulty of

reading instructions or opening medication packaging. The patient may also intentionally decide not to take prescribed medicine as instructed. In the five steps of the MM process described earlier, there were identified several functional components that are crucial for the whole process of MM [7]. These components are vision, memory and comprehension, hand function and mobility. Significant correlations were found between memory and vision and knowing what dose to take, as well as between hand function and opening of containers.

In Europe, there is regulatory pressure for making medicine instructions accessible for vision impaired. The directive 2004/27/EC [13] requires that package information leaflet must be made available in formats appropriate for the blind and partially sighted, and name of the medicine must be printed in Braille format on the packaging. The problem with Braille is that not all people who have problems with seeing can read it. For example, ageing often causes visual impairments, and learning to read Braille at an old age might be difficult.

Here, we will address only the problem of unintentional non-adherence, and specifically non-adherence and inconvenience caused by declined vision and difficulties of properly seeing and reading the medicine information and related instructions.

### A. Existing Solutions for Supporting Medication Adherence

A wide range of educational, behavioral and technological interventions to improve medication adherence have been developed and trialed. There is evidence that pharmacist medication reviews with individualized education and instructions can be effective in increasing medication adherence with older people [12], even though it is time consuming and therefore difficult to implement in practice for large amounts of users. Technological solutions presented in the literature include, for example, solutions based on medicine storage boxes or cabinets with embedded intelligence [14][15], electronic reminders [14][16] and behavior or activity monitoring and modeling [15]. The solutions based on special storage boxes or cabinets may be costly to purchase and install. In addition, the medicine administration may be difficult and time consuming. Even high-functioning older people have been reported to have major problems in placing medicines correctly in a medicine box [17]. Also, specific storage devices rarely take into account nor support the existing nontechnology-based methods for managing medications, such as spatial-temporal arrangements and temporal routines [18]. There is not much research available that provide strong evidence on the effectiveness and impact of technical solutions to medication adherence, and practically no evidence with older users.

### B. User Interface Solutions for Elderly Vision Impaired

Ishihara et al. [19] have discovered that problem with resolution, i.e. difficulties in reading small print, is the most prevalent visual problem with older people. The space limitations of the surface available on the medical packaging are tight compared to the amount of information that is needed to present. This inevitably leads to small resolution text, and difficulties for many to effortlessly read the textual information. An alternative for text would be to provide medicine information in audio. Audio interface requires a

technical computing device. A mobile phone provides a promising platform for audio interface, as it is relatively cheap and commonly used both by vision impaired and older users. The small keypad and screen-intensive user interfaces may cause difficulties for ageing users with declined vision and hand-eye coordination. However, encouraging results of mobile phone use as service interface have been achieved with mobile interfaces based on touch paradigm [20].

The interface solution adopted in our service concept is based on a technology enabler called Near Field Communication (NFC). With NFC it is possible to write and read data from electronic passive tags which can be attached to medicine packages. NFC reader can be embedded in a mobile phone. This allows building physical user interfaces that can be used simply by touching a tag with a mobile phone. The NFC tags and mobile phones are already commercially available.

## III. AUDIO INTERFACE FOR MEDICINE INFORMATION

In this paper, we present and discuss the results of user studies that aimed at evaluating how a mobile application based on touch-based user interface could support vision impaired older users in their daily medication processes. The focus of this paper is on exploring user experiences and acceptance of this medication management service concept called BlindNFC. The service concept is based on a co-design process [21] together with technology providers, elderly care personnel, representatives of associations for blind, and pharmacy professionals complemented with observation of vision impaired ageing people.

In the concept (described in more detail in [22]) an NFC-enabled phone and NFC tags are used in physical interface for providing audio information about medication for vision impaired people (Fig. 1). The BlindNFC prototype uses a PDA (1) where the Secure Digital (SD) card slot (2) incorporates a reading and writing device for NFC tags (3) attached to medicine packages (4). When the NFC tag is touched with the NFC-enabled PDA, the speech synthesizer transforms the text stored in the tag into audio. For example in Finland, all prescription medication is required to have the personal dosage instructions (written by the doctor) printed and attached to the medication package by the pharmacy. In our concept the computer used for printing patient package labels on the pharmacy is equipped with a NFC tag writer, and the same text that is printed in the package label is stored as text on the tag, and then attached into the medicine package by the pharmacist.

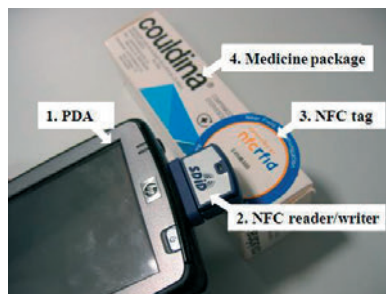


Figure 1. BlindNFC prototype.

One important aspect in the evaluation is how the solution is able to integrate or support the personal established procedures and methods created or adopted by the users for medication management. The service itself does not require the user to make significant changes to the practices s/he has followed in medication management. Nor does it require the user to store the medication in a specific way, or force the user into predefined schedules or activity procedures. If the user has created specific methods for recognizing the medication, s/he can continue to use them. Of course, the benefits of the scenario diminish, if the user does not use the mobile phone for listening to the medication information. If the user thinks s/he recognizes the medication correctly and trusts to remember the dosage required, there is a danger s/he does not use the technology as described in the scenario, and this might lead into situations of misidentification or wrong dosage. As the service concept has no mechanism for detecting non-adherence, it cannot react in such events.

This concept can be used for all medication needed both for prescription and over-the-counter medication. It can also manage regularly administered daily medication and medication that needs to be taken only occasionally when needed, e.g. in the case of an asthma attack or sudden head ache. As the medicine does not need to be stored in a specific storage place, the service can manage medicine in different formats, such as liquid, powder or pills, and medicine can be stored in refrigerator if needed. The only requirement is that a NFC tag stored with the medication information can be attached into medication packaging.

#### IV. USER STUDY

The main user groups involved in our study consisted of older people with varying level of problems with their sight and little experience with the technology. Another user group was somewhat younger people who were experienced with technology, and characterized by severe sight impairment or blindness, who all therefore had particular difficulties in activities such as identifying medicine boxes or instructions indicating doses and expiry dates. The first step in our research was concerned with analyzing needs and requirements of potential users. The methodology used to carry out the service concept feasibility analysis and user experience evaluation included interviews, observations and usability tests with a NFC-enabled PDA with an installed BlindNFC demonstration application. Interviews and tests were carried out at users' homes in Spain and Finland.

##### A. Data Collection

The methods used in the user study were a structured interview with both closed and open-ended questions, and observation and usability analysis of a prototype demonstrating the basic functionality of the system. Interviews consisted of the following main themes: (1) background data, (2) previous experience with mobile phones and computers, (3) different needs for daily support, and (4) practices and needs related to medication. After the interviews, the participants carried out usability tests with the BlindNFC prototype. These tests were aimed at giving the user a hands-on experience of using the particular technology and collecting the corresponding results.

The users were asked to use the prototype for pre-defined tasks, and the task performance was observed by the researchers.

##### B. Participants

In Spain, interviews and BlindNFC usability tests were carried out with two different user groups:

1) 17 people recruited through the ONCE association (Spanish National Organisation for the Blind). These users were blind or with severe eyesight deficiencies.

2) 10 older people contacted through the San Jorge Elderly People's Centre in Santurtzi. These users had slight hearing and/or visual impairment due to old age.

In Finland, two groups of users participated in interviews, and the first group also experimented with the BlindNFC prototype (one interviewee was hospitalized after interviewers' last visit, therefore being not able to participate):

1) Eight older people living in at the area of Caritas village with varying level of problems with their sight.

2) Four younger severely visually impaired people who are members of the Finnish Federation of Visually Impaired (FFVI).

Thus, altogether 39 people in Spain and Finland participated in the interviews, of whom 34 people also took part in the BlindNFC usability tests (only FFVI members did not participate in the tests). In Spain, the people interviewed were between the ages of 50 and 83. 62% were aged between 60 and 74. In Finland, the youngest interviewee was 34 years old and the oldest one was 92. Average age of the Finnish interviewees was 71 years, where the average age of the members of the FFVI was 47 years and the average age of Caritas village residents 84 years.

1) *Previous Experience with Technology:* With regard to technology experience, there were important differences between the two type of user groups involved (Table 1). People contacted through associations for blind (ONCE and FFVI) had more experience on both mobile phones and computers, being more fluent and advanced users of technology, while the Elderly People's Centre group and Caritas village residents were older and had little or no experience with computers, however, most of them had a mobile phone.

TABLE I. PREVIOUS EXPERIENCE WITH TECHNOLOGY

	Mobile Phone Usage		Computer Usage	
	YES	NO	YES	NO
ONCE Group (Spain)	14	3	8	9
Elderly People's Centre Group (Spain)	9	1	0	10
Caritas village residents (Finland)	4	4	1	7
FFVI members (Finland)	4	0	4	0
<b>TOTAL</b>	<b>31</b>	<b>8</b>	<b>13</b>	<b>26</b>
<b>%TOTAL</b>	<b>79%</b>	<b>21%</b>	<b>33%</b>	<b>67%</b>

2) *Functional Limitations:* In terms of functional limitations (see Table 2), the ONCE group in Spain was comprised of blind and severely visually handicapped people, while the group from the Elderly People’s Centre was composed of people with hearing and/or visual impairments due to old age. In Finland, in addition to problems with eyesight, several elderly interviewees from Caritas had clearly decreased motor and cognitive skills. Some of them had only minor problems with their sight as they had presbyopia (decreased ability to focus on near objects). Members of the FFVI were totally blind or their sight was clearly diminished.

TABLE II. FUNCTIONAL LIMITATIONS

<b>ONCE Group (Spain)</b>	<b>17</b>
Blind	11
Minimal remaining vision in one eye	3
Minimal remaining vision in both eyes	3
<b>Elderly People’s Centre Group (Spain)</b>	<b>10</b>
Elderly person	3
Elderly person + vision defects	4
Elderly person + hearing defects	3
<b>Caritas village residents (Finland)</b>	<b>8</b>
Presbyopia	4
Clearly declined vision	4
<b>FFVI members (Finland)</b>	<b>4</b>
Blind	2
Clearly declined vision	2

### C. Usability Tests with the BlindNFC Prototype

A set of simple tests using the BlindNFC prototype were carried out in conjunction with the interviews. The aim of these usability tests was two-fold:

- Firstly to find out how potential users react to a solution based on NFC when they try it for the first time, and to identify any difficulties which may arise together with the needed improvements to the existing solution.
- Secondly, to explore the user experience evoked by the service concept and to find out the degree of interest this type of technology triggers in the users themselves and the applications they can foresee.

The interviewees were asked to carry out the following four pre-determined tasks that tested how the users were able to interact and function with the BlindNFC device and how they performed with the NFC touch-based interaction technique:

**Task 1 - Location of NFC tags on medicine packages:** this test aimed to evaluate the ease with which blind and vision impaired people could detect and locate an NFC tag attached to the medicine package.

**Task 2 - Reading of pre-recorded tags:** test aimed at checking the ease with which users may locate and read the content of pre-recorded tags. Here the users were asked to read NFC tag (located and identified in the previous task) on the medicine package by using the NFC-enabled PDA device. This medicine package had the TTS (text-to-speech) voice message with a female voice.

**Task 3 - Comparison between different voices:** users were instructed to once again read the NFC tag with the PDA device, but this time the user was given a different medicine package with a pre-recorded natural female voice message. The user was asked to compare tags that were recorded in different ways, i.e. audio messages were presented with voice synthesis in the first case and human voice in the second. The aim was to find out user preferences between the two options.

**Task 4 - Tag writing using voice messages:** tested how the users themselves coped with recording tags using their own voice. In this last task the user was given a third medicine package equipped with a NFC tag, and s/he was asked to record own voice message. The users were guided through the recording procedure to store their own voice message.

## V. FINDINGS IN SPAIN AND FINLAND

In the following subchapters are introduced and analyzed the experiences and findings of the interviews and BlindNFC usability tests.

### A. Medication Needs Management

Nearly all people interviewed in Spain needed some form of medication (100% of the ONCE group), mainly aimed at controlling chronic illness. 52% of the interviewees in Spain took three or more different medicines daily. Comparing the two groups in Spain the ONCE user group had a higher need for medication. This indicates a higher need to identify and differentiate between different medicines each day and at various times during the day. An important difference could be observed between the two user groups in Spain regarding the management of their own medication. While 100% of the Elderly People’s Centre group carried out this management without the aid of other people, within the ONCE group this percentage fell to 65%, which is nonetheless still quite high. 35% of the people with severe visual impairment or complete blindness indicated a need for help from a family member for medicine management. They were mainly people consuming several different medicines per day (4 on average).

Also the most of people interviewed in Finland needed some form of daily medication in both younger (FFVI members) and older group (Caritas residents). They needed several different medicines daily, and 58% had to take medicines 3 or more times per day. In addition to regular medication, interviewees took some additional medicines when necessary. For example, heart stimulants were often prescribed to be taken when needed. In addition to prescription medicines, many interviewees used over-the-counter products from a pharmacy. 88% of the Caritas village residents and 50% of the FFVI members reported that they needed some sort of support in medication management. Usually relatives, nursing staff and pharmacy professionals helped them with their medicines.

One general difficulty experienced by the group of blind and severely sight-impaired people was access to the information written on medicine packages. Only a minority could access certain information they regarded important. When asked how they would like to obtain such information, they all opted for voice messages. Altogether, interviewees considered information on the personal patient packaging labels attached to a medicine package in a pharmacy to contain the most important information (medicine name, dosage instructions, what symptoms a medicine is prescribed for). In addition, particularly information about side effects and compatibility with other medication was regarded as important. Usually interviewees did not recognize medicines from their trade names. Thus, the best option would be if the user could decide the content of medicine information embedded into the tag. For example, in some cases “heart medicine” can be more descriptive than the trade name.

### B. Time to Complete the Tasks and Observed Problems in Executing the Task

**Task 1:** The total average time to complete the task was 13.1s. All the users were able to complete the task. This result is however somewhat affected by the fact that many of the users were able to locate the NFC tag on the medicine package much earlier, but they were not quite sure what they should be exactly looking for.

**Task 2:** The total average time to complete the task was 19.6s. Every user except for one was able to complete the task (her condition had visibly weakened after researchers’ first visit). There was great variation between users. Main problems in reading the NFC tag were related to finding the right touching angle or learning the appropriate touching duration.

**Task 3:** The total average time to complete the task was 3.7s, and again all the users except for one were able to complete the task. The average time achieved in this task is considerably less when compared to the time in the previous task. This shows how fast the blind and older users were able to adopt the touch-based interaction technique as practically none of the users (who executed the task) experienced any problems in managing to read the NFC tag.

**Task 4:** The total average time to complete the task was 22.6s, but ten users out of 34 were not able or willing to complete the task. The main reasons for failing to complete were because especially the older users found it nearly impossible to locate and identify the recording button on the PDA device, and pressing the button to start recording also appeared to be extremely challenging. This was the only task requiring input with buttons of the PDA – all other tasks were purely based on touch-based interaction. Pushing the button needs accurate direction of power, and some of the users failed to push it because of the lack of strength in their fingers. The instructions were not clear enough to help the user record the audio message. Most users that succeeded in completing the task required additional detailed instructions and support by the interviewers on each step of the task.

In Table 3 is summarized the user performance in the individual BlindNFC tasks. The results obtained were very similar in all cases irrespective of the level of visual

impairment. Although some people carried out the tasks quicker than others, basic functionalities were considered as simple. Only audio recording was found too demanding and complicated by many users.

TABLE III. USER PERFORMANCE IN BLINDNFC TASKS

	Completion Rate	Average Time to Complete in Finland	Average Time to Complete in Spain	Total Average Time to Complete
Task 1	100%	16.4s	12.2s	<b>13.1s</b>
Task 2	97%	17s	20.2s	<b>19.6s</b>
Task 3	97%	3.2s	3.8s	<b>3.7s</b>
Task 4	71%	47.5s	20.3s	<b>22.6s</b>

### C. Ease of Adoption and Use

Many users did not have any previous experiences about the use of mobile devices or computers, which set its own challenge when introducing and familiarizing the older people with the NFC technology. Despite this fact, the evaluations showed that the users were able to learn and use basic functionality of listening audio messages with a mobile device equipped with external NFC reader: “Quite nice and easy, when you understood what to do”.

1) *Locating and Identifying the NFC Tag:* A medicine box was supplied to users with a tag attached. Some of the long task completion times were caused because users were not sure what they should be exactly looking for: “I have never before seen a sticker like this”, “My own medicine packages do not have this”. However, the tag was located successfully by all users. Some problems were observed with blind or severely vision impaired people, but they also found the tag, often by moving their fingers on the surface of the medicine package. Insofar as subjective perception about finding the tag, of 34 participants only two persons (one totally blind and the other severely vision impaired) found it rather difficult. The rest thought it was either easy or very easy.

Thus, thicker tags would be appreciated especially by blind people to further ease the discovery and recognition of the tag. In addition, the users wished that the tag should be always positioned in the same place, together with a particular mark which could be easily recognizable by everyone, whatever their degree of visual incapacity. As far as the older users or people having residual vision were concerned, the means of identification used were by employing a different color on the tag from that of the medicine package. In this way these users were able to notice something different about the package. Deem [23] and Rice and Fels [24] have stated that the most legible combinations of colors are those with good contrast and enough distinction between opposing shapes, through appropriate color difference and spatial layout. In addition, the cognitive load of the user should be reduced by making sure that important elements are consistently positioned in the same location. The design should also be consistent in order to provide cue to support recognition rather than unassisted recall. In summary, the following issues should be taken into account when marking tags attached to packaging:

- Strong contrast in colors
- Easy identification with fingertips, e.g. upraised tag, Braille on a tag, or surface of a tag that differs from the package's surface
- Shape of a tag clearly different from package's shape
- Consistent design and positioning of a tag

2) *Reading NFC Tags:* With only a few repetitions, most users used the prototype for reading NFC tags without any problems whatsoever. Main problems in reading the NFC tag were related to finding the right touching angle or learning the appropriate touching duration. Unfortunately, these are issues that differ between reader devices, depending on the location and design of the antenna. Sometimes the angle of the reading device was perpendicular to the tag and the PDA reported about the malfunction. Users usually kept the PDA device on the NFC tag for too short time for initiating reading. Some users put the PDA over the medicine box to read the tag, forgetting that they have to work with the NFC device located on the top of the PDA. It seems that they unconsciously assimilated the reader device as if it was integrated inside the PDA. In some cases users instinctively drew back the reader on hearing the beep when tag reading commenced, causing an error by foreshortening the time needed to carry out the reading correctly. Once they had tried it a couple of times, however, they got the hang of it very quickly and successfully carried out the task: "When you learned what was sought after with this, it was easy".

3) *Comparison of Voice Messages:* The test was carried out with two medicine boxes, one of which had a message recorded with a synthesized voice, and the other with a recorded human voice. The results varied regarding the choice of preferred voice type, and are presented in Table 4 below.

TABLE IV. SYNTHESIZED VS. NATURAL VOICE

	Don't Mind	Natural Voice	Computerized Voice
Males	1	3	8
Females	6	6	10
<b>TOTAL</b>	<b>7</b>	<b>9</b>	<b>18</b>
<b>%TOTAL</b>	<b>20.6%</b>	<b>26.5%</b>	<b>52.9%</b>

More than 50% of participants preferred the computerized voice over the human one due to the clarity with which it is heard and the absence of background noise that was an inevitable side-effect produced during recording. Whereas slightly over 25% preferred the pre-recorded natural voice message, and around 20% stated that in their opinion there was no significant difference between the two voice messages. In addition, many older test users had difficulties in hearing the voice messages because of their impaired hearing. Overall hearing is proven to decline with age, about 75% about those between 75 and 79 years of age have some hearing impairment [25][26]. Thus, it is also necessary to provide easy-to-use volume control for adjusting the volume of the audio information according to users hearing capabilities.

Many of the people participating in these tests were used to hearing computerized messages, whether in telephones, clocks, screen reader programs etc., so they considered this type of voice quite "natural". The rest of the group was made up of older people with age-related incapacities, for whom technology plays little or no part in daily life, and who preferred to hear human voices in most cases. For example, Hawthorn [27] and Delogu [28] have shown that listening to and comprehending synthetic voices is more difficult than with a natural voice. However, this difficulty can and does decrease with the subject's exposure to said synthetic voices. Smither [29][30] has found poorer performance for older adults with remembering and understanding computer generated speech and attributed this to short-term memory demands.

Users commented that they missed the first few words of the messages: "I wasn't prepared to listen and I didn't know what to expect." Wolters et al. [31] have revealed that items in second place are easier to remember than items in first place, and persons and times are easier to remember than medications. With phonologically complex, unfamiliar medication names performance doubles for the natural voice compared to the synthetic voice [31]. However, people can remember and process synthetic stimuli just as well as those produced by natural speech if the text consists of familiar words and phrases as well as contextual cues [31]. As soon as unfamiliar and complex words are introduced, users' hearing affects how well they can understand the synthetic voice. We can exploit these findings by ensuring that tone alerts precede the actual audio messages to get the immediate attention of the user, and medication related prompts are redundant and contain frequent, familiar, and phonologically simple words.

4) *Recording NFC Tags by Voice:* In general, the users had great difficulties in locating and identifying the recording button from the PDA device since the button was very small and not colored or shaped to stand out from the device. In addition, both the interviewers' observations and users' own comments proved that they experienced it very challenging in pressing the button. The main reason for this lies in the older users' reduced motor skills and declined sense of touch. Also, the older users do not have enough strength on their fingertips, which on its part complicated the process of recording tags. Older adults are reported as having less ability to control and modulate the forces they apply [32], in addition to problems with control of fine movement [27].

The option of recording tags was however highly rated by the users, especially as a way of making reminders about medicine dosages. The users found it very useful if the tags were to come pre-recorded, avoiding the need to carry out recordings of all medicines. In many cases this would have to be done by a person other than the user, since identification would be difficult for those with residual sight, and impossible for the totally blind. Nevertheless, users expressed a need for the option of modifying these messages according to their own needs. They even proposed an option of being able to utilize NFC tags to mark and identify different objects around the home. However, if the application provides possibility to "record" own tags, finding and pressing the "recording button" must be made very easy.

#### D. Usefulness of the Service Concept

The users reported a high degree of satisfaction in the use of the device, together with the solution it offers. Following comments illustrate the typical responses: *“This is interesting, very exciting!”*, *“Really good!”* The users also expressed their interest in solutions that would help them carry out monitoring of vital signs; for example, they considered it useful of having a device to help them read blood pressure and glucometer measurements and give the measurements by voice: *“My husband wouldn’t then always need to be by my side to read the measurements aloud for me.”* In addition to medicine packages, identification of other everyday objects through a NFC-enabled mobile device, which may even include their own mobile phone, seemed attractive for the users.

However, some of the users were a little more skeptical toward the usefulness of the solution: *“I’m doubtful”*, *“I don’t believe I want a device like this for myself”*. The main reason for doubt was that the users had already established their own procedures for managing medication. They either had some remaining vision which helped in identifying and distinguishing between the medicines, or a person relied on the support of other people. The following procedures for managing medication were identified:

- Person takes one medicine only and keeps it separate so has no problem in identifying it,
- Person has slight remaining vision which helps in identifying and distinguishing between the medicines,
- A blind person can read Braille and is capable of reading the information on the medicine packages,
- Person has developed over time own established practices for managing medications independently, or
- Person relies on the support of other people in the medication management.

In addition, the lack of previous experience with technology was likely to have had an effect on users’ attitude toward the technology-based solution; some users expressed doubt and worry about their own competence with technology use: *“How difficult it would be to use this?”*, *“This is more suitable for young people”*, *“I have not learned to use devices like this”*. Older users also had some difficulties in comprehending the intended purpose of the system and trying to imagine the future situation of using the application.

#### E. Added Value to Existing Practice

As some older users were able to handle the medication management by themselves or many had a relative or nursing staff helping them, they felt that the system could not bring significant help for them. One user stated that she *“would hardly take this into use”* because she did not see that the system would bring any added value to her, as her son was already taking care of her medications. Thus, some users might have been reluctant to adopt the system in a fear that as a consequence their close one wouldn’t anymore have a need to visit them so often. In addition, another user believed that *“I don’t want for myself a device like this”* and found the system *“useless to me”*, mainly because the nursing staff at the

Caritas village took care of her medications by arranging on a weekly basis all her medicines in a medicine dispenser. These findings do not correlate with previous research stating that independence is highly valued and sought by older users [1].

#### F. Actual Need for the Service

Even if the users did not find this solution very useful for them, it was discovered that people need help for their medication management. The interviews revealed that almost all the users needed some support in medication management, usually from their relatives, nursing staff and pharmacy professionals. Only a minority of them could access the medication information they regarded as important. Several users reported that they especially had difficulties with managing their new medicines, since it is difficult for them to remember the names and dosage instructions of the new prescriptions. Usually the older people had been using same medications several years so when their medication plan was changed and old medicine was replaced or a new one was prescribed to them that caused some extra challenge and effort with their medication management.

## VI. CONCLUSIONS

The idea of the touch- and audio based service concept described in this paper is to allow vision impaired older users to manage their daily medications autonomously by providing them means to identify medicines and retrieve personal medication information. The requirement for the concept was to provide important support for more independent living of the older people without unreasonable costs. The developed BlindNFC prototype was evaluated with user studies in two countries, in Finland and Spain, where altogether 39 older people with varying level of problems with their sight and other functional abilities participated in the studies. The user study included interviews, observations and usability analysis conducted at users’ homes.

It was revealed that there is a need for some type of medication management support because users had difficulties in accessing the textual information on the medicine packages. The findings from the usability tests did not bring out any noteworthy differences between the two countries in relation to user experiences or task performance. In general, the older and blind users were able to learn and effortlessly use the basic functionality of listening audio messages with a mobile device equipped with an external NFC reader. However, both the physical interface and logic of recording audio messages were problematic and experienced too challenging by many users, even though many found this option potentially valuable for them. As a result of the user study, a set of design issues to be taken into account was identified, considering for example the size, shape, color and placement of NFC tags, and the voice messages the device gives to the user.

As a whole, users showed a high degree of satisfaction in the use of the BlindNFC device, together with the solution it offers. They found potential value in the technology also in tagging and identifying other everyday physical objects than medicine packages and using their own self-recorded audio messages for marking objects. Users also considered it useful

of having a device that would help them read health measurements using voice messages. Findings revealed that users' attitudes towards the service concept were positive and they thought that it would be valuable especially when new medicines are taken into a medication plan. However, they were not currently willing to adopt the system for continuous use. Many of the users had developed their unique ways of compensating for their slowly progressing loss of vision, and the users were observed to be reluctant to change these ways.

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PUBLICATION VI

**iShake: Mobile phones as  
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**User study findings**

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# iShake: Mobile Phones as Seismic Sensors – User Study Findings

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## ABSTRACT

The “iShake” system uses smartphones as seismic sensors to measure and deliver ground motion intensity parameters produced by earthquakes more rapidly and accurately than currently possible. Shaking table tests followed by field trial with approximately 30 iShake users were implemented to evaluate the reliability of the phones as seismic monitoring instruments and the functionality of the iShake system. In addition, user experiences were investigated with 59 iShake users, who provided feedback through a mobile questionnaire. Research included participative planning with a focus group to design and conceptualize how to improve iShake for future use. The shaking table tests demonstrated that cell phones may reliably measure the shaking produced by an earthquake. The performed user studies led to important guidelines for the future development and improvement of the iShake system. User studies also provided understanding of how iShake could best provide value to its users. The iShake system was shown to have great potential in providing critical information and added value for the public and emergency responders during earthquakes. Value creation for other users and first response through user-generated data was seen as a great source of motivation and commitment for active use of the system.

## Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces – *Evaluation/methodology, User-centered design.* J.2 [Physical Sciences and Engineering]: Earth and atmospheric sciences. K.4.1 [Computers and Society]: Public Policy Issues – *Human safety.* K.8 [Personal Computing]: Apple.

## General Terms

Design, Experimentation, Security, Human Factors.

## Keywords

Earthquake, seismic sensor, smartphone, Apple iPhone, post-earthquake notification, field trial, user experience, value creation, California.

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## 1. INTRODUCTION

Most of the population takes the stability of the earth for granted. Human adjustment to earthquake hazard requires adaptation to phenomena that confuses people’s senses and beliefs [20]. Earthquakes have been the cause of many of the most devastating natural catastrophes in the 20<sup>th</sup> century. Seismic zones are frequently subjected to earthquakes, which can cause a tremendous loss of lives and property. Unlike some other natural disasters, there is typically no or little warning, the impact is widespread, and the effects diverse. In the aftermath, fear of aftershocks and social and economic disturbances may last for years. Time and time again, studies have shown that populations subjected to large and frequent earthquakes suffer from on-going fear and anxiety [2]. Because earthquakes cannot be predicted, the only way to reduce damage and loss is through effective preparedness [29].

Dramatic changes in the features commonly available in cellular phones have produced a new breed of phones called smart phones that represent the convergence of sensing, computational power, and communication. While the smartphone is not technically designed to be a scientific sensor, the addition of inexpensive, lower-quality sensors into the device permits the exploitation of the device for such a use and allows one to treat the phone as a means of sensing ground motion data, along with the means of transmitting the data to a central system. Thus, the iShake project sets out to utilize the Apple iPhone as a mobile sensor to measure seismic activity, permitting measurements to be taken wherever there is a network connection.

California is an earthquake prone area that has had several severe earthquakes in recent history, such as the magnitude (M) 6.9 Loma Prieta and M 6.7 Northridge earthquakes in 1989 and 1994, respectively. The Uniform California Earthquake Rupture Forecast (UCERF) report [34] used improvements in the earth sciences to predict that “California has a 99.7 percent chance of having a magnitude 6.7 or greater earthquake in the next 30 years, and a 46 percent chance of having a magnitude 7.5 or greater earthquake in the next 30 years”. Regions subject to earthquakes have the benefit of having a population that is aware of the risks associated with earthquakes and potentially willing to utilize technology that can help them better manage the advent of a major earthquake.

Mobile phones are now referred as “a technology other than human observation itself that is as pervasively deployed out in the world” [22], and they offer powerful potential to enhance the role of the citizen observer, thus supporting advocacy and civic

engagement [11,22]. With iShake, we make the assumption that if people are offered a free service on their phone, a sufficient number of users would voluntarily participate to make the system operational and capable of collecting large amounts of data. The collected data will aid first responders and will be invaluable to scientists.

The San Francisco Bay Area alone is home to over 10 million people. If only one-tenth of those individuals with capable phones participate, 100,000 sensors would come on line. If just one-tenth of these sensors measure accurate data during a major earthquake, the U.S. Geological Survey (USGS) and the California Geological Survey will have semi-quantitative ground motion data from 10,000 sensors. This is more than an order of magnitude more instruments than are currently available in the Bay Area through ANSS (the Advanced National Seismic System). In areas of the Nation where ground motion stations are more sparse, the increase in the number of sensors will enable higher-quality maps to be prepared with resolution previously not possible.

The iShake project proposes an innovative use of cell phones and information technology for rapid, post-earthquake analysis and visual representation of seismic data. A series of one-dimensional and three-dimensional shaking table tests were performed as a part of this study, and the results of these tests served as a proof of concept for the development of the iShake. A field trial was subsequently conducted to test the iShake system, where users simultaneously used the iShake application and shook their phones to simulate an earthquake (hence the term “virtual earthquake”). Through the field trial and related user study activities, guidelines and requirements for iShake’s future development and improvement were developed. These tests also provided insight into how iShake could best provide value to its users and what kind of information and data visualization best serve the users during future earthquake events. Here, the purpose is not to validate the technical reliability and functionality of the iShake system, but to examine and analyze value parameters brought to users by iShake. Thus, the focus of this paper is on the qualitative findings of the iShake user study, and the shaking table tests and feasibility analysis of the system are not discussed at length in this paper, as they are detailed elsewhere [10].

This paper is organized as follows: Related work is described first, followed by justification of the iShake system development together with the results obtained from system feasibility testing and a description of the iShake system. This is followed by an overview of the iShake user study introducing the methodology used in user experience data collection as well as the field trial procedures used for system testing and evaluation. The paper continues by representing and analyzing the user study findings. The paper finishes with discussion and conclusions, proposing topics for future research.

## 2. RELATED WORK

Through pre-event earthquake mitigation measures, the risks from earthquakes can be reduced [12]. In addition, it is critical to assess rapidly the post-event situation and effectively marshal emergency responders to areas hardest hit by an earthquake. The U.S. Geological Survey (USGS) has made a major commitment to deliver post-earthquake information for these purposes. ShakeMap and “Did You Feel It?” are examples of some of the products that are currently being used [4,31,32]. Although they enjoy some success, there is the need for advancements and

refinements to improve the speed and accuracy of post-earthquake information.

ShakeMap [31] provides rapid, quantitative assessment of the level of shaking produced by a major earthquake. It works best in regions that contain a sufficient number of ground motion instruments to “capture” the event. While it does contain algorithms for estimating ground motions in areas of sparse station coverage, its reliability is hampered by the limited number of strong motion stations in a given area.

“Did You Feel It?” (DYFI) [4], on the other hand, uses human observations voluntarily submitted through the Internet after an earthquake. The mapping is based on the Modified Mercalli Intensity (MMI) scale [28,33], with individuals asked to respond to questions that lead to a value that best represents the local shaking at their location. A single MMI is assigned to each zip code and zip codes that have no response are shown as grey. The result is a Community Internet Intensity Map (CIIM) [32] summarizing the responses. However, the observations of untrained humans are a rough qualitative indicator of the effects of the earthquake. In addition, DYFI reliability is greatly hampered by the speed at which this information can be collected and disseminated. In turn system response is dependent on how fast people are able to access the Internet, which might be quite problematic depending on damage levels.

Another project for measuring and delivering post-earthquake information is the Quake-Catcher Network (QCN) [7] developed and run by Stanford University and the University of California, Riverside, which uses inexpensive accelerometers attached to personal computers and laptops to measure and detect earthquakes. The work done by iShake complements this project well, as it takes advantage of a resource not considered by Quake Catchers, and provides directional compass data that personal computers cannot measure, allowing the measurements to capture direction of first motion. Modern smartphones almost always come equipped with advanced geo-location services, which not only allow for a higher degree of accuracy for location in contrast to QCN sensors, but also allow the device to use the iShake application in any environment with a network connection.

## 3. RESEARCH SETTING

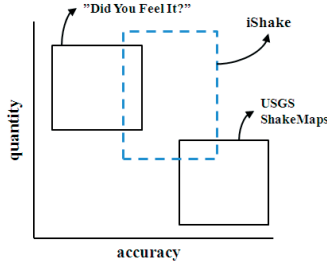
The following subsections present the technical innovation explored in the iShake user study.

### 3.1 Motivation for iShake

Emergency responders must “see” the effects of an earthquake clearly and rapidly so that they can effectively take steps to ameliorate the damage it has produced. When communicating the intensity of shaking with the public and emergency responders, on one side of the spectrum we have the high quality, but sparse, ground motion instrument data that are used to help develop ShakeMap, and on the other side of the spectrum we have the low quality, but sometimes larger quantity, human observational data collected to construct a “Did You Feel It?”-based map.

The primary objective of the iShake project is to use people’s smartphones to bridge this gap and occupy a third space, as phones can provide immediate post-earthquake information with a potentially large number of relatively good quality sensors (see Figure 1). Rather than solely relying on individuals’ feedback as measurement “devices”, the iShake project uses a ubiquitous

instrument that most people already possess to measure ground motion intensity parameters in a semi-quantitative manner. Participatory-sensing systems leveraging mobile phones have been acknowledged to offer unprecedented observational capacity [11].



**Figure 1. Bridging the gap with iShake.**

The current iShake system uses accelerometer-enabled iPhones to measure the shaking produced by an earthquake. The seismic data is immediately sent after the earthquake occurs to a server that analyzes and interprets the data. A key point of the iShake system is the immediacy with which the data is relayed to emergency response centers, as the cellular network will rapidly become overloaded. The initial minute is sufficient time to automatically broadcast earthquake data providing users with basic information such as magnitude of the earthquake, location of the epicenter, and potential areas with the most damage. The future scenario is the collection of relatively high quality shaking data from thousands of cellular phones, enabling the USGS to produce ground shaking maps more rapidly and accurately than can be generated with current tools.

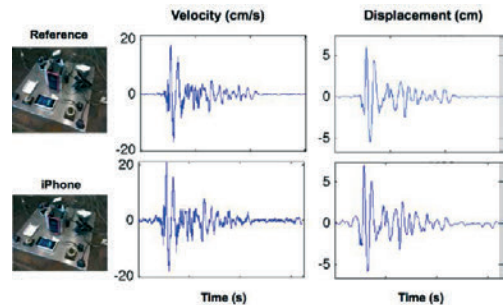
### 3.2 System Feasibility Testing

The Apple iPhone can best be modeled as an intelligent sensor that has the ability to transmit its data. Thus, we propose the use of the iPhone as a new ad-hoc sensor array based on participatory sensing. The nodes in the sensor array are cell phones voluntarily provided by participants, used to monitor vibrations when they are in a rest position.

In the first development phase, iShake was set out to utilize the iPhone as a mobile sensor for seismic data. While the iPhone is not technically designed to be a sensor platform, a variety of sensors in the device permit its use in this fashion. The iPhone uses the STMicroelectronics LIS302DL “piccolo” accelerometer. The dynamic range of the accelerometer may be adjusted by Apple to a 2 or 8 g range. To evaluate the performance of the accelerometers used in the iPhones, a series of 1-D and 3-D shaking table tests were performed at UC San Diego and UC Berkeley, respectively. Detailed findings from these shaking table tests are reported in technical report [10]. In these tests, four iPhone 3GS and three iPod Touch devices were mounted at different orientations and subjected to 124 earthquake ground motions at various intensities to characterize their response and reliability as seismic sensors. Also attached to the base platform were three orthogonal, relatively high-quality miniature accelerometers that were used as a reference for the phone measurements. The testing also provided insight into the seismic response of unsecured and falling instruments [10].

The devices and reference accelerometers captured the shaking events in a series of trials. For each trial, the reference accelerometer signals were compared to the mobile device-measured signals to study the reliability of phone measurements as seismic monitoring instruments. The recorded cell phone data were used to calculate seismic parameters such as peak ground acceleration (PGA), peak ground velocity (PGV), peak ground displacement (PGD), and 5% damped spectral accelerations [10]. The mean acceleration response spectrum of the seven iPhones compared well with that of the reference accelerometers, and slightly over-estimated the ground motion energy and hence, Arias Intensity ( $I_a$ ). The error in the recorded intensity parameters was dependent on the characteristics of the input ground motion, particularly its PGA and  $I_a$ , and decreased slightly for stronger motions with a higher signal to noise ratio. While mobile devices are not well-equipped to handle lower-intensity shaking events, as the intensity (and PGA) increases, the devices perform better.

Figure 2 shows representative velocity and displacement time-series recorded by the high-fidelity reference accelerometers, as well as those recorded by an iPhone device. The records were calculated by successive integration of the original accelerometer signal. It is obvious from Figure 2 that the peaks from the two sources are very similar and occur at the same time. PGA, PGV, and PGD statistics help in determining where the most severe shaking occurred during an earthquake. Particularly, the ground velocity is a good measure of damage to engineered facilities, which is valuable to emergency responders.



**Figure 2. The accelerometer records of the reference and mobile devices.**

An additional set of tests was run to evaluate whether meaningful data could be obtained from a phone not rigidly fixed to a table. The use of a high-friction device cover (e.g., rubber iPhone covers) on two unsecured phones yielded substantially improved data by minimizing independent phone movement [10].

The testing sequence showed that the iShake system was able to successfully deliver acceleration readings from the phone to the database on the server, at which point the data could be plotted for instant verification. The iPhones were proved to be successful in capturing key intensity parameters during shaking table tests. It was discovered that the iPhones are much more capable of measuring high-intensity events due to the limited resolution of the iPhone accelerometer. The results of the tests served as a proof of concept for the development of the iShake system introduced in the next section.

### 3.3 iShake System Description

Figure 3 provides an overview of the iShake system architecture.

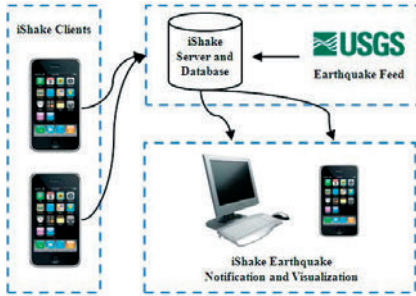


Figure 3. Overview of the iShake system.

#### 3.3.1 iShake Client

In addition to the accelerometer, the iPhone includes a 3-axis magnetometer, which acts as a compass in common use, and a GPS unit for geo-location and navigation. For a traditional seismic recording, the orientation and location of the seismograph are constant and known. These parameters are dynamic for the phone and must be determined and associated with any data that the accelerometer reports. Using the accelerometer, magnetometer, and GPS readings, the orientation and location of the phone can be estimated (Figure 4).



Figure 4. Mobile phone as seismic sensor.

To begin determination of earthquake events, the mobile device must be stationary for a period of time prior to recording. The reasons for this are twofold. First, to determine orientation of the device, the gravity vector must be determined, and this can only be accomplished if the device is not experiencing other forces. Second, the iShake project is only analyzing recordings from stationary devices. Thus, devices carried on a moving person or experiencing a great deal of movement unrelated to seismic events should not transmit their data to the server. Device movement is characterized by a change in the accelerometer reading.

Cellular phones are used by their owners only part of the time. In particular, when phones are being charged, they are not being used, and are in a rest or static position. This situation offers interesting opportunities for reliably sensing earthquakes, since during the charging time, phones have essentially unlimited power (and are therefore able to use all their sensing and communication equipment regardless of battery life), and can be stabilized. Thus, the phones are able to capture features from the environment uncontaminated by human motion, such as when they are being carried. In consequence, iShake users are asked to simply turn on the application when they plug in their phone, for example at night when they go to sleep. Then any possible earthquake triggers measured by the phone will instantly be streamed back to iShake servers for further processing and shake map generation.

Multi-tasking is not supported on iPhone models older than version 4.0. Hence, an alarm, text message, or a phone call may interrupt the successful and continuous running of the application. This problem is largely addressed in recent iPhone and iPod touch models. With the introduction of iPhone Operating System 4.0, all compatible iPhones have background activity capabilities. Receiving alerts such as text messages or phone calls will no longer disturb the application.

#### 3.3.2 iShake Server

The server for iShake acts as the administrator for the possibly large number of events being sent from the iShake clients. Although any data transmitted from the iPhone is considered a shake event, we may reasonably assume that most events sent by the phone will not actually correlate to a real earthquake. When shaking events are first received by the server, the event is classified as “unverified”. All unverified events are compared against a database of recent earthquake events reported by the USGS through an online xml feed. Since the iShake system is currently designed for California earthquakes, this verification process is considered to be acceptable. If our server receives multiple simultaneous accelerometer readings within the same region, it is likely an earthquake. Filtering algorithms are used to detect falling or loosely-attached devices, as well as device-specific responses to the event. Signals produced by devices experiencing sudden or unrelated forces should be removed.

#### 3.3.3 Earthquake Notification and Visualization

Once the server has validated and processed the transmitted data from the iShake clients, the summarized information will be visualized on the users’ phones. In a presentation similar to the ShakeMaps by USGS, iShake can produce a geospatially-varying intensity map from the filtered and processed accelerometer recordings of the iShake clients. For testing purposes the iShake client was given an additional functionality called the “Shake Monitor” where the users could generate their own shake events by giving the phone a trigger, e.g. by tilting the phone. These live “iShake Maps” of users’ shakes are made instantly available for viewing on the application as well as on the iShake website. Figure 5 shows the user views of the Shake Monitor interface and an example of iShake Map generated on client application from users’ individual shake events. This map visualized locations of anonymous iShake users around the “earthquake” area with a rough shaking intensity map showing the magnitude and duration of the earthquake in the user’s zone of interest. iShake users could select to view the information obtained from their own phone only or alternatively also those obtained from other users.

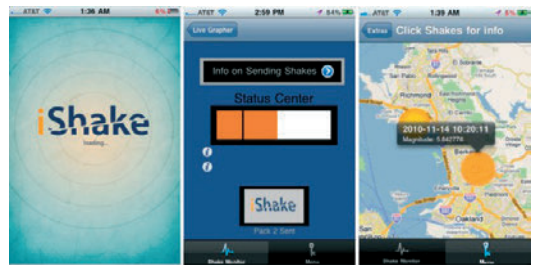


Figure 5. “Shake Monitor” interface and “iShake Map” generated on client application.

When the user first downloads the application, s/he is asked to register (this step is voluntary) to have the opportunity to access and view their own data and contributions also online at the iShake website. The information requested during the registration process does not inherently reveal or become associated with the user's real-world identity. On the Shake Monitor, the user is able to view "Live Grapher" displays of the forces his/her phone is currently feeling from the environment (see Figure 6). Registered users can view accelerograms sent from their iPhones as well as the time and location of each record through the "iShake Signal Grapher" link on the website.

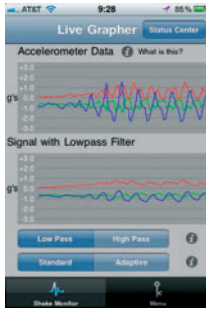


Figure 6. "Live Grapher" interface.

The application also provides users with other useful and interesting information related to earthquakes, and offers a detailed "handbook" of earthquake preparedness compiled from various reliable and official sources. The information bundle is intended to help the iShake users educate themselves and prepare in advance, as this is the key to surviving when natural disaster strikes [12]. This important educational preparedness information is presented in the form of text, video and images, and categorized under themes such as "before an earthquake", "during an earthquake", and "after an earthquake".

## 4. USER STUDY

To complete the shaking table experiments, the performance of the iShake system was also evaluated through field trial and related user study activities. Jurison [18] has concluded that applications which are perceived to offer high value from the start are adopted rapidly while those perceived to be of low value are adopted slowly and are unlikely to gain acceptance in the long run. Our aim is to have the users to adopt iShake in long-term use and use it as a critical information channel during earthquake. To achieve this, we need a deeper understanding on what kind of information and instructions users would like to receive from iShake in the event of an earthquake, and how to present this data to users.

Through the user study we wanted to obtain guidelines and requirements for iShake's future development and improvement. It was also essential to identify the individual value parameters brought to the user through iShake. Another side of the trial was to experiment the functionality and scalability of the iShake system, i.e., the sensing, transmission, and display capabilities of the iPhones.

## 4.1 Participants

Before the launch of the user testing, the free iShake application was released on Apple's own App Store. We hoped that enough value could be provided to iShake users through the application itself, thus giving users sufficient reasons to participate in the trial. The pool of potential iPhone users is large, but the number of trial participants was dependent on how many people eventually chose to install, and then use, the application. Our strategy was to exploit the large penetration of iPhones in the student body at University of California in Berkeley (UCB) as a starting point, and get volunteers to submit samples for the research data. The number of participants was limited because of the amount of time for which measurement data was collected, the incentive that users had to install the application, and the potential number of users who had the technical capabilities and belonged to the UCB community, which was used as a main recruiting pool for test participants and where the activities for finding test volunteers were centered.

In regards to data collection the users' identities were kept anonymous. When any user first launched the application, a unique identifier was generated that provided absolutely no information about the user. This unique identifier was used for all data collected for this particular user. No personally identifiable information existed which could link a user's data obtained from field tests to an actual person.

## 4.2 User Experience Data Collection

Given difficulties that need to be overcome for describing and understanding user experience, we decided to combine a variety of data collection methods that were complementary [35] in order to increase reliability and validity of the results. Data collection methods used during the field trial and related user study activities were as follows.

### 4.2.1 Observations

The potential users were encountered face-to-face when promoting the application on the UC Berkeley campus. In the same context, the initial expectations and thoughts of the users regarding the iShake service were preliminarily explored by informally communicating with the people during our recruitment activities.

### 4.2.2 Questionnaire

During the iShake field trial, we hoped to gather valuable user experience data with the data collection tool that could be used by subjects without supervision. We decided to create a real-time mobile questionnaire and make it available on the application in order to assess the phenomena at the time they occur as the people being observed are in natural settings. Thus, the users were asked to record on a mobile questionnaire various dimensions of their subjective experience evoked by the use of the iShake application.

### 4.2.3 Brainstorming

After the field trial with a small focus group comprising of three UCB students and two project team members a brainstorming session was arranged. Brainstorming participants were recruited among the iShake test users. The session included participative features, i.e. the purpose was to plan and vision together with the users how to improve iShake for future use. Jones and Marsden [17] have stated that in terms of new systems, focus-group session

method is best used for brainstorming possibilities rather than critiquing concepts.

The objective was also to more profoundly explore users' initial experiences and feedback of the iShake system. We wanted to better understand how iShake could best provide value for its users and what kind of information and data visualizations users would like to receive via iShake during the future earthquake events; what iShake could provide to users immediately after the earthquake and what kind of information would be useful before the earthquake.

During the brainstorming session the participating students were directed to discuss and reflect on future usage scenarios of iShake. The scenarios described how iShake could act as a critical information channel during the earthquake, in addition to providing other valuable information and instructions before and after shakings. The agenda and the structure of the brainstorming session were intentionally kept informal. The participants were requested not to limit their creativity with the current technological restrictions, but they were instead asked to let their imagination fly and not be too critical on their ideas. Participants were asked to create as rich a variety of iShake future usage scenarios and possibilities as possible.

### 4.3 Field Trial Procedures

The iShake field trial was carried out in the beginning of 2011. This was the first phase in the iterative process of the iShake system testing and evaluation and a basis for the next steps in the system development.

Abowd et al. [1] have pointed out that controlled studies in usability laboratories cannot lead to deep, empirical evaluation results. What is needed is real use in an authentic setting. However, we could not count on “conveniently” having a noticeable earthquake in California during our limited time frame allocated for user testing, which would enable us to trial the system in real situation. We chose to approach this problem by developing an additional functionality in our application that allowed users to generate their own “earthquakes”, i.e. shake events. These live and real-time shake maps of users' shakes were made instantly available for viewing on the application (see Figure 5) as well as on the iShake website. Through this measure, we hoped the users would get a better and more illustrative understanding of the future use of the iShake system, where the iShake application would provide critical information during earthquakes.

#### 4.3.1 Pilot Testing

Prior the iShake field trial, a comprehensive two-day pilot test was implemented with a delimited “insider” group of five people before introducing the application to the wider audience and releasing the application for users to download. The objective was to assess the iShake system functionality by testing and evaluating the planned field trial procedures. We also wanted to ensure that the information and feedback (push notifications and live iShake Map) sent to the user by the iShake system perform correctly.

#### 4.3.2 Field Trial

The iShake field trial began in the end of January 2011, with the focus on San Francisco Bay Area and especially on the UC Berkeley campus. The trial lasted two days. On the first testing day altogether 26 unique users around the U.S. and the world

contributed in generating virtual shake events and transmitting phone sensor readings to the iShake system. On the second day, a total of 9 users participated in the shake event. Of the participating users the majority, about 20 people, were from the Bay Area.

Apple provides the Apple Push Notification Service (APNS), allowing applications to send alerts to their users. These appear on the phone's screen as pop-up alerts which must be dismissed before the user can continue using the device. We took advantage of this system to notify users of upcoming shake events and also provided a clear mechanism for users to opt out of further data collection if they wanted to do so.

#### 4.3.2.1 Virtual Shake Events

During the field trial, we arranged two separate virtual shake events, during which the users simulated a virtual earthquake by all shaking their phones at the same, pre-notified time. The servers automatically collected and processed the measurement data from the users' iPhones during the test situation. A real-time iShake Map was generated showing the intensity of shake events obtained from the phones in the sensor network (see Figure 5). iShake Maps were instantly made available for viewing for the user on the application as well as on the iShake website. In addition, the user could view online the accelerograms sent from his/her iPhone as well as the time and location of each record.

The general form for the shake event was the following:

- 1) Early warning
- 2) Very late warning
- 3) Actual earthquake alert
- 4) Notification about new earthquake data
- 5) Request to fill out questionnaire

Both shake events followed the above five-point structure, in addition to:

- 6) Nightly reminder to turn on the application and leave it on

iShake users were asked to simply turn on the application when they plug in their phone at night. Then any possible earthquake triggers measured by the phone would instantly be streamed back to iShake servers for further processing and iShake Map generation.

#### 4.3.2.2 Virtual “Fake” Earthquake Alerts

During the field trial, we also produced and delivered notifications about a “fake” earthquake event happening in user's close proximity, and consequently showed an iShake Map visualizing this imaginary earthquake with 100 random points in “earthquake zone.”

The test users were naturally notified that the earthquake notification sent to them was not real, but they were asked to treat the information as it was authentic and to consider the received information and their corresponding user experience in the context as it happens. The aim was to get the user to better comprehend what kind of information and instructions iShake could send to the user in real situations in the future, and imagine oneself in the situation in which the earthquake occurs and iShake acts for the user as a critical information channel.



## 5. USER STUDY FINDINGS

In the following subsections are introduced and analyzed the experiences and findings of the iShake user study.

### 5.1 Observations

When promoting the iShake service concept to potential users our observations revealed that for the people living in the earthquake prone area the concept for receiving earthquake notifications on a mobile device is something they would readily welcome. However, the limitations on service adoption set by the required technical capabilities pointed out the need to expand the service to other types of smartphones as well in future phases of the project. In addition, people's spontaneous reactions and comments when introduced to the iShake service concept brought out a demand for an early warning system. It came out that not all the people fully internalized the actual functionality of the current iShake system at first sight, as some were expecting to be able to receive right away also detailed earthquake forecasts.

### 5.2 Pilot Testing

Pilot testing confirmed that the iShake system was able to successfully record and deliver acceleration readings, i.e. shake events generated by the users, from the iShake clients to the server, at which point the received measurement data was automatically processed and plotted for instant visualization on users' phones.

In addition, pilot test participants provided detailed comments and feedback from engineering-minded and user-minded backgrounds. They made very useful suggestions related for example to restructuring the application navigation and further clarifying the graph and data presentation. Based on achieved feedback, some modifications were made to the iShake system accordingly before proceeding to actual field trial phase, and also some ideas for iShake's development were reserved to be explored further and possibly implemented in the future product.

### 5.3 Questionnaire

We received a total of 59 responses to the iShake questionnaire, and among them were those who participated in producing virtual shake events. The age distribution of the respondents was quite diversified; however, the majority (~58%) of the users were under 35 year old. 64% of the users were male, and 81% were native English speakers. Many of the respondents had a technological background, as around 20 out of 59 users were studying in some UC Berkeley Engineering, Computer Science, or similar study program.

78% of respondents had some experience of earthquakes. On a scale of 1 to 5 (where 1=not scared at all and 5=very scared), the respondents reported that they were only moderately scared of earthquakes (avg. 2.79, sd. 1.01). In general, users rated themselves as intermediate experienced iPhone application users (avg. 3.40, sd. 0.95), where the scale was from 1 to 5 (1=no experience and 5=expert).

Unless stated otherwise, a six-point Likert scale [23] ranging from 1 (strongly disagree) to 6 (strongly agree) was used to measure the questionnaire variables discussed in the following.

The respondents agreed that the iShake application is straightforward and easy to use (avg. 4.61, sd. 1.14), and that they liked the iShake user interface (avg. 4.50, sd. 1.07). In addition,

the majority reported that they considered iShake as very exciting and important mobile application (avg. 5.02, sd. 1.03), and thought the information and instructions provided on iShake on earthquake preparedness were useful (avg. 4.81, sd. 1.14) and interesting (avg. 5.07, sd. 1.04). Respondents agreed that in the event of future earthquakes, receiving similar kind of information as provided on the "iShake Map" would be valuable (avg. 5.28, sd. 0.77), and considered the received earthquake information also fascinating (avg. 5.02, sd. 1.05).

The users to some extent thought that iShake would give them a better feeling of safety in the event of an earthquake (avg. 4.10, sd. 1.39). In addition, they highly valued the possibility of being able to receive critical information about future earthquakes on their mobile phone (avg. 5.36, sd. 0.92). In the event of an earthquake, users would like iShake to provide them information on their family's and friends' whereabouts (avg. 5.07, sd. 1.16). Users reported not being especially eager to share their own experiences and emotions after an earthquake with other iShake users via the application (avg. 3.84, sd. 1.44), but they were a slightly more interested in reading other iShake users' messages and experiences about earthquakes (avg. 4.03, sd. 1.38).

Users experienced the possibility of having iShake earthquake notifications personalized according to their location as very important (avg. 5.14, sd. 0.77), as well as stated that they would like to have the notifications personalized based on their individual preferences and needs (avg. 4.92, sd. 0.83). Users reported that they were going to take iShake into the long-term use (avg. 4.93, sd. 0.94), and believed that they would use iShake in the event of future earthquakes (avg. 5.05, sd. 1.00).

Users were also provided a free-word for iShake's future development, and they most of all expressed a need for earthquake forecasting and early warning system in order to help them to be safe from the future disasters.

### 5.4 Brainstorming

Three iShake test users participated to the brainstorming session, in addition to two project team members. None of the participants had previous experience of serious earthquakes, and according to participants' own estimation they were not particularly concerned with earthquakes.

In general, users preferred getting the information and instructions in the form of text and pictures instead of videos, as they experienced that videos are not so user-friendly and socially accepted since they could easily disturb other people. This has also come out in other user studies conducted earlier [e.g., 16] where users have expressed preference to other media formats over video in order to avoid embarrassing and socially disturbing situations caused by the loudness of the suddenly appearing sound. Regarding the earthquake data, graphs and illustrative and informative visualizations were preferred over text.

In Table 1 are introduced the themes that came most evident on the future iShake usage scenarios envisioned during the brainstorming session. Among the participants, these were considered the ways in which iShake has potential to create most value for its users and emergency responders.

**Table 1. iShake value themes**

<b>Value theme</b>	<b>Description</b>
<b>Education of the public</b>	Earthquake preparedness: knowledge on how to adequately prepare oneself for an earthquake
	List of essentials to keep in hand, i.e. how to prepare survival kit
<b>Easily accessible earthquake information</b>	Earthquake alerts on a device that is always at hand
	All the useful information in one place
	Available anytime and anywhere
<b>Safety instructions immediately after the earthquake</b>	Dos and don'ts, where to go, what areas to avoid, nearest safe places
	If in a car, how to get safe: fastest route to safe, risk factors along the route
<b>Emergency service information</b>	Hotline emergency number Shelter locations Missing persons' wall
<b>Forecast and forewarn of aftershocks</b>	After the first shake know to move to safer areas in time
<b>Help search and rescue</b>	If trapped below debris, press an 'emergency' button and send signal with GPS data
	Know high population density areas, and guide the first response accordingly
<b>Ease the concern of close ones' well-being, and vice versa</b>	Share location data within the pre-specified group of people
	Know close ones' whereabouts at the moment of earthquake, and damage level on that area
	Switch the map view based on different significant locations, e.g. own and parents' home
<b>Recovery after the disaster</b>	Connect with people affected by the same earthquake
	See other users' videos and photos on "iShake board"
<b>Contribution of the nodes in the iShake network</b>	How many users using the app at the moment
	How many users contributed on this particular region
	Compare own contribution with others
	Ranking system and competition between users
<b>Value creation for first response and other users</b>	"How am I using iShake and how I helped someone"
	Know that your data actually accomplished something
	Source of motivation and commitment

Brainstorming findings also revealed that if the users would get sufficient benefit from the system, they were respectively ready to provide some personal information for the application. This finding is also supported by Chellappa and Sin [6] who state that the consumers' value for personalization is almost two times more influential than the consumers' concern for privacy in determining usage of personalized services. But in exchange, the user would need to know where their data is used and why, and what would they get in return [21]. As a consequence, the user would then be able to make own educated judgments. In addition, the iShake users reported being willing to share their GPS data with the system, so the application could then keep track of user's location and update it automatically. Based on a combination of user manually provided and system automatically retrieved data, the system would be able to direct the user with the most relevant and valuable earthquake notifications and safety instructions.

## 6. DISCUSSION AND CONCLUSIONS

During this first phase of the iShake project, the objective was to create a prototype system on the UC Berkeley campus, which serves as a case study and proof of concept towards scaling the system up in the future. The eventual application of iShake would provide several benefits to the public and emergency responders and would help reduce losses from earthquakes in the U.S. and other countries. In September 2011, the iShake user base had increased to encompass around 1,900 users around the world.

The goal of this work was to create a system that moves beyond "DYFI" and USGS ShakeMaps by taking advantage of the accelerometers most people already have in their cell phones, so that a more accurate portrayal of the damage effects of an earthquake may be provided to government officials, emergency responders, and the public immediately after an event. The aim of this research was to expand the number of users beyond the largest number of sensors in a given seismic sensor array today. We believe that by using participatory sensing, the technology has the potential of providing real-time earthquake data at a significantly lower cost than dedicated infrastructure. Furthermore, the increased resolution will allow emergency responders to focus efforts at a more local (neighborhood) level. Due to the automated nature of the iShake system, the response time for post-earthquake rescue efforts could be reduced.

The results gained from the shaking table tests proved that iPhones (and soon other cellular phones and personal computers that contain accelerometers) can measure reliably the shaking produced by an earthquake. In addition, field trial procedures confirmed that the iShake system is able to reliably record and deliver acceleration readings from the clients to the server, at which point the received measurement data are automatically processed and disseminated. Through the field trial and related user studies we also gained great insights into iShake's future development and improvement. The user studies provided insight into: how to provide the desired earthquake-related information to the users in a meaningful way; how to effectively motivate and commit the users to take the iShake application in a long-term and active use as well as utilize iShake during emergencies.

Our findings revealed that users place most value on the possibility to receive critical earthquake information on a device that is always at hand. Users also expressed a need for information of their close ones' whereabouts and well-being after an earthquake. Hence, the users recognized that iShake has great

potential to help ease the concern of other people's safety. In addition, users hoped to receive the most relevant earthquake information and notifications that are personalized according to their location and personal preferences and needs. When delivering earthquake data to users, other media formats should be used instead of video with sound, which is also supported by previous research [16]. Furthermore, graphs and illustrative data visualizations were preferred over text by the iShake users.

Akason et al. [2] have suggested that the first active mitigating action observed after an earthquake is the victims' own efforts to seek relief from each other. The most effective type of mutual seeking for emotional relief is to start talking about feelings and sharing own experience with others who have been through the same kind of ordeal [2]. However, this finding wasn't supported in our user studies, as the iShake users did not place much emphasis on this form of recovery from the earthquake-induced trauma. Instead, they expressed their somewhat indifferent point of view on sharing their experiences and communicating with other users through this application.

The surveys also pointed out that users would need incentives to turn on the application and leave it on at night or at other times when charging the phone. For engaging the user to voluntarily download and regularly turn on the iShake application, a kind of competition between users could be created. Users could also be given tangible feedback on how their phone's data was used to provide information and help other people during crises. Thus, value creation for other users and first response may be seen as a great source of motivation and commitment for active use of the system.

In his research, Loewenberg [24] discovered that after each earthquake, rumors and fears of upcoming aftershocks turn up immediately. Our findings revealed that users place emphasis on the value of an early warning system. Thus, the future iShake should be able to send up to minute warnings to users' phones that an earthquake is going to hit. We envision this feature to be available in the future of the iShake project. However, one needs to remember that earthquake early warning is not earthquake prediction. In fact, earthquake prediction is not something that most earth scientists think will be possible in the foreseeable future [3,15,19]. Rather, earthquake early warning involves rapid detection of the beginnings of an earthquake, assessment of the likely shaking, and then sending subsequent warnings to those in the zone likely affected [3].

## 7. LIMITATIONS AND FUTURE WORK

It can be assumed that since the iShake application downloading and utilization were purely based on volunteering, the field trial participant population was generally more aware of future earthquake risks, and also likely on a more affluent and technologically-savvy side. In addition, because the sample size was fairly small and cannot be seen to represent the general population, the user research findings cannot be reliably generalized to encompass the entire potential user population. However, our results serve as a valuable basis and provide important guidelines and information for the future development of iShake.

In the next phase of this project, additional shaking table tests will be conducted that will evaluate and address in more detail the detection of erroneous measurements when the phone is not in a stationary position (i.e., the response of falling and moving

phones). Additional work is required to make the phone and server software more robust, and research is underway to better understand the response of other types of smartphones such as Androids. In addition, the technology will be re-tested in a field operational test that will then lead to deployment through a recruiting campaign with the goal of reaching several thousands of cell phones (and therefore sensors) from as diversified user population as possible.

The provision of information to citizens regarding environmental hazards is a central feature of emergency planning and management. Thus, also special needs population (i.e., individuals characterized by social vulnerability) need to have equal opportunities to use the same services and get access to the same information as the large population. However, special needs populations are disproportionately affected during disasters and, because of their invisibility in communities, mostly ignored during recovery [9]. The social science community has identified as some of the major factors that influence social vulnerability to include, among others, age, gender, ethnicity, socioeconomic status, social capital, beliefs and customs, language barriers, and educational level [5,8,9,14,27,30].

It has been discovered that special needs population might be more likely to perceive hazards as risky; less likely to prepare for hazards or buy insurance; less likely to respond to warnings or take them seriously; more likely to die, suffer injuries, and have proportionately higher material losses; have more psychological trauma; face more obstacles during the phases of response, recovery, and reconstruction; likely not to receive, understand, or believe earthquake warnings [9,13,14,25,26]. From this point of view, it would be highly beneficial to also test and evaluate iShake with the special needs population when continuing to the next steps in the system development and planning its future use. It would be crucial to know how different user groups differ in relation to receiving, understanding, and treating the emergency earthquake information.

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# WAYFINDING AID FOR THE ELDERLY WITH MEMORY DISTURBANCES

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# WAYFINDING AID FOR THE ELDERLY WITH MEMORY DISTURBANCES

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## Abstract

*A global increase in aging population, combined with a growing number of people with dementia, creates new challenges to develop guiding technology for people with memory disturbances in their daily activities.*

*In this study we have tested the prototype of a wayfinding aid using predefined routes. The orientation advice was given through three modalities, visual, audio and tactile signals, two of which were used at a time.*

*Nine subjects, aged 59–90 years (with a median age of 84 years) participated in the user study at a rehabilitation unit in Pyhäjärvi, Finland. Their severity of dementia ranged between mild and severe, and walking abilities ranged from “frail to hobby skier”. In addition, two elderly persons were recruited as control subjects.*

*In most cases, the orientation with the wayfinding aid on predefined routes succeeded, with a few misinterpretations. The most common difficulties included: straying from the defined route, finding the right door, and the attractions of real-life context like other people. The severity of dementia didn't seem to predict success in orientation with the wayfinding aid. Using the landmarks wasn't as successful as using “left”, “right” and “go straight on” commands as the wayfinding advice.*

*Keywords: Wayfinding, Assistive technology, Elderly, Memory disturbances*



# 1 Introduction

Population is aging globally, with the percentage of those aged 60 and over expected to double between 2009 and 2050. Also, the older population itself is aging. Currently, the eldest group (persons aged 80 years or over) constitute 14% of the population aged 60 or over, and constitute one of the fastest growing segments of the population. It is expected that by 2050, 20% of the eldest population will be aged 80 or over. (OECD 2007; United Nations 2009) Over twenty-four million people have dementia today, and that number is expected to double every 20 years to 81.1 million by the year 2040 (Ferri et al. 2005).

Memory loss with disorientation is often the first symptom of dementia, and can be a frustrating and frightening experience (Brawley 1997). Getting lost is also a safety risk. In a five year longitudinal study by McShane et al. (1998), 40% of the subjects who were suffering dementia and lived at home with a caregiver got lost outside their home. The number could have been higher if their poor physical or cognitive ability didn't immobilize them or if they haven't been prevented from exiting by locking the doors.

The aging of the population, along with increasing numbers of people with memory disturbances, creates challenges to develop and design guiding technology that assist persons in their daily activities. New technologies should be suitable for domestic use since, according to our previous study, the elderly are willing to carry on their existing lifestyle (Sorri and Leinonen 2008). Another reason for developing assistive technology for domestic use is the weakened opportunity to get help from family members, because the proportion of the elderly living alone is increasing. In addition, the children of the elderly are also ageing. (United Nations 2009) Also, moves to unfamiliar environments such as nursing homes are associated with negative performance in orientation (Sheehan et al. 2006), along with the considerable costs of institutional care for both society and the patients and their families.

Successful independent living involves more than just the ability to carry out daily activities in the home. The ability to stay mobile, to get out and use local facilities and outdoor environment, to maintain social connectivity and enhance quality of life also contribute to successful independent living (Goodman et al. 2005; Sorri and Leinonen 2008). Wayfinding aids could also serve the purpose supporting the safety of the elderly, their long-term and temporary memory, and control of own life, which have been identified as other respected values of novel technologies (Sorri and Leinonen 2008).

The aim of this study was to raise these challenges by developing technology which would help the elderly with memory disturbances in wayfinding. The paper first presents the theoretical background, as well as the related research and motivation for this study. We continue by describing the research methods and practical implementation of the research. Finally, we introduce and analyze our findings and conclude with discussion and proposals for future research.

## 2 Related Research

### 2.1 Human-computer interaction and the elderly

The literature available on ageing and technology use is extensive and includes many studies conducted on computer use and training for the elderly (Bradley and Dunlop 2005; Czaja 1996). However, very little research has focused on what makes an interface usable for the elderly (Hawthorn 2000; Bradley and Dunlop 2005). Zajicek (2001; 2004) has investigated the burden and influence of traditional user interfaces among the elderly. Literature reviews done by Hawthorn (2000) and

Zaphiris et al. (2005) have suggested that the physical and cognitive burden on the elderly should be taken into account when designing a user interface for the elderly. However, there is still lack of the research that includes subjects from the most elderly age group and those with memory disturbances.

Developing a wayfinding system raises many human-computer interaction (HCI) research issues with multi-modal interfaces, for example small displays and adaptive user interfaces. The characteristics of the small display devices and the cognitive, sensory, and motor skill characteristics of the elderly imply that traditional user interfaces relying on icons and textual labels are inappropriate for the elderly to use for effective communication. Oviatt and Cohen (2000), and Beeharee and Steed (2006), argue that there is also a need to develop novel interaction interfaces based on audio and speech modalities. Oviatt (2000) recommends that an adaptive user interface be designed; in other words, an interface that changes over time to better support repeated tasks and particular behavioral characteristics of the individual user. Jorge (2001) considers that another important HCI research challenge is how to provide context sensitive assistance to help mobile but cognitively impaired users. There are few studies focused on user performance of multimodal feedback with the oldest old and the elderly with memory disturbances. For example, Burke et al. (2006) performed a meta-analysis of 43 different studies, and none of the studies included research subjects from these pathological populations. In addition, Goodman (2005) notes that current navigation device designs do not usually consider the needs of the elderly. Mobile devices often have small displays and complicated menu structures. Goodman also notes, it is important that navigation systems for the elderly place minimal cognitive demands on the user to avoid causing distraction and confusion.

## **2.2 Wayfinding with dementia**

People with dementia tend to fail in planned wayfinding. According to Passini et al. (1998) one reason for this is that Alzheimer patients have problems creating an overall plan for wayfinding. They have far better performance in simple wayfinding sub-plans like reaching an entrance. Monacelli et al. (2003) and Brawley (1997) note that spatial disorientation is frequently observed with individuals aged 70 and over who show no other sign of mental deterioration. McShane et al. (1998) argue that wandering away from home is a common symptom of memory disturbances, and may be a reason for institutionalization. For elderly people with dementia it is common that they cannot position themselves accurately (Brawley 1997), and they have difficulties in finding and retracing their steps to return back home (McShane 1998; Passini et al. 1998). Unfamiliar environments have been found to be especially challenging to the elderly with memory disturbances (Kulyukin et al. 2008; Brawley 1997).

A study by Liu et al. (1991) argues that memory and visuospatial deficits influence the wayfinding problems for elderly people with memory disturbances, which may pose frustration among the elderly (Brawley 1997). According to Sheehan et al. (2006), designs of outdoor environments that encourage safe navigation for elderly people with memory disturbances may have direct benefits on quality of life, and indirect benefits in terms of reduced institutionalization.

Brawley (1997) and Passini et al. (1998; 2000) both state that elderly individuals with memory disturbances are able to understand signs. The signs should be kept simple, because numbers are easily forgotten and colour codes or abbreviations or pictograms don't work. (Passini et al. 1998; Passini et al. 2000). Passini et al. (1998; 2000) also say that Alzheimer patients' difficulties with understanding signage originates from problems in distinguishing relevant information from irrelevant, and making nonsense links between closely situated messages. Landmarks are particularly useful in wayfinding for the elderly (Goodman et al. 2004; 2005). Findings from the study by Sheehan et al. (2006) reveals that subjects with dementia and the control subjects were able identify close and distant landmarks equally,

and the demented used them consciously in wayfinding. Distinctive landmarks are useful in wayfinding even in subjects with moderate dementia (Brawley 1997).

## **2.3 Previous studies of wayfinding aids**

There have already been some efforts in developing technological solutions to help the elderly and people with various functional impairments in wayfinding. For example, Strothotte et al. (1995) developed the MoBIC travel aid to increase the independent mobility of blind and elderly travellers by providing useful information for the user. The MoBIC consists of two interrelated components: the MoBIC Pre-Journey System to assist users in planning journeys, and the MoBIC Outdoor System to execute these plans by providing users with orientation and navigation assistance during journeys. Helal et al. (2001) designed a wireless pedestrian navigation system for blind individuals. This system integrates several technologies including wearable computers, voice recognition and synthesis, wireless networks, Geographic Information System and Global Positioning System. The system augments contextual information to the visually impaired and computes optimized routes based on user preferences, temporal constraints (e.g. traffic congestion), and dynamic obstacles (e.g. ongoing construction work). Environmental conditions and landmark information queried from a spatial database along the user's route are provided instantaneously through detailed explanatory voice cues. The system also provides capability for the user to add intelligence, as perceived by the blind user, to the central server hosting the spatial database.

Goodman et al. (2004) describe the design of a pedestrian navigation aid for a handheld computer, which guides the user along a route using photographs of landmarks, together with audio and text instructions that reference these landmarks. This aid was designed with older users in mind who often find their mobility hampered by declines in sensory, cognitive and motor abilities. Also, Veldkamp et al. (2008) have created a pedestrian navigation system for the elderly with beginning dementia. The system consists of a palmtop computer (PDA) that sends audio information via Bluetooth. Chang et al. (2007) have presented a wayfinding prototype system with deviation recovery for individuals with cognitive impairments. This system is based on geo-coded tags, PDAs and a tracking system. The PDA displays the photographic just-in-time directions and instructions to the user on a web browser.

Heuten et al. (2008) have developed a non-visual support called the Tactile Wayfinder that utilizes the sense of touch by guiding a mobile user en route with the help of a tactile display. It was proven that their normal subjects were able to perceive stimulation changes quickly and accurately, and could feel where they occurred. A spatial tactile display worn as a belt conveys the necessary information non-visually, non-intrusively, and hands-free.

iWalker is a multi-sensor, walker-mounted wayfinding system for the elderly with cognitive and visual impairments designed by Kulyukin et al. (2008). It is designed to operate in a physical space equipped with embedded sensors. The sensor suite of the iWalker device consists of an encoder, a digital compass, two radio-frequency (RFID) readers, and two RFID antennas attached to the rear wheels. All the sensors communicate with a laptop mounted on the walkers's seat.

## **3 Research Methods and Implementation**

### **3.1 Methods and study setting**

The aim of this research was to develop a prototype of a technological solution to help the elderly with memory disturbances with wayfinding. The focus of this study is on wayfinding, and preventing wandering away from home is out of scope for this study. The target user group of the appliance is the

elderly still living at home. To develop the system to suit the individuals with possibly declined cognitive abilities, a decision was made to test the system with subjects who already have memory disturbances.

This user study serves as a basis and proof-of-concept for the next phases of our research. In this first phase of the research the objective was to test and evaluate a prototype for wayfinding, and gain valuable experiences and input for future research. User-centred methods were used to understand the needs, expectations and usability requirements of the target group (Abrams et al. 2004; Beharee 2006). The user-centred design teams benefited from an extensive literature review, previous study (Sorri and Leinonen 2008), and brainstorming sessions with the multidisciplinary research team, which included experts from the areas of information systems, architecture, geriatrics and medical technology. For evaluating the developed technological wayfinding aid “Wizard of Oz” method was used, in which technology being refined is simulated to appear as a coherent entity for the user (Veldkamp et al. 2008). In the early phase of the design process subjects were carrying out selected tasks of wayfinding in real-life contexts. Abowd et al. (2002) pointed out that controlled studies in usability laboratories cannot lead to deep, empirical evaluation results. What is needed is real use in an authentic setting. Problems were expected with information acquisition from the subjects, as there are only some previous experiences of data gathering with the oldest old (Schwartz et al. 1998; Suzman et al. 1992). Also, memory disturbances may present their own challenges. The subjects tend to forget recent events and questions presented in the interview, and they may also have abstract thinking and verbal ability impairments (Edwards 1993).

The wayfinding advising technology was tested on predefined routes. The routes were built in common areas of the Karpalokoti dementia rehabilitation unit and its’ near surroundings in Pyhäjärvi, Finland. In order to create the study setting to resemble the wayfinding obstacles the subjects are likely to face in their daily lives, wayfinding tests were performed both indoors and outdoors and in the same environment in which regular activities were happening in the rehabilitation unit and surrounding areas. To test if the subjects were following the navigational aids provided by the system, some parts of the routes were designed to purposely increase the chance of leaving the correct track. For example, the architecture did not always support the guided track, and there attractions were incorporated such as other people or pleasant views. The test consisted of three different indoor routes with stopping points between each one instead of having one long route; the purpose of this was to provide the subjects an optional resting spot between individual routes in consideration of the age and other functional impairments of the subjects. Activities were organized in intermediate stopping points that were planned to provide us more information on subjects’ eye-hand coordination, discernment ability and readiness to participate in this study.

### **3.2 Wayfinding aid and tested components of orientation**

Wayfinding advice was given through three modalities, namely visual, audio and tactile signals, of which two were used at time. The wayfinding aids described in section 2.3 incorporated only one modality except the aid designed by Goodman et al. (2004), which utilized two different modalities. Nevertheless, there was no comparison of modalities. According to Burke et al. (2006) an additional modality to visual feedback improves overall performance, since an additional modality captures user’s attention more quickly than visual alone and thereby improves performance scores and reduces reaction times with little to no impact on error rates. According to Lemmelä et al. (2008) the aural, visual, physical and cognitive loads of walking in a public place are equal, therefore without testing a different set of modalities, prediction of which modality would be the most successful and optimal one is impossible. The combinations of modalities in this study were chosen according to the Reeves et al. (2004) and Obrenovic et al. (2007) recommendation of taking into account subject’s preferences and

their capacity of senses. In order to ensure better understanding among the research subjects, the wayfinding advice was kept as intelligible as possible.

Presbyopia is the normal worsening of vision with age, especially near-sighted vision, and it affects everyone (Mordi and Ciuffreda 1998). In addition, extreme sensitivity to glare, reduced contrast sensitivity and restricted color recognition are age-related. Ability to comprehend written text starts to decline with moderate dementia, but single words can still be effective in orientation (Brawley 1997). In addition to different degrees of vision impairment, approximately two thirds of people 75 years and over have at least mild hearing impairment. Typical features of presbycusis are declined capacity to separate high frequencies, recruitment (silent sounds are inaudible, intense sounds soar), and word recognition is low compared to hearing decline (Sorri and Huttunen 2003). In addition, reduced sensitivity to touch is found to be age-associated (Brawley, 1997).

Previous studies also lack sufficient testing and evaluation on what type of wayfinding cue in a given modality (e.g. text vs. photograph vs. arrow on visual signal) are the most appropriate and effective for the elderly with memory disturbances. Thus, in addition to investigating the most optimal combination of modalities, this study also focused on exploring the usability of different types of wayfinding cues.

The visual signal used in this wayfinding system included text with a picture. This study used both the text and the picture since they support the meaning of each other. The pictures used were direction arrows on top of a blank background or on top of a photograph taken from the subject's current position (see Fig. 1). Photographs of landmarks were also utilized. The color of a direction arrow was yellow, since that color is most easily identified by the elderly and Alzheimer patients (Wijk et al. 2002). To assure good contrast, the text consisted of black block letters on a white background. Maps are the traditionally used to display geographical data, but were not used in this study due to the increasing complexity and because some people with memory disturbances have severe difficulties in understanding maps. Additionally, in a study by Goodman et al. (2004), the subjects preferred pictures of landmarks to map view.


<p>Visual signal:</p> 	<p>Audio signal:</p> <p>Käännä vasemmalle (in English: Turn left)</p>
	<p>Tactile signal:</p> <p>Left wristband vibrates</p>

Figure 1. Wayfinding advice in three modalities.

The audio signal used was a natural voice to prevent anxiety in the subjects, since synthesized speech is highly intelligible but rarely natural (Howard et al. 2009). Smither (1992; 1993) discovered poorer performance in older adults with remembering and understanding computer generated speech, and attributed this to short-term memory demands. A low female voice was used in the implementation because the subjects were presumed to have declined capacity to separate high frequencies (Sorri and Huttunen 2003). The advice given by audio signal was simple and very similar to the correspondent visual signal (see Fig. 1).

The tactile signal used was vibrating wristbands, the purpose of which was to support turning left and right (see Fig. 1).

The tested components of orientating included: starting out on the routes, keeping on the correct track, recognizing landmarks, being guided back to the correct track, and recognizing the destination.

### **3.3 Study equipment and data collection**

The transmitting visual signal a walker-mounted 10.1 inch screen with internet connection was used. Audio signal was transmitted via mobile phone and Bluetooth wireless headset which covered one ear only to allow the subject to hear the sounds of surroundings and to be able to communicate with other people. Tactile signal was transmitted via vibrating wristbands that communicated through shortwave radio. There was a recall button mounted to the walker for use if the subject wanted the advice repeated. For locating the subjects, walker-mounted cameras, surveillance cameras at the rehabilitation unit, and shortwave radio were used.

The test events data was collected by videotaping, audio recording, recording the walker-mounted cameras, participatory observation and taking notes, and interviewing the subjects. For data analysis the videotapes, audio recordings, and researchers' notes were transcribed, and time stamps were added for every single event occurring during the wayfinding routes. The data analysis was done in collaboration with a multidisciplinary research team.

## **4 Research Subjects**

The study was conducted during 2009-2010 at the Karpalokoti dementia rehabilitation unit in Pyhäjärvi, Finland. Three, two-day test events were conducted; the first one in December 2009, the second in January 2010 and the third in June 2010. Nine subjects, consisting of five females and four males between the ages of 59 and 90 (median age of 84 years) participated in this study (see Table 1). Some subjects participated in more than one test event, and the total number of test rounds was seventeen, comprising of twelve indoor test rounds and five outdoor test rounds. The severity of dementia of the subjects was between mild and severe, Mini-Mental State Examination (MMSE) scores (Folstein et al. 1975) were between 3 and 23 (average 12) and walking condition ranged "from frail to hobby skier". The frail subjects participated only in indoor wayfinding test rounds. There was no remarkable difference in MMSE scores of the subjects participating in indoor or outdoor routes. The subjects were customers or permanent residents of the dementia rehabilitation unit. The subjects in this study were significantly older and their MMSE scores lower than in studies mentioned in section 2.3. The controls were two males, aged 72 and 82 years, who lived in a senior house nearby. The subjects and/or their relatives had given their informed consent for the study participation.

## **5 User Study Findings**

In analyzing the data researchers' on-site observations and notes were heavily relied on. Interviewing did not prove to be a successful method for acquisition of information from the subjects as the subjects had more severe memory disturbances than in previously discussed studies. During the wayfinding test events the subjects occasionally times got help from the nurses without asking, even though nurses were requested to abstain from helping the subject along wayfinding routes in any way. Aforementioned aid appeared as very discreet, i.e. at some decision points a nurse might have secretly steered the subject in the correct direction. Therefore, performance of some subjects was possibly enhanced due to this outside help.

The majority of the subjects succeeded in wayfinding with a few misinterpretations. The subjects performed surprisingly well in turning left and right at points where there were no strong outside attractions. Indoors, two out of twelve subjects continued straight on instead of turning, but no subjects turned in wrong direction. The subjects made 0-4 errors per an indoor route and 0-6 errors on the outdoor route, and the controls performed the route without any mistakes (see Table 1). Subject's severity of dementia or gender didn't seem to be a predicting factor for success in orientation with the wayfinding aid. The subject's physical condition and spryness during the test event seemed to be a bigger predicting factor for performing better. As was expected based on previous studies, the most common difficulties were straying from the predefined route (Sheehan et al. 2006), finding the right door among the similar ones on a double-faced corridor (Brawley 1997), and real-life attractions like other people or pleasant view. Straying from the defined route occurred at intersections of separate spaces. The strayed subjects were guided back to the defined route with wayfinding prompts. Another discovery was that guiding subjects back to the correct route could be further reinforced by addressing the subject using his or her name together with the corrective orientation advice. Finding the correct door on the route turned out to be the most complicated task, even though they were marked with 20\*20 cm red and green rectangles and used them as additional cues, i.e. as artificial landmarks. Another reason for signage being unsuccessful was some subjects paid attention only one side of the corridor.

Subject	Gender	MMSE	Modalities	Indoor 1	Indoor 2	Indoor 3	Outdoor route
1a	F	15	Audio + tactile	1	4	2	-
2a	F	23	Audio + tactile	1	3	0	-
3a	M	13	Audio + tactile	0	2	1	-
4a	M	16	Audio + tactile	0	0	0	-
5a	F	16	Audio + tactile	0	0	1	-
4b	M	13	Visual + tactile	0	2	0	-
2b	F	23	Visual + tactile	1	1	1	-
6a	M	3	Visual + audio	0	1	1	-
1b	F	15	Visual + tactile	0	0	1	-
7	F	11	Visual + audio	0	0	1	-
5b	F	16	Visual + tactile	0	-	-	-
1c	F	15	Visual + audio	-	-	-	2
2c	F	23	Visual + audio	-	-	-	5
3b	M	13	Visual + audio	-	-	-	6
6b	M	3	Audio + tactile	-	-	-	0
8	M	7	Audio + tactile	-	-	-	1 (short)
9	M	Control	Visual + audio	-	-	-	0
10	M	Control	Visual + tactile	-	-	-	0
11	F	10	Visual + audio	2	2	1	-

*Table 1. The number of wayfinding errors. Letters a, b and c indicate separate test events. Dashes indicate no participation. The subjects are listed in chronological order of the test events.*

The actual poor performance data of two subjects (5b and 11) is inaccurate in reporting the number of errors. Subject 5b was in weak physical and cognitive condition during the test event. She completed only the first indoor leg with extreme hesitation and lots of outside help preventing her from making wayfinding errors. Further, subject 5a's performance was far better in previous month's test event, which can be explained by the fact that performance of the pathological subjects can vary from day to day (Edwards 1993). The poor performance of the subject 11 can be explained by severe perceptual impairment. She needed substantial outside help in order to prevent her from injury. She was walking against the walls and she didn't recognize the edges of the paper when she was painting. When using

technology the impairment appeared as denial of touching the screen (she didn't recognize the edges of the screen) and experienced difficulties understanding visual wayfinding advice.

In general, using the landmarks didn't turn out to be as successful as "turn left/right" and "go straight on" as wayfinding advice. The landmarks were mostly tested outdoors since there were no distinct landmarks to utilize indoors. In indoor setup the previously mentioned bright colored rectangles on the doors were used as artificial landmarks. However, some subjects used pre-existing written signs on the doors instead of the rectangles, even though some rooms were named quite abstractly and the text size of the signs was quite small. Most likely, the subjects were used to using the existing signage rather than the new ones. Outdoors the landmarks were more natural and distinctive, like the first intermediate stopping point which was a table with violets and flowerpots. The table was well recognized. The other two landmarks, which were on first two test rounds (1c, 2c), were not so successful. They were a blooming apple tree and a green shed. The subjects didn't recognize an apple tree and they called the tree "rowan". The shed most likely didn't have strong enough contrast to the early summer green background. We changed the apple tree to an orange chair located under the tree and installed a red post-box on the wall of the shed. These two new landmarks proved to be more successful, and more easily recognized.

All used advice and wayfinding equipment proved to be usable. None of the pieces of the equipment caused false sense perceptions, such as the vibrating wristbands being mistaken tics. A majority of the subjects who were given visual advice followed them. The text was especially important to them and they were reading it aloud. The text cues and direction arrows were found to be complementing each other's meaning. The photographs behind the direction arrows didn't seem to bring much additional value, since the simple arrows on a blank background worked equally well. However, the photographs were useful in presenting the distinctive landmarks, and thus contributed to the success in wayfinding tasks. Audio signal was also well comprehended. Only one subject required an audio signal change from the phonetic form to a synonym to ensure better understanding. Comprehension of tactile signal was bit unclear, since the tactile signal was only used for turning points, and interviews didn't elicit additional information about subjects' subjective perceptions of tactile signals since, as stated before, interviews proved to be quite unsuccessful for use with the target group. Still, one subject was able to communicate that tactile signals indeed helped her to better distinguish between left and right. An accident that occurred during one test route gave us valuable information on the importance of constancy of the modalities. After the headset moved away from the ear and the subject stopped receiving the audio advice, her performance declined remarkably. The recall button mounted to the walker proved to be useless for the subjects. They didn't use it independently, but the use of recall button was prompted by external help (nurse or researcher). We assume that the subjects forgot or didn't internalize its purpose.

True performance in starting out on the routes and recognition of the destination point were hard to evaluate because of the study setting. At the starting point there were several researchers preparing the subject for the route, and the subjects also knew they were participating in a test event. Similarly, at the destination point there were already researchers waiting for the subject's arrival.

The correct timing of the wayfinding advice was found to be crucial but difficult because of the varying walking speed of the subjects. If the advice appeared too early the subjects could forget them or, alternatively, they complied with the advice literally and as a result in worst cases, turned against the wall. Confirming subjects were on the correct track turned out to be beneficial for longer legs of the routes. Confirmation is also recommended by Brawley (1997), even though she refers to static



advising. The need for confirmation appeared strongly with subjects who often sought help or support for their decisions from the nurses or researchers.

In cases of misinterpretation the subjects got “stuck” in repeating actions like revolving. The “sticking” is a common symptom of dementia (Brawley 1997). With some subjects the orientation as an ongoing task weakened during the test event. In this study, external distractions such as vehicles or, nurses passing by didn’t cause any errors in wayfinding. In some cases external distractions even interrupted sticking and/or restored the orientation to the ongoing task.

## **6 Conclusions**

The impact of the severity of dementia on performance in wayfinding is hard to evaluate because of the limited number of the subjects, and because only one subject had mild dementia and the others at least moderate. In addition, in some cases the external help from nurses affected the subjects’ performance. Nevertheless, we believe that the study findings serve as a proof of concept that the elderly with memory disturbances can benefit from wayfinding advising technology. In order to support the optimal and enjoyable multimodal interaction for wayfinding for the elderly, we have gained valuable insights into the most intuitive and effective combinations of the modalities for orientation advice, as well as an understanding of which features in indoor and outdoor environments are most effectively and reliably used in wayfinding by elderly people.

Our findings indicate that subject’s physical condition and spryness during wayfinding tasks appear to better predict succeeding in orientation with the wayfinding aid than the severity of dementia. The most common difficulties turned out to be the straying from the defined route, finding the right door, and the attractions of real-life context. Quite surprisingly, using landmarks didn’t prove to be as beneficial as “turn left/right” and “go straight on” as guiding advice. Precise and correct timing of giving advice was found to be crucial for subject’s performance, and the need for confirmation of being on the correct track appeared strongly with our subjects.

Wayfinding advising technology has the potential to provide important support for the elderly by motivating and empowering them to perform their daily activities, thus leading to more independent living. Solitary and isolation problems of the elderly can also be reduced, and quality of life as well as safety during daily activities can be improved. Furthermore, maintenance of the independence of the elderly contributes to reduced institutionalization.

In next phases of the research, exploration of different circumstances in real-world scenarios should be used to evaluate to what extent and complexity wayfinding aids can be used to aid the elderly in living independently and effectively. In addition, future research should focus on detecting undesired circumstances such as getting lost and sticking in repeating actions, while at the same time the explore options for allowing normal activities like stopping and browsing in a shop.

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Title	<b>Value in experience</b> <b>Design and evaluation framework based on case studies of novel mobile services</b>
Author(s)	Mari Ervasti
Abstract	<p>The concept of 'value' has received extensive interest in research in the fields of psychology, marketing and, more recently, human-computer interaction (HCI). Gaining insights into users' personal values can lead to a better understanding of user behaviour. However, the concept of value is not clearly defined, and researchers have produced differing views on the conceptualization of the construct. In the past decade, user experience has received considerable attention in HCI research. Yet the relationship between user experience and value has not gained much attention. The goal of this dissertation is to better understand and articulate the value in user experience. The focus is on novel mobile service solutions, taking into account the viewpoint of different user groups. Achieving an understanding of different user groups will greatly help design successful mobile services for target user populations.</p> <p>The empirical foundation for this dissertation is findings concerning user experience from seven individual case studies conducted in the field with the end-users. Interpretive case studies of novel mobile services in varying usage contexts involved different user groups: children, teenagers, college students and vision and memory - impaired older people. An initial value framework is developed as a synthesis from the literature. By utilizing this framework, the user experience findings obtained are re-examined from the point of view of value through a cross-case analysis and synthesis. Based on this analysis, value parameters from individual mobile service case studies are interpreted and categorized. The initial value framework is complemented by relying on the value parameters identified from the case studies.</p> <p>This work contributes to the field of HCI by showing that user experience and value are closely intertwined. The thesis proposes the concept of "value in experience (ViE)", which refers to the user's iterative (subconscious and conscious) interpretation and evaluation of user experience with a service. A value design and evaluation framework is presented and demonstrated by evaluating value in experience from the case studies. Also the designer values are analysed and compared with the value in experience. The framework presents a rich description of value dimensions relevant to specific user groups and mobile service domains in varying usage contexts. Furthermore, value in experience design and evaluation guidelines related to different user groups are proposed.</p> <p>The proposed conceptualization of value in experience offers insights to help understand the dimensions of value, and serves as a lens to guide interpretive analysis of value in experience. The complemented value design and evaluation framework is a tool for identifying and describing the key value dimensions for value in experience evaluation. Furthermore, the framework can support service design processes. The cross-case study findings provide insights into the special characteristics of different user groups and their value priorities in specific service domains. Even though the framework is based on mobile services, its main constructs are expected also to be applicable to other types of digital services.</p>
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## Value in experience

### Design and evaluation framework based on case studies of novel mobile services

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