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Preface

Copenhagen Business School, Department of IT Management is happy to host the *Eleventh Danish HCI Research Symposium* (DHRS2011). The symposium aims to stimulate Danish research in human-computer interaction and create an overview of current activities and opportunities for networking amongst researchers and reflective practitioners.

The papers in the following were prepared by the authors following a call-for-papers that included:

- Mobile, CSCW & distributed collaboration
- Electronic/hardware/sensorbased interaction sketching
- HCI and technical communication
- Regional and intercultural HCI
- HCI & management
- Usability & user experience Design
- Work studies and HCI
- Comparative informatics
- HCI and participatory design in different contexts
- Social Informatics

We would like to thank all the contributors for taking the time to contribute their work to the symposium. This year, we have received eighteen submissions for DHRS2011, representing work typical of Danish HCI research. The papers for DHRS2011 demonstrate the breadth of Danish HCI research. Spanning both technical work, prototyping, usability, research methods, ethnographic interventions, work and interaction design and conceptual work, we hope this collection of papers will be inspiring to both the Danish community of HCI researchers, reflective practitioners as well as others who are interested in the state of Danish HCI research.

The organizing committee for DHRS2011 is Torkil Clemmensen, Mads Bødker, Ather Nawaz ,Gitte Skou Petersen, Olav Bertelsen, Morten Hertzum and Ravi Vatrapu. Special thanks to Noam Tractinsky, Information Systems Engineering, Ben-Gurion University, Beer-Sheva for delivering the symposium keynote.

Mads Bødker, Ather Nawaz and Gitte Skou Petersen,
Copenhagen, November 2011

DHRS has existed since 2001. The previous symposia have been hosted by University of Aarhus (2001, 2006, 2009), University of Copenhagen (2002), Roskilde University (2003, 2010), Aalborg University (2004, 2008), Copenhagen Business School (2005), and IT University Copenhagen (2007). The proceedings from the previous symposia can be found online at the sigchi.dk website (www.sigchi.dk/sigchi/dhrs).

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Keynote

Noam Tractinsky

Information Systems Engineering, Ben-Gurion University, Israel

Noam Tractinsky is one of the first scholars to have studied the visual aesthetics of information technology. His work (with March Hassenzahl) on the concept of "user experience" is one of the most cited in the field. Noam's main research interests relate to human use of information technology. He has published in top-ranked journals and conferences in the fields of management of information systems (e.g. MISQ journal, ICIS conference) and human-computer interaction (e.g. HCI journal, CHI conference). He has been an Associate Editor of Behavior & information technology and is currently on the editorial board of the AIS transactions of HCI. Noam is an Associate Professor at the Department of Information Systems Engineering, Ben-Gurion University of the Negev, Beer Sheva, Israel.

Visual aesthetics in human-computer interaction: Justification and findings

Noam Tractinsky
Ben-Gurion University of the Negev

1. Introduction

Research on visual aesthetics in HCI has largely overlapped with changes in the information technology industry. Since the late 1990's, the industry has experienced a strong shift towards visual aesthetics. The increased interest in aesthetics among the industrial and academic communities reflects the maturation of the HCI field , the increased role of the user as a consumer, the increase in discretionary (as opposed to mandatory) use, and the overcoming of many of its growing pains as a discipline that struggled with unreliable technology on the one hand and with the need to satisfy users' basic requirements on the other hand. Additionally, broader societal processes emphasizing design and style emerged at about the same time (Postrel, 2002), further reinforcing shifts towards aesthetics of products in general (Bloch, 2011) and specifically of interactive systems (e.g., Tractinsky, 2006).

Several approaches to the study of aesthetics in HCI were identified by Udsen and Jørgensen (2005). The term "Visual aesthetics" correspond roughly to the approach which Udsen and Jørgensen identified as "Functionalist". It refers to the pleasing appearance of things (in our domain, interactive products). Researchers in this area usually adapt an interactionist approach (rather than the objectivist or subjectivst approaches). Such an approach accepts the existence of individual tastes and preferences on the one hand, as well as considerable agreement between individuals and experts on the other hand. The effects of visual aesthetics encompass both cognitive and emotional processes on various levels (e.g., Norman, 2004) and may range from instinctive-like reactions to contemplative and reflective evaluations. Finally, the field is characterized by work that is primarily empirical and descriptive (i.e., "what *is* considered beautiful") rather than normative (i.e., what *should* be considered "beautiful") (Hassenzahl, 2004).

2. A place for visual aesthetics in HCI

The case for the importance of visual aesthetics to the field of HCI can be made from various perspectives. Here I present three central perspectives – the design perspective, the psychological perspective, and the practical perspective.

2.1 The design perspective

Traditionally, aesthetics has been an integral, often dominant, part of any design discipline. This truism may have been abandoned by early HCI researchers and practitioners in lieu of more pressing needs. However, visual aesthetics has reemerged as an inseparate design feature of interactive technology with the enhancement of hardware and software capabilities, coupled with the permeation of information technology to every aspect of our lives.

One of the reasons for the neglect of (if not the objection to) visual aesthetics in HCI stemmed from a concern that attending to aesthetic aspects would come at the expense of other design aspects, especially usability (e.g., Norman, 1988). However, this objection has been mitigated both because the community has recognized the importance of criteria for good design other than usability (e.g., enjoyment, fun) and because empirical evidence show that at least in terms of perceived design attributes, aesthetics and usability can be viewed as positively correlated (Tractinsky et al., 2000; Lavie and Tractinsky, 2004). In addition, upon closer inspection of usability guidelines it becomes apparent that there is no inherent conflict between usability and aesthetic principles.

2.2 The psychological perspective

Research on visual aesthetic in HCI has much of its roots in the "positive psychology" movement (Seligman and Csikszentmihalyi, 2000). Basically, the idea is that aesthetic design has positive effect on emotional and cognitive processes (Norman, 2004; Leder et al., 2004), which, in turn, color people's reactions to interactive technology in a more positive tone (e.g., Thuring and Mahlke, 2007). From this perspective, there are three major aspects to visual aesthetics' contribution to HCI.

The first aspect deals with the fact that visual aesthetics serves basic human needs (Maslow, 1954; Dutton, 2009) and that it contributes to human pleasure and well being (e.g., Santayana, 1896; Postrel, 2002). Studies have shown that, like other products and environments, visually pleasing design enriches our experiences with interactive systems (Tractinsky, 2006; Hassenzahl, 2008) and increases our pleasure during the interactions (e.g., Thuring and Mahlke, 2007; Porat and Tractinsky, in press)

Modern information technology is highly flexible and malleable. Thus, both software and hardware elements of interactive products can be personalized to suit users' tastes. Such practices can be seen on a very large scale in the use of software skins and mobile devices covers, charms and other ornaments. Software skins are chosen mainly due to their aesthetic value (e.g., Tractinsky and Lavie, 2002). The personalization is in large part a manifestation of people's desires for self-expression, to be seen in specific ways by others (Hassenzahl, 2003) and as part of an ongoing process of identity formation in a social context.

Another aspect is that aesthetic impressions can be very fast. Reliable and consistent aesthetic judgments are formed with exposure of less than 500 milliseconds (Lindgaard et al., 2006; Tractinsky et al., 2006). These are likely to be our first judgments of the system and as such they contribute significantly to our attitudes towards it. The finding that "what is beautiful is (perceived to be) usable" (Tractinsky et al., 2000) can be explained to a large extent by this mechanism, which may be similar to the "what is beautiful is good" stereotype (Dion et al., 1973) that suggests that a person's physical appearance affects how others view the person's hidden qualities (e.g., personality traits).

2.3 The practical perspective

The commoditization of interactive technologies increases the importance of aesthetics as a differentiating factor between competing products. Relative to interactive technology in the early days of HCI, today's systems, products and applications are more oriented towards enhancing the user experience (UX); much of the commercial battle between producers of interactive systems involves attempts to catch the consumer's eye and heart with appearance and design-based value (Schmitt and Simonson, 1997).

In addition, information technology has made the traditional interlacing of technology and visual aesthetics even more pronounced. Postrel (2002) argues that information technology is particularly friendly to aesthetic applications. Its ability to handle aesthetic material – including copying, creating, manipulating, and communicating it – is revolutionary. It provides designers greater freedom to explore options in order to create more appealing products; it offers ordinary people tools to create and disseminate their own aesthetic work. Thus, we are witnessing an aesthetic cycle in which constant supply of visually aesthetic stimuli increases people's aesthetic sensitivity, which in turn increases demand for aesthetics (Postrel, 2002).

3. Research Findings

We can examine research on visual aesthetics in HCI in terms of three main categories of the aesthetic process: (1) Antecedents of the aesthetic evaluation, that is, what make people engage in aesthetic evaluations, and perhaps more importantly, what cause variations in aesthetic evaluations; (2) The aesthetic evaluation itself and the psychological processes that are involved in it; and (3) outcomes or consequences of aesthetic evaluations. In addition we should look at moderating variables, or intervening factors that influence that process.

3.1 Antecedents of visual aesthetics

Research under this category has mainly examined two questions: What make a system look beautiful, and what dimensions or categories of aesthetic designs do people perceive. Studies dealing with the first question have dealt with a broad range of visual design attributes. Such attributes can range from a relatively low level (e.g., Kim et al, 2003) to broad principles (e.g., Hekkert et al., 2003). Studies have also tried to identify formal, objective attributes that affect aesthetic judgment (e.g., Bauerly and Liu, 2006; Datta et al., 2008), although such attempts have been criticized for not allowing for individual, cultural and contextual difference (e.g., Kripendorff, 2006). In response to the second question, researchers have tried to identify general perceived aesthetic sub-dimensions (e.g., Park et al., 2004; Lavie and Tractinsky, 2004; Moshagen and Thielsch, 2010).

3.2 Evaluation of visual aesthetics

Research under this category is quite basic and usually falls outside the realm of HCI. However, some high-level models of HCI-related aesthetic processing were proposed (e.g., Thuring and Mahlke, 2007; Lindgaard et al., 2011).

3.3 Outcome of aesthetic design

A significant share of HCI research on visual aesthetics falls under this category, perhaps because it deals with the most significant and relevant issue for the HCI community: What are the effects of visual aesthetics on HCI-related variables? Studies have shown that visual aesthetics may influence users' perceptions of a range of other system qualities, such as usability (Kurosu and Kashimura, 1995), overall satisfaction (Lindgaard and Dudek, 2003), preferences (Schmidt et al., 2009), and trustworthiness (Kim and Moon, 1998). In addition, visual aesthetics may positively affect emotions and even performance (Sonderegger and Sauer, 2010). Not least, visual aesthetics is considered an important antecedent of the user experience in general (Hassenzahl and Tractinsky, 2006). As such, it joins other system qualities such as usability, functionality, responsiveness and so on, as sources that interact with the user and the use context to influence the UX (Roto et al., 2011).

3.4 Moderating variables

It is unlikely that the complex and context-dependent nature of HCI design would allow deterministic relationships between visual aesthetics and the various outcome variables described above. Indeed, some studies have not found such relationships (e.g., Hassenzahl and Monk, 2010). Thus, exploring the contingencies which may affect those relationships should be an important and fruitful research area. The challenge would be to identify those contingencies and potential effects. Elsewhere (Tractinsky, 2006) I have suggested a partial list of potential moderators, such as the type of system used, the use context, individual and cultural differences, and so on.

4. Summary

The growing interest of the HCI community in the study of visual aesthetics has corresponded to technological, societal and commercial developments during the last decade. Research in this area has provided many interesting insights. In this article I briefly reviewed some of these findings, but it is clear that research thus far has also opened up additional issues, research questions and challenges that may occupy us for a long time.

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Metaphors as a design tool

A qualitative study in the use of abstract and literal metaphors

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ABSTRACT

There are interesting issues in the research of metaphors, when metaphors are used in user interfaces. A discussion concerns whether designers should use metaphors with little in common with the conceptual system the metaphors are intended to represent, or if designers should use metaphors, that are closely related to the conceptual system the metaphors are trying to explain.

To shed light on what kind of metaphors are the most favourable to use in user interfaces, we conducted an experiment with an abstract metaphor and a literal metaphor in user interfaces, to find out how and why the users interact with the metaphors the way they do.

The hypotheses were tested by using two mock-ups of coffee machines. The result was that some of the test subjects followed their mental model created on the basis of the abstract metaphor, even when this differed from the conceptual system. Additionally, test subjects, that were in full control of the conceptual system, used elements from the literal metaphor.

Categories and Subject Descriptors

H.1.2 [**User/Machine Systems**]: Human factors; H.1.2 [**User/Machine Systems**]: Software psychology; H.5.2 [**User Interfaces**]: Graphical user interfaces (GUI)

General Terms

Human factors, Experimentation, HCI

Keywords

Design, Metaphor, Literal, Abstract, User Interface

1. INTRODUCTION

Products like cellular phones, MP3 players, computers, control panels, domestic appliances etc. provides the user with an user interface or a graphic user interface, which has to be operated in order to get the product functional. How to operate a certain function of a device, by the graphic user interface, might be unknown to the user, and thereby lead to poor usability. By using metaphors in graphic user interfaces, you can enrich the usability.

The purpose of metaphors is to bring something the user is familiar with to the interface. A metaphor can e.g. provide a structure that is similar in some way to aspects of a familiar entity but with it's own behaviours and properties [7].

In 1980 Lakoff and Johnson [3] published their work about metaphors and their analysis is widely known and used today. They explain that:
The essence of metaphor is understanding and experiencing one kind of thing in terms of another [3].

So, a metaphor is the concept of understanding one thing in terms of another. Lakoff and Johnson further elaborates this by saying:
the primary function of a metaphor is to provide a partial understanding of one kind of experience in terms of another kind of experience. This may involve pre-existing isolated similarities, the creation of new similarities, and more [3].

So, a metaphor only gives a partial understanding of a term. When metaphors are used in computer user interface one definition is according to Alan, F. Blackwell [1]:

a representation created to help the user understand the abstract operation and capabilities of the computer. These abstract capabilities are therefore presented as though they were something else that the user might already understand [1].

The definition of a metaphor that will be used in this article, and are based on the above-mentioned references, will be:
A metaphor is a part or parts taken from one concept to partially represent another concept.

The use of metaphors in an user interface help explaining to the user, what he is doing or trying to do, in terms that are familiar to him. In order to achieve this, the metaphor's properties must have some resemblance to the properties of the conceptual system[1]. If the properties of the metaphor is closely related to the properties of the concept, the metaphor helps the user understand the properties of the conceptual system. If the properties of the metaphor and the properties of the conceptual system differ, the metaphor can cause the user to create a wrong mental model [5].

[1]The conceptual system will be used to describe the concept on which we use the metaphor. This is also known as the target domain or the topic of the metaphor.

According to Donald A. Norman [4] a mental model is a model the user creates of how a concept of a system works. If the user has a good conceptual understanding of a system, the user will create a good mental model which allows the users to feel that they are in control. [5]. If a user does not have a prior conceptual understanding of a specific system then it can be beneficial for the user if the user interface contains a metaphor, to give the user the initial familiarity with the system.

The use of metaphors in graphic user interfaces have been discussed in textbooks and by researches whether it is beneficial or not to implement [1]. According to Norman metaphors should be avoided, because it is guaranteed to get in the user's way [5]. A metaphor can be appropriate in the temporary initial stages of learning a new device, but the metaphor is not temporary. Norman advise the designer not to use metaphors, but instead make a clear and understandable model of the system, so the user creates an adequate mental model [5].

Research done by Blackwell [1] supports Norman's statement about the benefits from using metaphor in the initial stages of leaning a new system. Blackwell focus on the problems that might occur when the properties of the metaphor and the properties of the conceptual system differ, if the user tries to compare their mental model with the conceptual system. Blackwell stress that an abstract metaphor is beneficial to use, because the user in this way does not have any basis for comparing the mental model with the conceptual system [1].

According to Lakoff and Johnson everything we know can only be understood in therms of metaphors. If this is true, then it is not possible to create a model without using metaphors [3]. The only thing you can do is to use a metaphor that have a lot in common with the conceptual system - in this article such a metaphor will be referred to as a literal metaphor.

The differentiation between an abstract metaphor and a literal metaphor can be understood in terms of Peirces sign theory[6], if we see the metaphor as a sign or a representamen and the conceptual system as the object, then the number of interpretations pointing from the sign to the object will decide the abstractness of the metaphor. An abstract metaphor will have only a few or no interpretants pointing to the object and the literal metaphor will have a lot of interpretants pointing to the object [6].

2. METHOD

There are certain controversies about whether a user will interact with the user interface according to the mental model even if any contradictions between the mental model and the conceptual system is present. We have no knowledge about any studies arising this question, and we therefore conduct an experiment to investigate this question. The hypothesis that will help us gain the knowledge is:

Hypothesis 1: *When having a metaphor in a user interface design to a conceptual system, the user will interact with the user interface as if it was the mental model, which has been created on the basis of the metaphor, even when the metaphor deviates from the conceptual system.*

Another interesting matter is if there are any differences between a user that has no knowledge about a specific conceptual system, and an user that is in control of the specific conceptual system. A user is in control when the user knows what to do, when to do it and what to expect. Will the two types of users perform differently if they are interacting with an user interface, which either has an abstract metaphor or a literal metaphor?

Hypothesis 2: *If a user is in control of a specific conceptual system, then the user will benefit from the elements incorporated in a design with a literal metaphor.*

In order to confirm the hypotheses, we conducted an experiment. The test subjects performed a number of task regarding an interaction with a user interface designed with an abstract metaphor, and a user interface designed with a literal metaphor. Afterwards, an interview was conducted in order to obtain qualitative data for further analysis. The purpose of the interview was to clarify the test subjects thoughts about the conceptual system, the metaphors and their mental model. The interview was conducted with an exploratory approach, so no fixed boundaries were set. This was done in order to ask in-depth questions and sub-questions to the test subjects, if there was a chance that further questions could elaborate the test subjects' opinions.

When having the concerned hypotheses and the expected data of the experiment in mind, we did not anticipate to be able to make a final conclusion whether or not we had confirmed the hypotheses based on a statistic evidence. Since we collected qualitative data from interviews, it was crucial to ask the right questions, and even if the right questions were asked, we could not be sure the test subjects would put their thoughts into words.

The conceptual system in this experiment was inspired by a fully automatic coffee machine. We defined the conceptual system as the concept of an automatic coffee machine and the functionalities of the automatic coffee machine, and not the coffee machine itself. By the concept of an automatic coffee machine, we mean the properties that people relates to an automatic coffee machine, like that it is automatic, and therefore it is not necessary to add coffee and water, every time you brew a new cup of coffee.

The conceptual system was, in this experiment, accessed through two different user interfaces: a user interface designed with a literal metaphor, and a user interface designed with an abstract metaphor.

The user interface designed with a literal metaphor was inspired by an industrial coffee machine, which often is found in cafeterias and gas stations. The metaphor is literal when compared to the conceptual system, because the differentiation between the properties of the conceptual system, and the properties of the metaphor is minimal. The users have to turn on the coffee machine and they are then presented with a list of choices: small/large cup, mild/medium/strong intensity of the coffee. The metaphor also becomes literal because, as in the conceptual system, the users have to press the start button in order to start the brewing.The user interface designed with a literal metaphor is shown in Figure 1.

Figure 1: **The user interface designed with a literal metaphor.**

The user interface designed with an abstract metaphor is based on a traditional filter coffee machine. The abstractness of the metaphor is present when compared to the conceptual system, because the properties of the metaphor differ from the properties of the conceptual system, in such a degree that no relative similarities are present. The metaphor becomes abstract because the interface only partial function like the conceptual system. For instance, a filter coffee machine will start brewing as soon the power is turned on, and users would have to add water and coffee each time new coffee is to be brewed. Also, water, milk, sugar etc must be added manually. Neither is it possible to stop the brewing without turning the power off.The user interface designed with an abstract metaphor is shown in Figure 2.

Figure 2: **The user interface designed with an abstract metaphor.**

It is important to mention that when we can only define the metaphors, in the two user interface, to be abstract or literal, when they are compared to each other. We can only define our abstract metaphor to be abstract, because it is more abstract than the literal metaphor. And we can only define our literal metaphor to be literally, because it is more literally than the abstract metaphor.

2.1 The Experiment

Twenty four students from Aalborg University participated in the experiment, eighteen males and six females.
The experiment was a within subject design. All test subjects had to complete all tasks in the experiment. The test subjects was introduced to two mock-ups of a coffee machine. One mock-up had an abstract metaphor in the design of the user interface (UI-A) and the other mock-up had a literal metaphor in the design of the user interface (UI-L).The test subjects had to interact with the mock-ups, as if they were real coffee machines, by pushing the buttons on the mock-ups to complete the tasks.

The test subjects had to complete eight tasks, four tasks with the UI-A and the same four tasks with the UI-L, before they were to be interviewed.

If the test subjects made errors or failed to complete a task, the facilitator asked relevant questions right away in order to find out the reason for failing the task. This was done in order to collect qualitative data while interacting with the given metaphor in the user interface. If the test subjects did not know how to perform any of the tasks, the facilitator gave verbal cues on how the tasks were to be performed. After completing each task the facilitator asked the test subjects about the problems that might occurred during the tasks. The facilitator interviewed the test subjects, after all eight tasks were completed, about the interaction with the two user interfaces. the whole scenario were videotaped.

A balancing did occur in the order in which the two different user interfaces were presented. Twelve test subjects got the tasks with the UI-A first, and the other twelve test subjects got the tasks with the UI-L first.

Procedure: Various students at the University of Aalborg were asked if they wanted to participate in an experiment with the duration of 10-15 minutes. The participants were giving both written and oral instructions about the experiment and it's tasks.

When the facilitator was done reading the first task out loud, the test subjects could hold a piece of paper with the task description. The reason was to avoid that the test subjects had to guess, because they could not remember the task. If the test subjects did not complete or did not understand the task, the facilit ator first asked relevant questions about the test subjects' problems when the test subjects' indicated the test subjects could not complete the task. Only if the test subjects failed the task or did not understand the given task the test subjects received verbal cues from the facilitator. The facilitator did, during the task, give verbal feedback to the test subjects. This was done because of the mock-ups missing possibility to give feedback when interacting with the user interface on the mock-up.When the test subjects had been given all the tasks they were interviewed.

Interview: The interview was a semi-structured interview [2] that covered the interesting aspects, and template questions that could be used to cover these aspects. The questions were not fixed and could be changed during the interview to create a more spontaneous approach in order to get as detailed answers as possible. We had the opportunity to clarify that answer by asking more in-depth questions [2].

3. RESULTS AND ANALYSIS

The results of the experiment consist of 24 interviews and 24 video recordings of the test subjects participation in the experiment and further 24 summaries written by the assistant while the experiment was in progress. The extraction of relevant data from the video recording was conducted stepwise.

The first step was to go through each video recording of the 24 test subjects and each of the 24 summaries. This was done in order to sort the data from the videos including both experiment and interview, and get an overview of the data for further analysis.

The second step was to go through the classified data of the 24 test subjects, and to single out all the test subjects' data, which could be used to shed light on hypothesis 1. These are denoted as "Group A". To answer this hypothesis we first saw how many test subjects, made mistakes with the abstract metaphor. Then we filtered out the test subjects, who either made mistakes because they misread the tasks, forgot what buttons they had pressed, or similar mistakes. This selection lead to eleven test subjects in Group A.

Afterwards, we once again went through all the data of the 24 test subjects, to single out those test subject's data, which could be used to shed light on hypothesis two. These are denoted as "Group B". This was done by singling out the test subjects, that had completed the tasks with both user interfaces, who either made no mistakes or only minor mistakes. This selection lead us with nine test subjects in group B.

The third step was to carefully go through all of the extracted data and findings for all of the test subjects in Group A and Group B.

Among these eleven test subjects in Group A, it was possible to determine that five test subjects followed their mental model, when interacting with the user interface with an abstract metaphor, even though the mental model differed from the conceptual system. The determination was based on the test subjects' interactions with the user interface using the abstract metaphor, and answers, and comments in the experiment and interview.

Among the nine test subjects in Group B, five test subjects stated or made gestures, that indicated that they had benefited from the literal metaphors' elements.

4. DISCUSSION AND CONCLUSION

In our analysis we determined that five test subject acted according to the mental model even when this differed from the conceptual system, and we determined that five test subjects were in full control of the conceptual system pointed out certain elements from the design of the literal metaphor.

We were trying to clarify, what the test subjects were thinking, without giving them any leading questions. There were some cases were it seemed very much like the test subjects were interacting accordingly to their mental models, even when it differed from the conceptual system, but we still had doubts and therefore we chose not to include these test subjects in the further analysis, and even though we only managed to prove that five test subjects acted according to their mental model, even when this differed from the conceptual system, it does not mean that the other test subjects did not.

Another aspect that we have to bear in mind when interpreting these data, is that we have only seen how test subjects interact with two user interfaces with metaphors. We can not say for sure how people would interact with an user interface that is perhaps even more abstract or more literal. Based on the five test subjects that acted accordingly to the mental model even when this differed from the conceptual system, we can not conclude that the users always will follow their mental model, when this differs from the conceptual system. Users will, at least sometimes, follow their mental model, when it differs from the conceptual system. Therefore it is problematic to use abstract metaphors as a design tool. By using an abstract metaphor, the mental model and the conceptual system will differ more often than by using a more literal metaphor, and if the users follow their mental model, they are apt to make mistakes.

Based on the five test subjects that were in full control of the conceptual system and benefited from elements of the design of the literal metaphor, we can not conclude that the users always will use elements from the literal metaphor. The result shows that users at least sometimes will use elements from a literal metaphor in a user interface. This is properly because it gives a more direct representation of the conceptual system, that the user knows how to use[5].

The results of the experiment indicate that there are problems with making user interfaces with abstract metaphors and that some users do benefit from the elements of literal metaphors. Even if these results turn out not to be valid for all users, it still indicates, that you should use literal metaphors in the design of an user interface. "Even in a small-scale experiment like this, it is evident that the selection and use of metaphors have a highly significant impact on users' mental models and hence their performance with the system. Designers should avoid or be especially cautious when using abstract metaphors, whereas literal metaphors seem to be less problematic."

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Drawing as a User Experience Research Tool

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ABSTRACT

This paper discusses the use of participant-generated drawings as a user experience research method. In spite of the lack of background literature on how drawings can generate useful insights on HCI issues, drawings have been successfully used in other research fields. After briefly introducing such previous work, two case studies are presented, in which drawings helped investigate the relationship between media technology users and two specific devices, namely television and mobile phones. The experiment generated useful data and opened for further consideration of the method as an appropriate HCI research tool.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation (e.g. HCI)**]: User Interfaces – *evaluation/methodology.*

General Terms

Measurement, Experimentation, Human Factors.

Keywords

Drawing, user experience, memories, television, mobile phone.

1. INTRODUCTION

Exploring detailed aspects of people's life can be done in many ways: Standard ethnographic methods include interviews (in-depth, repeated), activity logging (automatic or via diaries) or remote prompting. These methods help researchers immerse into people's life more or less deeply and over various time periods, from a specific point in time to several weeks, months or even years. However efficient these methods are, they suffer from being time consuming in planning, conducting and analyzing. Sometimes one might need a snapshot of a specific part of people's life from a sample of participant bigger than what can be afforded using the abovementioned methods. Decreasing the resources necessary to measure personal user experiences has been on the agenda of HCI researchers, and thus rapid UX evaluation strategies have been developed and applied. Beebe introduced and defined "Rapid Assessment Process" [3], and Miller further proposed to focus on three key aspects of evaluation design [6]: Focus and key informants (to limit the amount of data collected), Interactive observations (to improve the quality of the data collected), and Collaborative data analysis (to help analyzing the data collected).

This paper examines how drawings can tackle the methodological challenge of providing deep insight on test participants' personal matters in an easy way, in a timely fashion, and using a relatively large sample size. The type of personal stories collected and the level of intimacy user experience researchers can access through drawings will be exemplified through the application of the method to a specific research agenda, namely investigating the relationship between users of televisions and mobile phones and the devices.

The study related in this paper partly took place during a visit to a foreign institution as part of the author's doctoral study. The socio-historical approach to media studies taught at the visited institution encouraged the author to investigate technology-free user study tools. Moreover the cultural and linguistic gap experienced during the stay provided an excellent opportunity to try non-verbal user experience investigation methods.

2. DRAWING AS A RESEARCH METHOD

Drawings and sketches have been part of humans' communication tools palette since their early evolutionary stage. Whether it is for visualizing specific ideas, expressing artistic inspiration, supporting learning process, or ensuring durable memory, drawings are used almost everywhere. In fact when learning how to express themselves, humans rely on drawings very early, prior to writing. In their first years of life, children learn to use drawings as a communication mediator. At the same time, the child gradually includes writing in the drawings, enhancing clarity in the ideas expressed [1]. The important role drawings play in human development explains the vast academic literature available related to children's drawings and their interpretation.

It has been argued that simple drawings can help convey complex ideas, especially in the business world [8]. For instance Dan Roam demonstrates that drawings help clarifying ideas, expressing them rapidly without the need for complex technology, and sharing them openly encouraging discussions. It is further argued that "*the value of visual information lies […] during the action of drawing*", that is during the creation process of the image rather than in the image itself [7]. Mills considers drawing as a visual conversation, for which the performance itself is crucial to make sense of the message conveyed.

In design, drawings are widely used in order to illustrate and explore scenarios and ideas through storytelling, and storyboards are considered an efficient and powerful tool for illustrating a succession of events [9]. Exploring people's life, opinions and thoughts through drawing are however less popular.

Recently, ethnographers have used drawings to discuss medical conditions with patients. While using drawings for exploring how people understand illness, Guillemin demonstrated that drawings can indeed generate a broad and in-depth perspective on the study at hand. The author agrees with Mills in saying that studying the drawing produced alone is not enough, but should be complemented by the analysis of the knowledge built by the drawer while creating the drawing [4]. Additionally, Guillemin notes that a drawing is a snapshot of how the drawer understands a subject at the specific time of the drawing. She reckons the limitations of this visual expression tool and argues that drawings should be used as a complement of additional research methods.

Guillemin's findings are corroborated by Kearney and Hyle who identified the following benefits and drawbacks of using drawings as a research method for investigating the emotional effects of change in an educational institution [5].

1. Drawings reveal emotional aspects that would not be covered in word based communication
2. Participant focus on the key aspect of their story
3. Drawings needs to be complemented by participant explanation
4. Response to the drawing task varies according to personal and situational characteristic that may be hard to control
5. The lack of boundaries associated with drawing alleviates participants freedom of expression
6. Likewise, researcher-imposed structure determines interpretation of drawings
7. Drawings is suitable for data triangulation when used in complement to other research tools

Furthermore, considering drawings as a support for focus groups involving children, Yen presented evidence that drawings had the following positive effects on the study outcome [11].

8. It helped create a relaxed and comfortable atmosphere, and released the pressure to answer immediately
9. It enhanced the communication between the researcher and the children by providing further insight on the children's perspective on the topic discussed, as well as offering children the possibility to express more personal experiences
10. It allowed better identification of groupthink and gave each idea expressed an equal chance for consideration

It should also be reminded that drawings can be culturally reflective. In a study comparing children drawings in Japan and the United States, La Voy et al (2001) discovered that when drawing people, Japanese children tend to include more details and represent humans larger but with fewer smiles than their American counterpart. These differences are explained by cultural clues of how children are raised in both societies. [10]

A limitation to the method, which is common to all qualitative methods, is a matter of validity, bound to interpretation. When someone (the drawer) communicates an idea through drawing to somebody else (the viewer), the idea goes through various levels of interpretation, which may alter the original meaning thought of by the drawer. First, mental images are hard to draw due to their high level of abstraction, their tendency to get easily disturbed, and their dimensionless nature [2]. Second, the drawer verbalization and viewer interpretation are prone to inaccuracies potentially leading to confusion. However this critique applies to any visual- and verbal-based exchanges between an author and an audience. Rather than considering this an issue, Guillemin suggests considering the drawings as one of the many ways to perceive the study subject.

3. CASE STUDIES

This section presents two specific applications of drawing as a mean of understanding the relationship between media technology users and two media devices: television and mobile phone. The first case served as a pilot study in order to test and improve the method. Nevertheless, it also generated valuable data which can be analyzed. The second iteration builds from the pilot study and was conducted in a different cultural environment.

3.1 Pilot Study: Project Seminar in Japan

3.1.1 Setup and participants

The pilot study took place as a social event during a three-day project seminar. All participants knew each other, for the project had been running for several years and members met at multiple occasions prior to the seminar. After the second day's dinner, everyone gathered in the meeting room where further discussions about the project were to take place after the drawing experiment. Participants were handed a set of paper sheets. On the first sheet, a description of the author's project and the purpose of the study reminded the participants about the experiment. The four remaining sheets contained a few lines of instructions and a large empty square on the rest of the page for drawing. Pens of various types and colors were available to all participants, who could use any combination of them. Participants were sitting on the floor either in small groups or individually. Interaction between participants during the experiment was possible but not mandatory. A total of 30 minutes was allocated to the entire test, including introductory speech. The sets of paper sheets were collected after each participant completed his/her drawings, in order to limit potential alterations.

Twenty-one participants took part in the pilot study. At thirty-six years old in average, they were mainly males (17 against 4 females). Their occupation was closely related to the academic world, and included nine researchers, five students, four professors, two assistant professors and one graphic designer.

3.1.2 Tasks

The study investigated participants' relationship with TV and mobile phone separately: The two first sheets focused on television and the two last on mobile phone. On the first sheet participants were asked to draw the layout of their house, indicating the media devices regularly in use. Additionally, participants were instructed to illustrate media devices used simultaneously. For the second drawing, participants were asked to illustrate an impressive memory related to television. It could be a memory about anything that marked them somehow deeply. The drawings concerning the mobile phone followed the same approach: First participants had to picture themselves, depicting the mobile devices they carry around with them. Then they should recall and illustrate an impressive memory associated with their personal mobile phone.

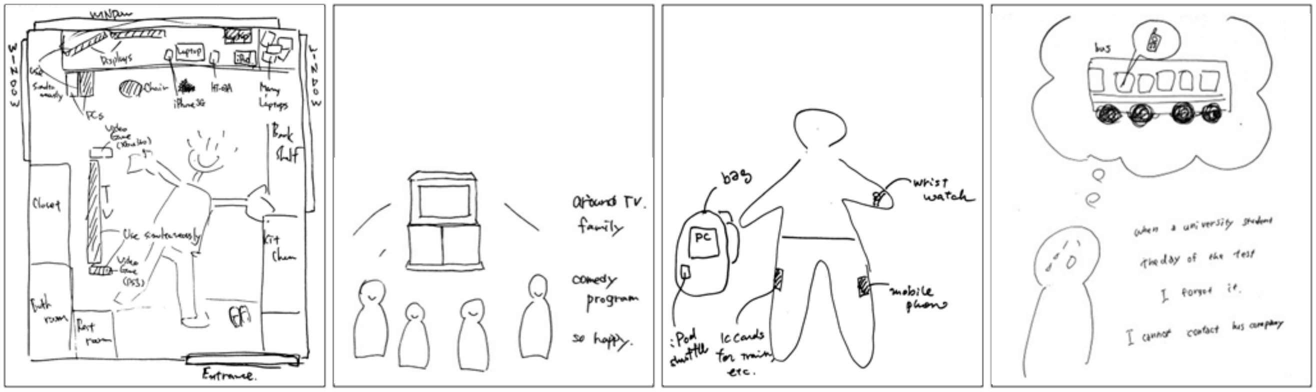
3.1.3 Results

Analyzing the data collected solely based on the drawings can be a difficult exercise and has been argued to be insufficient [4]. Nevertheless, as a first step into the analysis it leaves the opportunity to interpret participant answers and identify trends and categories. Later this can be used for selecting a few participants for further examining representative contributions.

Focusing on home media usage, the analysis should filter out the excess of information that appears in most drawings. Sketching the layout of the home is only the support task for studying where and how media devices are used in the home. This comment is actually valid for all drawings regardless of the topic at hand. As illustrated in Figure 1-(a), Japanese home drawings are usually complemented by text clarifying a device, piece of furniture or specific use situation.

When asked to depict a memory related to television, the majority of Japanese participants (58%) portrayed memories related to the TV content, and little about the device itself or the social interaction around it (21% each). Half of the memories (50%) involved the participant alone, and 29% involve family members (as illustrated in Figure 1-(b)).

Self-depicting oneself leads to reflecting on one's behavior, which some Japanese participants expressed through there drawings. Additionally, four participants specifically represented several situations in which they carry mobile devices. In general, participants depicted themselves carrying 2.5 mobile devices



(a) (b) (c) (d)

Figure 1. Drawings collected during the Japanese project seminar illustrating a home and media devices in use (a), an impressive memory involving TV (b), a self-depiction including mobile devices (c) and an impressive memory involving mobile phone (d).

(such as mobile phones, computers, or music players). A few considered more exotic devices (e.g. watch, transportation cards). Concerning mobile phones, they were mostly located in a pants pocket (48%), often in a bag (26%) and sometimes in a jacket pocket (19%). Figure 1-(c) is an example of typical self-depiction.

Finally, memories about mobile phones mostly related to experiences where the device had been broken, lost, forgotten or otherwise misused (48%, as depicted in Figure 1-(d)), as well as specific use situations (43%). Those memories were mostly associated with negative feelings (52%), rather than positive (24%) or neutral (14%) ones. Even more than with memories involving TV, mobile phone related memories concerned the participant alone (62%).

3.2 Study 2: Graduate Course in Denmark

The second experiment repeated the pilot study in a different cultural context, and included a few minor modifications in the setup. The tasks remained strictly identical in both studies. The participants also differed in the second study as all were graduate students attending a User Experience Design course.

3.2.1 Setup and participants

This study took place during a two-hour lecture introducing students to qualitative methods for user experience research. The exercise was conducted after a short break at the beginning of the second hour of the lecture. The lecturer gave a brief and general introduction to the method before starting the exercise, which lasted about 20 minutes. The task sheets differed from the pilot study by the size allocated to each drawing. In order to avoid potential blank page syndrome, two drawings were expected per page, instead of one per page during the pilot. Participants were sitting at their desk as during the lecture and could interact between each other. Pens were distributed to participants who didn't have one.

Thirty-seven graduate students took part in the second study. They were again mostly males (26 against 11 females) and 24 years old in average.

3.2.2 Results

Drawings from the Danish students could be categorized in a similar way then their Japanese counterpart.

The home drawings can be classified in two categories according to the amount of details included. The range of complexity between drawings varied considerably from minimalistic (illustrated in Figure 2-(a)) to very detailed, a short majority belonging to the former category.

When it came to remembering a remarkable event related to TV, Danish students mentioned the device itself in majority (46%), mostly illustrating scenes of use or acquisition (illustrated in Figure 2-(b)). Memories related to the TV content (38%) as well as the surrounding social environment (29%) were also mentioned. The people involved in most of these memories as well as the associated feelings were unclear and were matter of interpretation.

Danish students represented themselves carrying 1.8 mobile devices in average, mostly focusing on the cell phone, sometimes complemented by a laptop or music player. Most participants (38%) represented themselves using their mobile phone, hence carrying it in their hand (as illustrated in Figure 2-(c)). The second most popular location for carrying mobile phones was the pants pocket (35%). A surprisingly representative number of drawings (16%) pictured the user and devices separately.

Finally, memories related to mobile phones referred equally to situations in which the device was broken, lost, or misused, than to specific use situations (37% each). Those memories involved mostly the participant alone (58%). As with the TV-related memories, the feelings associated with mobile phone related memories were very hard to identify without making assumptions based on the content depicted.

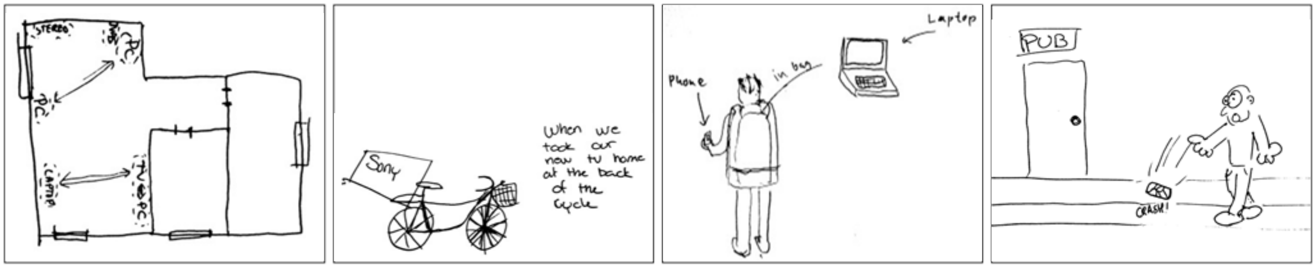
4. DISCUSSION

The following topics emerged in the high-level evaluation of the drawings collected through the two studies.

4.1 Personal Matters

It seems that drawing makes it easy to express personal matters. In both Japan and Denmark, intimate stories were depicted. It is argued that these stories would take longer to collect through verbal interviews, as the act of drawing provides both a personal sphere to reflect in (centered around the paper sheet) as well as time to think and organize one's thoughts.

It is further argued that drawing provides an opportunity for reflecting on one's behavior, which opens for further discussions with the drawer. For instance both Japanese and Danish participants realized that they were sometimes using two phones at the same time and that could be considered strange.



(a) (b) (c) (d)

Figure 2. Drawings collected during the Danish graduate course illustrating a home and media devices in use (a), an impressive memory involving TV (b), a self-depiction including mobile devices (c) and an impressive memory involving mobile phone (d).

4.2 Ubiquitous Mobile Phones

Environmental factors should be considered when asking people to remember a remarkable event related to a specific device. Some participants in both Japan and Denmark expressed their difficulty to think about such a memory related to mobile phones. In fact they considered the device to be so present in their everyday life that finding an extraordinary event linked to it was hard.

4.3 Japan vs. Denmark

In general Danish drawings were more ambiguous and harder to interpret on their own than the Japanese ones. For instance it was easy to determine whether a Japanese memory was associated with positive, negative or neutral feelings. On the contrary drawings collected in Denmark were ambiguous and could only be guessed, calling for further discussion with the authors.

In both countries most memories related to mobile phones referred to the use or misuse of the device by the participant alone. However when remembering an event related to TV, Japanese participants referred mostly to the TV content, while Danes focused on the device more frequently. Japanese also visibly experienced these events either alone or with family members, while Danes were more ambiguous on the matter.

4.4 Acquaintance among Participants

Even though test users should work on their own to produce the drawings, the presence of colleagues, friends or strangers around might influence productivity and the level of attention to details. However, the drawings collected during both experiments seem to indicate no influence of the level of acquaintance among subjects on the output. It could even be argued that both familiar and unfamiliar social surroundings may positively influence how people perform during such activity. In a familiar social setting, one might want to produce something to impress or amuse friends, and when surrounded by strangers, one might want to appear assiduous. Nevertheless, consistency bias may occur in case of participants exchanging heavily during the study.

5. CONCLUSION

To the extent of the knowledge acquired while conducting the study and during the evaluation process, drawing seems to provide qualitative insights on the user experience with technology. The following statements have been verified and summarize the findings of the experiment so far:

1. Drawing helps create a relaxed and comfortable atmosphere in which test participants are willing to express personal matters
2. The absence of boundaries in drawings further encourages participants to reveal personal aspects of their lives
3. Responses are influenced by the experimental setup
4. Drawings should be used in triangulation with other research methods

These findings however need to be further investigated, combined with additional user experience evaluations as suggested in the literature and compared to other inquiry methods in order to assess the performance of drawings as a useful HCI research tool.

6. ACKNOWLEDGMENTS

The author thanks all participants who challenged their drawing skills and shared personal stories for the purpose of this study.

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RoMo: Avoiding Conflicts Between the Physical and Digital Model in Tabletop Interfaces with Robotic Tangibles

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ABSTRACT
In TUIs, physical/digital conflicts can occur when the digital model does not match the model implied by the spatial layout of tangibles. We show how tangible tabletop interfaces (TTI) can be modified to allow robot movement of tangibles, thereby avoiding conflicts. We present RoMo, an open source Java library that allow existing TTI applications to perform robot movement, and demonstrate its functionality with three applications.

Author Keywords
Tangible user interfaces, bidirectional user interfaces, robotic tangibles

ACM Classification Keywords
H.5.2. User Interfaces. D.2.2. Software libraries.

INTRODUCTION

In a landmark paper in the field of tangible user interfaces (TUIs), Ishii and Ullmer described the risk of physical/digital conflicts [3]. Physical/digital conflicts emerge when the digital model does not match the model implied by the spatial layout of tangibles. Conflicts can occur if the digital model is dynamically changing (i.e., if it depends on other data-sources than user input) or if multiple users are collaborating on TUIs in different places sharing the same digital model. Physical/digital conflicts destroy the perception of input/output unification and may lead to ambiguous interpretations of the tangibles' spatial layout.

To address the problem of physical/digital conflicts in the field of tabletop tangible interfaces (TTIs), researchers have developed bidirectional tangible interfaces that are capable of moving tangibles around the tabletop surface. In contrast to unidirectional tangible interfaces, this capability allows bidirectional user interfaces to use tangibles as output devices and display changes in the digital model physically. The bidirectional tangible interfaces may be divided into two groups: (a) interfaces with small unpowered pucks, moved by an electromagnetic array situated under the tabletop surface [1, 5, 6], and (b) interfaces with battery-powered robots that move on the tabletop surface [7–10,12]. Most notable is PICO [6], an interface that uses magnetic attraction and repulsion as haptic user guidance, thereby allowing the computer and the user to collaborate in solving optimization tasks.

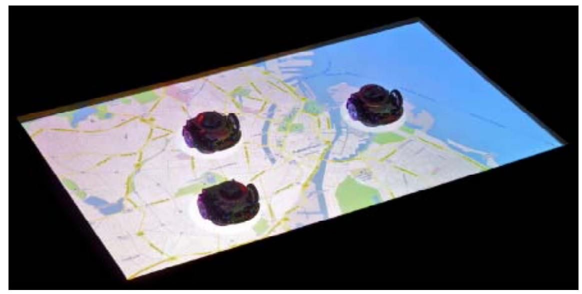

Figure 1. A map application using RoMo to move three robotic tangibles.

Whereas existing bidirectional tangible interfaces in part preclude physical/digital conflicts, they introduce other problems. The systems that employ electromagnetic arrays use custom-made hardware to move the pucks, and building them requires advanced engineering skills. The number of magnets and control boards required to move the pucks grow with the size of the tabletop, making these interfaces very expensive. The systems with battery-powered robots require far less hardware and are easier to build. However, existing systems rely on custom-made tracking and moving software which makes it impossible for other systems to adopt their robot control technologies.

The present paper makes two contributions to the field of tangible tabletop interfaces. First, we describe the hardware setup (Figure 1) and the steps needed to convert a unidirectional TTI to a bidirectional TTI using only off-the-shelf components. Second, we present RoMo, an open source Java library that allows existing applications to perform robot movement. We describe the design behind RoMo and demonstrate the functionality of the library with three applications that use robot movement to correct physical/digital conflicts. The robots and the RoMo library have previously

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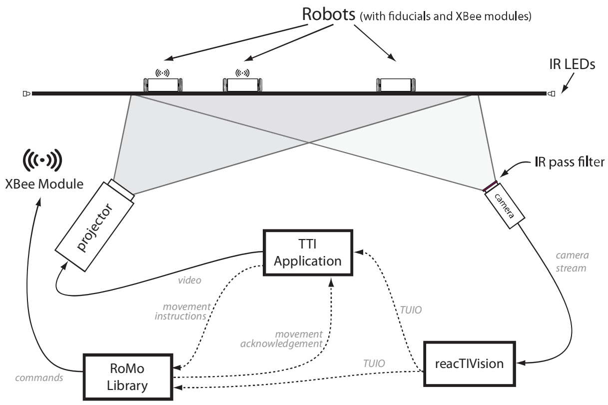


Figure 2. Overview of the system components.

been employed in [7] to study interaction with robotic tangibles.

RoMo HARDWARE DESCRIPTION

In this section we describe the hardware needed to use the RoMo library.

Tabletop

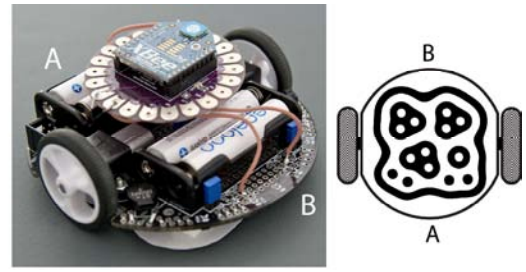
Figure 2 shows an overview of the components used in our tabletop setup. The setup is similar to that of unidirectional interfaces: Tangibles are marked with fiducials, which are illuminated by infrared light and tracked. The tracking information is sent as TUIO messages [4] to the TTI application where it is interpreted according to the interaction design of the application and where graphical visual feedback is generated. We use a DSI table [11] with reacTIVision [4] as tracking software, but any computer-vision based TUIO compatible setup will work.

The only hardware change made to the tabletop is the addition of a XBee Series 2.5 module to the hardware setup. The XBee module is mounted in an XBee Explorer USB-to-serial unit and is running as Communicator in API mode. This allows RoMo to communicate wirelessly with the robots at a speed of 115.2 kbps.

Robots

We use 3pi robots from Pololu [1] as tangibles (Figure 3). With a diameter of 9.5 cm and a weight of 83 g., they can easily be moved with only one hand. Moreover, the 3pi robots move and turn very quickly (100 cm/second). They are equipped with an Atmel ATmega328P micro controller running at 20 MHz and are programmable in C, Processing and Arduino. Each robot has a Lilypad XBee with a XBee series 2.5 module soldered on to the serial communication pins of the robot so as to allow wireless communication. The table in Figure 3 shows how the robot and the module are connected. A fiducial marker is attached to the bottom of the robot to make it visible to the tracking software. The fiducial marker must be oriented as shown in Figure 3.

[1] http://www.pololu.com/catalog/product/975



Lilypad	+	–	rx	tx
3pi robot	VCC	GND	PD1	PD0

Figure 3. A Pololu 3pi robot with a XBee module mounted in a Lilypad XBee. The table shows how the module is connected to the robot. A and B indicate how the fiducial should be oriented on the bottom of the robot.

MOTION IN RoMo

In RoMo robots are tracked with computer-vision and communication happens wirelessly. This introduces some challenges when controlling robots. In this section we explain how motion is achieved in RoMo.

Control and communication

Tracking and movement computations are performed solely by the control computer; the robots hold no positional information. The computer continously tracks the orientation and speed of each robot, determines the proper robot action and communicates this action to the robots in a round-robin fashion.

The steering of the robots is performed with robot movement frames. Each movement frame contains three values: (1) speed value for right motor, (2) speed value for left motor, and (3) movement time in milliseconds. The movement time helps avoid unwanted autonomous movement in case of package loss or package delay.

Rotation

Rotation is achieved by sending a pair of negated speed values to the robot. The value and the movement time are calculated from the angular distance to the destination angle; the bigger the difference, the higher the values. The maximum rotation speed is 220 deg/s.

Movement

Robot movement is done by driving in a straight line from the starting to the finishing position. In theory, this could be achieved by rotating the robot to the correct starting angle and driving straight until the finishing position has been reached. In practice, many challenges have to be addressed to make robot movement work. The two motors on the robots are not perfectly matched and at even motor speeds the robots pull to one side. Also, because of the kinetic energy stored in the motors, changes in motor speed are not immediately observable. Moreover, the latency caused by the tracking software and the wireless communication result

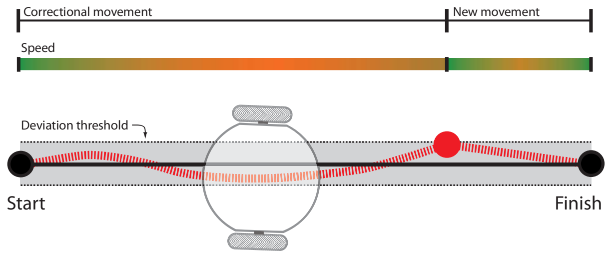


Figure 4. The robot's speed and movement direction is continuously adjusted to keep the robot on the path. If the robot exceeds the deviation threshold a new path is calculated and a new movement is initiated.

in a slight inconsistency between the actual robot position and the tracked robot position. Hardware challenges like the above mentioned are not specific to RoMo or bidirectional tangible interfaces in general; they are commonly discussed in the field of robot research, e.g. [2]. The robot control algorithm takes all these factors into account by performing constant tracking and adjustment of robot's speed and movement direction. In the following we describe our algorithm.

The robot controller initially calculates the equation for a straight line between the robot's starting position and its destination. The robot controller then rotates the robot to a position in which it is facing the destination and starts moving the robot at even left/right speed values. For each new position sample the robot controller receives, the deviation from the path is calculated. The deviation value is determined by calculating the minimum distance between the robot and the line. Small deviations are corrected by adjusting the motor speeds without stopping the robot. However, if the robot exceeds the deviation threshold, it is stopped, then a new path is calculated, and a new movement initiated. This results in a moving pattern similar to the one displayed in Figure 4. The deviation threshold and the maximum robot speed can be adjusted to achieve faster or more precise movement. As shown in Figure 4, the speed of the robot is adjusted depending on the distance to the finishing point. To ensure stable tracking and control, the robots move at a maximum speed of 24.5 cm/s.

THE RoMo LIBRARY

The RoMo java library consist of a small number of methods that TTI applications can use to initiate robot movement. In this section we cover the most important ones. RoMo is implemented to fit the observer design pattern commonly used in Java. The TTI application simply instructs RoMo to move a robot to a specific position or angle; when the desired destination has been reached, the TTI application is notified.

Rotation

One advantage of using robots in TTIs, compared to electromagnetic TTIs, is the ability to rotate tangibles. In RoMo robots can be rotated with the method `rotateRobot(int fID, float angleDegree)`, where `fID` is the fiducial id of the robot to be rotated and `angleDegree` specifies the angle ($0 \leq angleDegree < 360$) to which the robot should be rotated. With `angleDegree` set to 0, the robot is aligned parallel to the vertical edges of the screen facing the bottom edge.

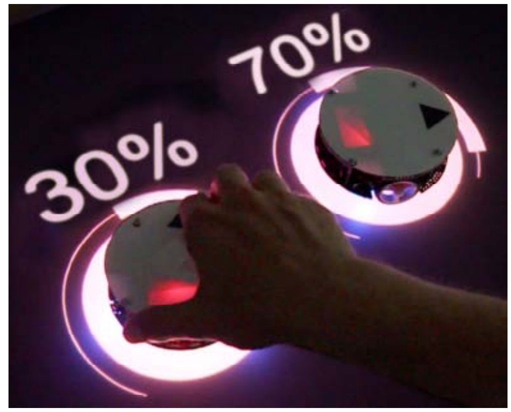


Figure 5. A user rotates a tangible to adjust the percent value. Physical/digital conflicts are avoided by rotating the other tangible, thereby preventing the total from exceeding 100%

Figure 5 shows an application that makes use of robot rotation to avoid physical/digital conflicts. Here, each robot is associated with a percent value displayed above the robots. The user adjusts the values by rotating the tangibles, using them as knobs. When the user rotates a robot to adjust the value, the other robot immediately rotates to the corresponding percent value, thereby ensuring a total percent value of 100%.

Movement

Robot can be moved to a new position by using the method `moveRobot(int fID, float x, float y)`, where `x` and `y` specify the coordinates to which the robot should be moved. `x` and `y` are expressed as percentage of the width and height of the screen ($0 \leq x, y \leq 1$). Figure 6 shows a simple application that uses robot movement to introduce constraints on the spatial layout of tangibles. In the application the user moves tangibles freely around the surface, and when the user stops interacting, the application forms an equilateral triangle by moving one tangible. The robot's movement path is displayed as a yellow dotted line.

The interaction design of this simple application illustrates an important difference between designing for unidirectional interfaces and bidirectional interfaces. In unidirectional interfaces the tangibles are only moved by the user and therefore tangibles can be used for interaction at any time. This is not possible when designing for bidirectional interfaces, as RoMo cannot differentiate autonomous robot movement from human intervention. If the user grabs and stops a moving robot, RoMo will interpret this as package loss and keep resending robot movement frames until the robot is finally at its finishing position. Consequently, the interaction design of applications for bidirectional interfaces will often need to

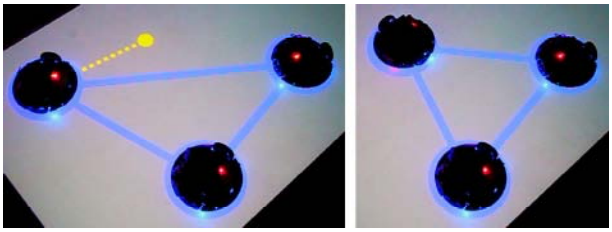


Figure 6. RoMo is used to introduce constrains on the spatial layout of tangibles. In this application robots are moved to ensure that the tangibles form an equilateral triangle.

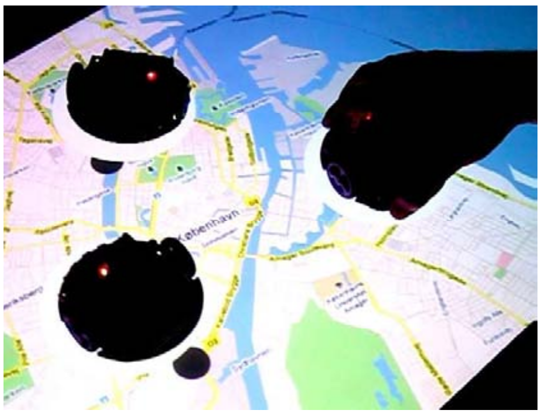


Figure 7. A map application using RoMo to allow panning and rotation the map. Here, the user rotates the map by rotating a tangible.

employ turn taking and provide the user with feedback on when tangibles can be manipulated.

Figure 7 shows how RoMo may be used to allow interactions that would be impossible to employ in unidirectional tangible interfaces. In this application the user places tangibles on the map to mark certain sites (i.e., good places to dine). In unidirectional interfaces this would lock the view of the map, making it impossible to pan or zoom without creating physical/digital conflicts. However, in the bidirectional application shown in Figure 7, the robots move with the map, allowing the user to rotate the map by rotating a tangible or pan the map by moving one tangible. These interactions are normally only seen in multi-touch applications.

CONCLUSION

We have presented RoMo, an open source Java library that allows existing TTI applications to perform robot movement. We have described how unidirectional TTIs can be converted to bidirectional TTIs using only off-the-shelf components. In this paper we have focused on the use of RoMo to avoid physical/digital conflicts in TTIs. While we consider this an important quality of RoMo, we look forward to exploring and evaluating the novel interaction techniques that RoMo introduce to TTIs (i.e., undo of actions, recall of prior spatial layout and imitation of movement).

In our future research we plan on addressing the inability to detect human intervention by adding proximity sensors to the robots. Also, we will experiment with omnidirectional wheels to improve the robot's freedom of movement.

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Segmentation as an approach to understand adoption of mobile services and content

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ABSTRACT
This short paper presents four distinct mobile user segments providing a more nuanced understanding of mobile phone users. The four segments are based on user behavior and what features users prioritize in relation to a mobile phone. The analysis is based on the TNS Gallup Telecom Index 2009 database which contains 3796 cases randomly sampled but each case however screened for having a mobile phone. The data used in this research relates to claimed user behavior on mobile phones and what features the user prioritizes on the mobile phone. A common practice in both academic research and market research is to create consumer and user segments to help a better understanding of behavior and preferences. In this research the same approach is used. Using cluster analysis four distinct segments are created and this paper describes them. This research is a part of the CAMMP project, a joint venture research and development project between academic institutions, commercial enterprises and a public service broadcaster. The CAMMP project focuses on converged multimedia content on mobile platforms. This paper outlines the basis of user research conducted within the CAMMP project.

Author Keywords
Segmentation, cluster analysis, user profiles, user behavior on mobile phones, features prioritized on mobile phones

ACM Classification Keywords
H.3.4 Systems and Software: User profiles

INTRODUCTION

In recent years mobile phones has become increasingly advanced; from being merely focused on oral communications to becoming so called Smartphones with advanced navigation systems as GPS, internet access, music devices, video devices etc. Today using the mobile phone to a greater extent than just calling is common and at an accelerating speed new and innovative services to the mobile phone are being developed. But this also calls for a more nuanced understanding of the different groups of mobile phone users' adoption of new services and technologies.

Within the CAMMP project (Converged Advanced Mobile Media Platform) [1] there is a particular interest in researching and discovering the potentials for new converged mobile, interactive, media services. The project aims at providing prototypes for mobile media platforms and researching on different business models for the commercialization of the project's results. This, of course, includes a special focus on potential users of CAMMP services. Thus there is a need to learn who is already using more advanced services and functions on the mobile phone and who is not and to learn how widespread is advanced usage of the mobile phone. This paper presents an approach to insight into the Danish mobile phone users.

The study was done during 2008 to 2009 and results have been used within the CAMMP project since late 2009.

The paper is organized in the following set-up: first section describes the approach and the basis of the research. Next section shortly presents the data being used in the research and explains the method used to create the segments. The segments are then presented and described and related to the CAMMP research project. Last section is perspectives and what further research is to be done.

RESEARCH APPROACH

The approach is to create segments. This is not a new approach and has been done for many years and in many different research areas. Market research has long relied on creating consumer segments to learn how to target consumers more efficiently [2].

Even though Smartphones have grown in popularly within the recent years not everyone owns a Smartphone and not every mobile phone user proceed to functions beyond calling and text messaging.

Adoption of innovations has been very thoroughly described by Roger [3] and as argued the innovators and early adopters, both groups being users of advanced functions on the mobile phone, are relatively small groups compared to early majority and late majority.

Thus the hypothesis is to identify least one large group that is not using advanced functions and at least one group that in size must be relatively small that is using advanced functions. However one large group and one small group are not sufficient when the aim is get a varied understanding of Danes' using mobile phones. The aim is to create more than two segments. A short explanation of the methodical approach is given in Data and Methodology section.

The approach in this paper is somewhat familiar with Eronen's approach when identifying three distinct segments based on preferences and expectations towards at that time the forthcoming digital TV in Finland. Eronen's segments were referred to as Pioneers, High-Flyers and Comfort-Lovers [4].

DATA AND METHODOLOGY

The research in this short paper is based on data from TNS Gallup Telecom Index 2009. TNS Gallup interviews 7500 individual Danes per year with approx. 100 questions relating to fixed phone, mobile phone and internet behavior. In this specific research case the yearly released database is used which includes 3796 cases all selected randomly sampled but however screened for having a mobile phone. TNS Gallup is a renowned market research institute and The TNS Gallup Telecom Index is used by most Tele communication Companies in the Danish market.

The TNS Gallup Telecom Index has many questions regarding usage of the mobile phone. The research in this particularly case focus' on claimed usage (eg. listen to radio/music, using internet, sending text messages etc) combined with demographic variables as gender and age. All these different variables have been computed using cluster analysis.

Using cluster analysis based on the k-means clustering four distinct segments was created. Cluster Analysis (or clustering) is the classification of objects into different groups. More precisely, it is the partitioning of a data set into subsets (clusters or classes), so that the data in each subset (ideally) share common trait - often proximity according to some defined distance measure.

The K-means approach to clustering performs an iterative alternating fitting process to form the number of specified clusters. The K-means method first selects a set of *n* points called cluster seeds as a first guess of the means of the clusters. Each observation is assigned to the nearest seed to form a set of temporary clusters. The seeds are then replaced by the cluster means, the points are reassigned, and the process continues until no further changes occur in the clusters [5].

Four clusters were selected. It was the best solution as five segments would create a too weak segment and three segments did not give enough distinctiveness.

The distribution between the four segments is as follows:

Cluster 1	Cluster 2	Cluster 3	Cluster 4
51%	36%	10%	3%

INTRODUCING THE FOUR DISTINCT SEGMENTS

The cluster analysis creates four distinct segments which in total add up to 100% of all Danes having a mobile phone. The four segments are The Basic User, The Buzz User, The Bling User and The Business User. The names relates to what features they prioritize on the mobile phone and their claimed behavior on the mobile phone.

The Basic User

This segment comprises 51% of all mobile phone users in Denmark. This segment being the vast majority of persons having a mobile phone is mainly using the mobile phone for its original purpose: to make and receive calls. They send and receive text messages but fewer in numbers compared to the other segments. They understand the mobile phone as a phone and do not care for advanced features.

This segment does not own the newest cell phones, and when they finally buy a new one, the technical properties are not a priority, while e.g. large keypads are. The segment consists of an equal number of men and women who are typically over 50. But it is worth noting that 20% of the segment is under the age of 20.

Even though this segment is never online using their mobile phone they are still connected to the internet. 50% within this segment in this segment is online on a daily basis and 50% within this segment has a wireless internet at home. 30% within this segment has a webcam at home and the same number has portable music device. This is to say that this segment is indeed not disconnected from the evolving world of consumer electronics.

The Buzz User

This segment comprises 36% of all mobile phone users in Denmark. The Buzz User is the second-largest segment and comprises 36% of all Danes with a mobile phone. The typical age is between 13 and 50 years and women slightly outnumber men in the Buzz user segment. They are active users of the mobile phone, they receive and make calls and when they do not talk in the device, they text on it. Thus the name Buzz users, the mobile phone is their connection to the world and they are constantly using it.

The Buzz user segment is also capable of sending MMS messages.

When buying a new mobile phone they prioritize camera, radio player and MP3 player features. They also prioritize brand, design and size of the mobile phone.

The size of the mobile phone does matter in this segment and they are keen on small size mobile phones that fit into purses and pockets.

They are heavy users of internet on computers, 90% are online on a daily basis and when online social networks and communities are of key interest.

The Bling User

This segment comprises 3% of all mobile phone users in Denmark. The Bling user is typically a younger person aged 13-40 but particular under 30 years of age. Male comprises 75% of this small segment.

What makes the Bling users "Bling" is the mobile phone show off: they buy ringtones, wall papers and skins to their mobile phone and combined with a short life per mobile phone they are trying out the latest mobile phone trends.

This segment has the latest mobile phone and they indeed prioritize technical features when buying a new. They also prioritize a large screen and by no surprise they are very active accessing the internet on their mobile phone. In this segment we also find the most technological advanced users. Using Voice over IP applications such as SKYPE on a mobile device is not a common thing to do but in this segment we actually find users capable of installing and using such applications. In this segment we also see the highest penetration of Danes online using their mobile phone a total of 91% of all Bling users are online using their mobile phone within a month.

Their media behavior is also exceptional. Almost all is on the internet on a daily basis and within this small group you also find Danes podcasting the most. Even though they are heavy users of new media Television and Radio is still not forgotten.

The Business User

This segment comprises 10% of all mobile phone users in Denmark. The business segment is also advanced users of their mobile phone. But they are more focused on features that enable a more efficient way of gathering and processing information. This segment is also well dominated by males which make up 80% of the segment. They use e-mail on their mobile phone and when not checking mail they read news and sport results. On the move, they use GPS and travel planners on their mobile phone. Compared to the Bling segment they have a less playful approach to the mobile phone but instead focusing on functionalities that fulfill a need in relation to work or getting around.

In this segment we also find the largest group of users having their mobile phone subscription paid by their employer.

They are also heavy users of the internet and again, almost all are on the internet on a daily basis.

FURTHER RESEARCH AND PERSPECTIVES

This study was done using the TNS Gallup Telecom Index data from 2009. Much have happened since 2009 and recent studies show that the Smartphone is becoming increasingly popular and the usage of mobile services other than calling and text messaging are increasing in popularity too.

No doubt the segment sizes have changed since they were constructed in 2009. No doubt that increasingly advanced behavior has spread into the buzz segment probably due to much lower data prices, WIFI enabled Smartphones and an interest to use social media services on the mobile phone.

So even though the segment sizes have changed and some of technical behavioral indicators within each segment are different today than in 2009 the frame work remains relevant to the CAMMP project. Using the segments have proven to be beneficial when validating CAMMP services and conducting other user related studies.

But understanding users are an ongoing process.

ACKNOWLEDGEMENT

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Experience Sampling as a Study Method of Mobile Media Consumption

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ABSTRACT
In this paper, we address experience sampling as a study method of mobile media consumption for the Norwegian MiniTV mobile TV service. The main findings regarding the responses we obtained from a four week Experience Sampling campaign, where we received a total of 200 responses from 17 users, who were prompted 2 times per day, giving an overall response rate of 21%.

The main findings about the usage and social and locational contexts show that the miniTV is mainly used during transportation (public or private).

The campaign suffered from some technical problems, leading to a lower than expected response rate and a main conclusion is to stress the importance of the communication and motivation of respondents in experience sampling scenarios before and throughout the sampling period.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**] Ergonomics, Evaluation/methodology, Theory and methods, User-centered design.

General Terms
Human Factors, Experimentation, Measurement.

Keywords
Experience sampling, mobile media, smartphones, user studies.

1. INTRODUCTION
This paper address the suitability of experience sampling (ES), defined in 1983 by Larson & Csikszentmihalyi [1] as a method for a mobile television study. The purpose of ES is to record feelings, actions and momentary thoughts of people in their normal everyday life (striving towards ecological validity) – in this case pertaining the usage of mobile television.

As Cherubini and Oliver put it, '*It [Experience sampling] consists of randomly or semi-randomly sampling the user experience, usually by sending a message to the participant and asking him/her to answer a short questionnaire on a mobile device right at the moment when a relevant event is produced*', [5]. In addition to answers constituted by simple selections or written input to questions, voice recordings, pictures and video clips could also be valid input from respondents during ES, [6].

Contrary to recall-based self-report procedures such as diary writing and Gaver's cultural probes [4], ES does not require respondents to retrieve or reconstruct data from their memory as it allows respondents to report content and awareness in situations in which that awareness takes place and minimizes thus cognitive bias. Naturally, the validity of ES depends however on the assumption that respondents have access to information of relevance and actually want to report it, [1].

Following this section, some of the important parameters for ES is discussed in section 2. Section 3 presents our study and section 4 reviews some of the findings, which are discussed in sections 5 and 6.

2. EXPERIENCE SAMPLING
ES has been employed in a large number of studies, see [1],[2],[3],[5],[6],[7],[8],[10],[11]. In particular, the advent of smart phones as a convenient technical platform has given rise to a number of frameworks for ES, e.g. [9],[12]. This section discusses some of the most important parameters for an ES study; the timing and frequency of the prompts and the motivation of the participants.

2.1 Timing
Sampling (or prompting) can occur either at random (signal contingent), scheduled/at regular intervals (interval contingent) or in response to events of interest (event contingent) with adjustable levels of prompting questions that can be presented in a fixed or random order, [1].

In [7] it is cautioned that scheduled and event-based sampling might introduce cognitive bias (for the latter, especially if the events are triggered by the participant). A refined ES method (rESM) for use with cell phones has therefore been proposed that automates the collection of data via information that can be captured from the cell phone (e.g. automatic picture taking) and that furthermore is triggered by objective user-generated events (e.g. the user making a phone call), [5]. Similarly, the MyExperience open source project by Froehlich and colleagues [8] allows the participants to respond with photos, audio recordings or rating scales. The platform is very flexible and allows the experimenter to define new prompting schemes, such as clickable bitmaps, etc. One drawback is that it only runs on Windows Mobile Phones [9].

As the use of mobile TV happens independently of cell phone usage, MyExperience or rESM do not seem suitable for this study. Random sampling seems therefore most appropriate – of course within a suitable time window during the day (e.g. 08.00-20.00 to cover the day time as well as situations of use during morning and evening activities) in order not to disturb respondents unnecessarily. The duration of the entire survey was planned to be up to two months.

2.2 Frequency
The amount of prompts (per day and in total) sent to participants when prompting in situ is always to be carefully considered. Again, this is a tradeoff between validity, outcome and

motivation. By prompting too aggressively (in order to obtain a large number of samples) there is an increased risk that respondents get annoyed or suffer from general fatigue and give up – with the consequence of less or biased data collected.

In [10] 11 participants were prompted approximately 6 times a day within a 10-hour time window over a period of 10 working days. With this setup an average response rate of approximately 68% was obtained.

In [7] users' information needs were investigated using ES. Here, 31 participants were prompted 10 times a day within a 12-hour time window over a period of 7 days. With this setup an average response rate of 80% was obtained. In this study, it was furthermore investigated *why* respondents did not reply to all prompts. According to the respondents, the primary reasons for this were inconvenient situations of being prompted and not noticing the alert (vibration alert from a Palm m500 pocket PC).

The daily prompting frequency for the substantially longer period (months instead of days) intended in this work needs to be somewhat lower than in the studies referred to above: Assuming that an average response rate of approximately 75% is considered acceptable, and if the proportion is related (among other factors) to the total amount of samples this can be calculated to not exceeding 65 prompts for the duration of the study. Assuming a two month period, each respondent is thus to be prompted twice a day.

2.3 Motivation

Maintaining a constant motivation for the respondents to participate in a survey is of crucial importance to the overall outcome of this. The task of motivating respondents can be argued to be two-fold; first, participants need to be motivated to actually take part in the survey. Secondly, they need to be motivated to *keep* participating.

Financial compensation is typically used when trying to motivate people to take part in ES activities. As an example, participants in the survey described in [7] were offered an incentive of $50 for participating (and returning equipment) plus $1 for every completed questionnaire. Determining an appropriate amount of compensation is critical: A too low reward may not attract enough participants. On the other hand, a too high reward may attract participants who are not intrinsically motivated to participate, [11]. As argued in [11] a better approach may be to assure that respondents understand the importance of the study.

For this study a combined approach is taken: In addition to participating in a lottery with tickets to popular TV shows, respondents are explained that by participating they may have the opportunity to shape the future of mobile television. Respondents who complete all surveys (ie. an initial recruitement survey, the ES prompts and a post-test survey) also take part in a final draw for a mobile TV receiver.

The task of maintaining motivation throughout the entire survey period can be approached in a number of ways. In addition to offering incentives, another way is to limit the burden that respondents feel by participating in the survey. Questionnaires have therefore been designed to take no longer than two minutes to complete, as recommended in [7].

3. RECRUITEMENT AND PROMPTING SCHEME

This section describes the recruitement of participants and the employed ES prompting scheme.

The approach taken in this study consisted of three phases:

1. Recruitment and pre-screening.
2. Longitudinal in situ study of user behavior.
3. Post-interviewing.

For the first phase, a piggy-bagging strategy was applied through which participants from a prior survey campaign among users of the Norwegian miniTV mobile television broadcast network were invited to take part in our study as well. In addition to this, miniTV viewers were invited through advertising web-links displayed in the broadcast stream. A third scheme was via postings in the miniTV Facebook group. For all strategies, participants were informed that the study would be ongoing for a longer period of time and consist of several prompts a day on their cell phones. An important requirement was that the participants must own a smartphone (defined as a mobile phone with a web browser and 3G access), as the participants were to use their own phones and miniTV terminals.

This resulted in a total of 17 participants who agreed to carry out the whole longitudinal study. Out of these, 13 actually completed it.

All participants were pre-screened to get an overview of their background, demographic properties and media habits before actually being subjected to this study.

3.1 Prompting and Data Collection Platform

For the second phase a server-based prompting framework utilising SMS and mobile web communication was applied. As illustrated in Figure 1 the basic concept is that a server sends out text messages to the participants containing a link to a brief online corresponding questionnaire. The participants click on this link and fill out the survey using the built-in web browser of their cell phone. After having done so, the participants can submit their answer to the prompting system which stores this in a database. In the present study, a platform developed by UNWIRE [12] was used. Among other functions, the platform ensures optimal formatting of the forms, depending on the type of the mobile phone used, and records the users' ID through URL encoded ID-numbers. Thus, it is possible to keep track of individual participants' responses without depending on technologies such as cookies.

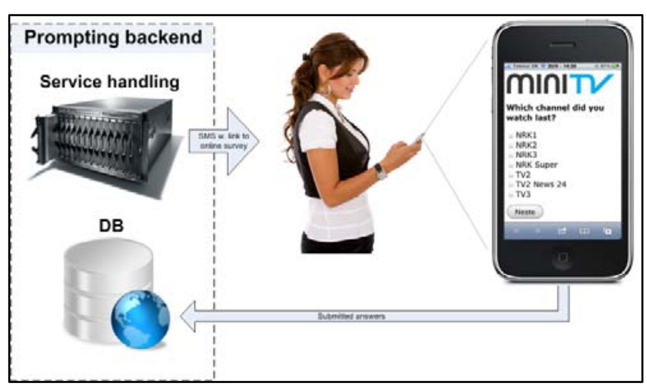

Figure 1 The prompting framework used in the study.

The platform includes a web-based administrator interface, allowing experimenters to design the prompts, define when and to who to send the SMSs, track and record the responses and compile various forms of brief summaries presented graphically. The full data sets can be downloaded and imported into e.g. Excel or a statistical package for analysis.

4. RESULTS

The focus is on the ES itself as a method, rather than the concrete information about mobile media use we gained during the ES. The main findings regarding the responses we obtained from a four week ES campaign, where we received a total of 200 responses from 17 users, who were prompted on average 2 times per day giving an overall response rate of 21%.

4.1 Daily Response Distribution

Figure 2 below shows the distribution percentage of the prompts answered by the respondents during the daytime.

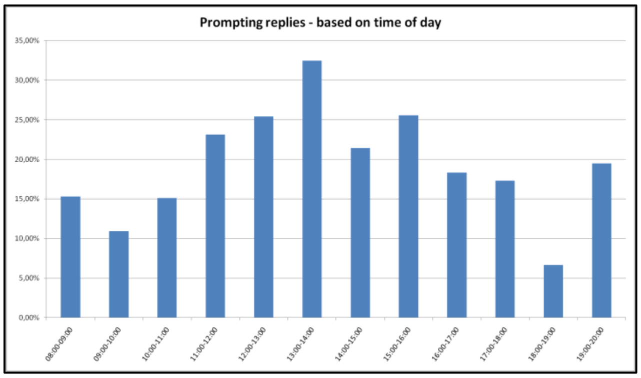

Figure 2. Time Distribution of prompts.

The prompts were sent randomly between 8-20 hours, and there is clearly a preference for the period from noon into the afternoon for responding.

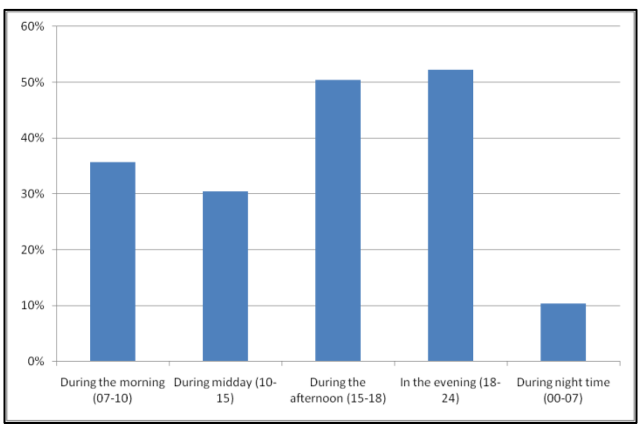

Figure 3. User's reported preferences.

This fits well with the reported preferences in the pre-screening questionnaire, as shown in Figure 3, where 50% of the respondents finds MiniTV most useful in the afternoon and evening.

4.2 Response Distribution over the ES period

Figure 4 shows the response distribution during the four week ES period. There is a very clear drop in responses after the first five days. On day six, there is a clear peak and after that, the response rate stabilizes at a much lower rate. This is due to a software error in the ES platform, which resulted in an excessive number of prompts being sent to the respondents. As a consequence no prompts were sent on day seven, which causes the gap in the graph.

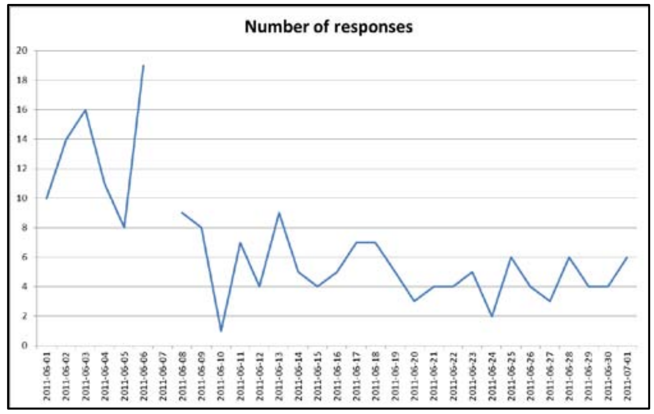

Figure 4. Response rates during the four week period.

4.3 Location and Social Context

A number of the prompts dealt with the location and social context in which the MiniTV was used. These were repeated throughout the ES period. The responses are showed that MiniTV was mainly used during transportation (71%), on the job (7%) or in other situations (21%), such as outdoors.

Regarding the situational context, 47% reported they last used MiniTV to seek "privacy in a public setting", 29% last watched MiniTV with friends or family during public transportation and 12% watched it alone during transportation.

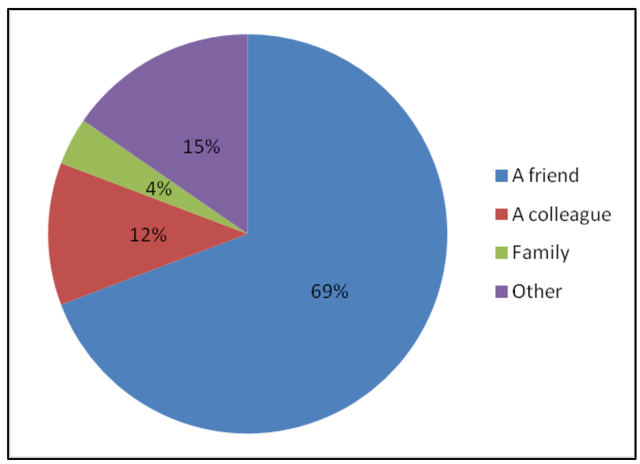

Figure 5. Social context.

Figure 5 shows with whom the respondent last watched miniTV. There is a very clear preference for watching with friends or colleagues (81%) rather than family.

In the pre-test survey 58% of the respondents reported that they find "during transportation" a most useful situation. Other significant responses are "at the job" (25%), "as extra TV screen at home" (35%) and "waiting for someone" (46%) and "when I absolutely must watch a program" (56%).

Apart from "transportation", this is quite different from the ES responses. However, the ES survey did not include evenings after 20 hours, so this probably explains why the "extra TV screen at home" is not present there.

5. DISCUSSION AND CONCLUSIONS

Looking at the results it is evident that both the number of respondents and responses are lower (about 20%) than could be expected from those reported in the literature (c.f. section 2). We assume there are several reasons for this. Most notably, the recruitment process suffered from a number of problems. Due to technical and other problems, there was a very long period (more than two months) between the respondents agreed to participate and the ES actually started. Therefore, some respondents had forgotten they agreed to participate, or could have changed their mind during this period. Furthermore, the ES was intended as a direct continuation of the pre-test survey, and this link was clearly broken because of the delay.

Another reason for the low number of responses was that a few days into the ES period, a software problem led to an excessive number of prompts being sent, which might have annoyed the respondents. After this incident, the response rate dropped to about half of that prior to that problem.

The incentive for participating was several draws of ticket for popular shows and a final draw for a miniTV terminal. Compared to those used in comparable studies (c.f. section 2), this is clearly lower – in [7] the participants were, as an example, offered a reward of 1$ per response.

A subset of the respondents participated in a post test survey. In this the majority of these felt that there were too many prompts per day. This is surprising when comparing to previous studies, [7], [10]. Some respondents were also frustrated with the high amount of similar prompts.

Some experienced problems with their phones having to copy the links from their phones to a regular browser.

Turning to the actual responses, these show a good correlation with the pre- and post-test surveys, except for a few cases as described above. This can be interpreted as confirmation and extension of the findings from the surveys.

As a final conclusion, we stress the importance of the recruitment process and communication with the test respondents as deciding factors for their willingness to continue to participate and respond to an ES test.

6. ACKNOWLEDGMENTS

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[1] http://www.minitv.no/

[2] http://unwire.dk/

[3] http://hoejteknologifonden.dk/

[4] http://cammp.dk/

Rapid Prototyping of Tangibles with a Capacitive Mouse

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ABSTRACT
This paper presents the Toki toolkit: a do-it-yourself guide and API to support the rapid prototyping of tangibles. The toolkit provides support for two common requirements for tangibles: capture of touch input by an user and communication of such input to a computer. At the core of the toolkit lays the capacitive surface and communication capabilities of a Microsoft TouchMouse, both of which are appropriated to fulfill the mentined requirements. Unlike existing approaches for rapid prototyping of tangibles like the Arduino boards, using the Toki toolkit does not require developers/designers to program a chipset, configure wireless interfaces, and define and implement communication protocols. The do-it-yourself guide illustrates how to create a cover for the mouse required to re-use its capabilities. The API offers a set of services to develop computer applications that interface with the tangible.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces: Input Devices and Strategies, Prototyping

General Terms
Design

Keywords
Tangibles, D.I.Y, Rapid Prototyping, Framework

1. INTRODUCTION
Tangible interaction uses electronically augmented physical artifacts to trigger digital events. Its implementations cover a wide field of interdisciplinary approaches ranging from playful installations supporting learning [10, 11, 12], to practical tools for interacting with digital information [6]. The core feature of tangible interfaces is the coupling of physical artifacts to computational models [13] and/or digital information. In most cases, the tangible receives user input, computes it according to a predefined model, and provides feedback which can be visual, auditory or haptic.

Figure 1: The touch mouse and the Toki pyjama.

In designing tangible interactions, designers usually follow an iterative process. Not too long ago, this was an expensive and time consuming process that required both programming and engineering skills. More recently, new technologies help cut both time and costs for *rapid* prototyping, as well as lower the programming and electronic hacking skills needed. An example to draw upon is the Arduino platform[1], a tool specifically designed to support the rapid prototyping of hardware by abstracting the complexity of circuit design and low level programming. This simple platform is aimed at learners and hobbyists.

However, despite these efforts to make the field of tangible interaction more accessible, much work remains to be done. For example, in order to build a simple tangible wireless controller for a computer application, even the Arduino platform poses a high level of complexity, requiring to: 1)- wire the artifact (optionally solder components), 2)- program the Arduino board, 3)- add a wireless communications shield to communicate with the computer, and 4)- define and implement a communications protocol between the two. On the other hand, the input capture and communication capabilities already exist in most computer peripherals like the mouse, which can communicate relative movement (x,y) and different click events. A special case is Microsoft's capacitive Touch Mouse[2] which communicates the state of its active capacitive surface as a byte matrix (13x15).

This paper presents the **Toki toolkit**, a method to appropriate the input handling and communication capabilities of the Microsoft Touch Mouse and use them to support the rapid prototyping of tangible controllers without the need to program the tangible object. The toolkit relies on a custom made cloth cover – pyjamas – (see figure 1) which tightly

[1]http://www.arduino.cc/
[2]http://goo.gl/d7bPJ

wraps the mouse and offers multiple contact points that can be linked to different parts of the tangible by means of metallic cables or conductive thread. The kit is composed of by a do-it-yourself guide to create the pyjamas and a software API to handle the events happening at the contact points.

2. RELATED WORK

At a conceptual level, tangible user interface (TUI) researchers have suggested a variety of taxonomical frameworks, concerned with defining terms, categorizing and characterizing systems, and types of coupling [5, 8, 13].

At a practical level, multiple projects studied development support for tangible interaction; consisting mainly on detecting interactions with physical objects and associating these real world events with a virtual counter part. Papier-Mâché [7] uses multiple sensing techniques (RFID, image recognition, and barcodes) to recognize objects and allows users to associate custom routines to the appearance of disappearance of such objects from the display. Phidgets [4] and iStuff [1] take a different approach and provide a set of pre-determined hardware components (sensors and actuators) which are supported by the framework and can be programmed by the developer. Hardware platforms like Arduino integrate with a wide range of standard electronic components requiring circuit building, wire soldering and programming in the *processing* language. The LilyPad Arduino [2] is designed for wearables and e-textiles, and therefore can be sewn to fabric and connect to power supplies, sensors, and actuators with conductive thread.

Moreover, educational computing research studies tangibles through the notion of *digital manipulatives* – computationally-enhanced versions of traditional children's toys [11] to support learning. A large subset of these educational toys is modular such as Topodo [10], LEGO Mindstorms [9], and Spelling Bee[3]. This modularity encourages creative thinking as each 'bit' can be put together with another 'bit' in new and unexpected ways, which suggest emergent affordances.

Our toolkit design aims to simplify the physical prototyping of tangibles. And although creating tangible interactive user interfaces is still non-trivial, there now exists technologies, like capacitive touch surfaces (phones/mice), which can be reappropriated to build simple forms of tangible interaction.

3. TECHNICAL APPROACH

The Microsoft Touch Mouse is a wireless mouse with a capacitive surface capable of detecting contact with a *grounded* object; the human skin is recognized as *ground* and this is the base for touch interaction. The mouse surface is represented as a 13x15 matrix with individual byte values (0-255) indicating touches at the each point of the surface. The mouse communicates this matrix to the computer it's paired to at a 120fps rate. The Microsoft Touch Mouse provides an API that receives this matrix and passes it on to any software application. Figure 2 shows the user touching the mouse and its matrix representation.

Due to the nature of capacitive surfaces, it is possible to extend the surface by adding wires or other conductive materials. Touching the wires will still change the capacitance of the surface and the change is reflected on the matrix. Our

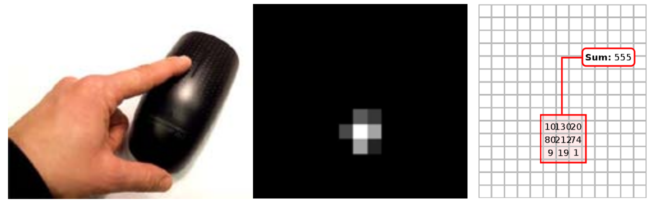

Figure 2: Interaction representation.

proposal is to use this extensibility affordance of the mouse to wire different parts of a tangible to pre-determined areas of the mouse surface. Figure 3 shows how the capacivite surface registers different values when the user is touching or not, and when the touch is directly on the surface or through a conductive wire extension.

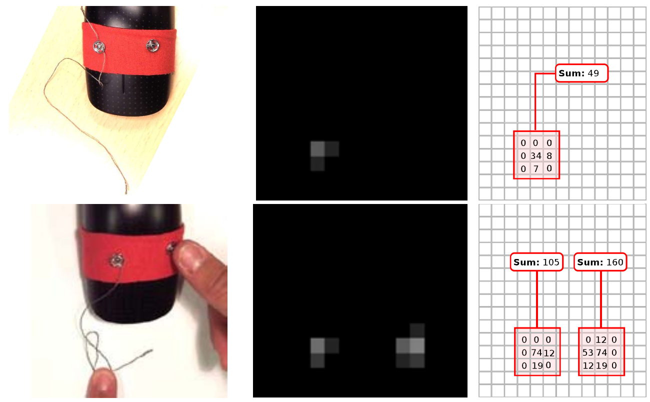

Figure 3: Interaction with and without extension.

Figure 3-top shows a challenge arising from extending the surface through conductive wires: the wire itself is registered on the mouse surface even though it's not being touched by a person. Figure 4-left shows the sum of all contact points for two different zones (a zone is a 3x3 square in the mouse matrix) where one is not extended and the other is extended with a 20cm conductive thread. The average sum of values for the zone once the wiring is added is what we call the **zone baseline**. The change on the sum when a human touches the wiring is what we call the **target margin**. Figure 4-right shows how the length of the wiring on each zone impacts both the zone baseline and the target margin. The longer the cable the higher the zone baseline and the smaller the target margin.

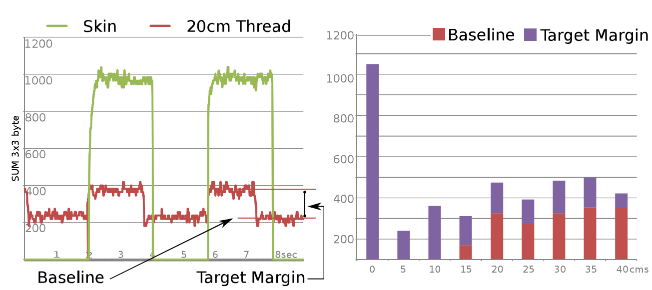

Figure 4: *left* – baseline and target margin on surface and at 20cms; *right* – target margins at different lenghts.

The Toki D.I.Y. toolkit aims at supporting amateurs in building and experimenting with simple designs of tangible interactions. The toolkit leverages the extensibility affordance of capacitive surfaces in the construction of tangibles, in a way that does not require prior knowledge about electronics, and consequently has the potential to alleviate some of the initial difficulties that novices to the field can experience. The toolkit's central element is a mouse pyjamas: a cloth wrapper for the mouse that holds 9 metal buttons in a 3x3 array, each touching the capacitive surface of the mouse. As the buttons are conductive, touching one will be registered as a touch on the mouse at the point where the button is located. By adding wires or conductive thread to each of the buttons, the surface is further extended and will register touch when the naked wire is touched. This construction is the core of the Toki toolkit - by wrapping the mouse in the pyjamas and adding wiring between this and any object, the mouse will recognize touches at the end of the wiring. The mouse with the pyjamas can then be added to any physical object to augment it with touch-recognizing capabilities.

In order to build and leverage the mouse pyjamas, the toolkit is made of two components which are explained in the following sections: 1) a do-it-yourself guide, and 2) a .NET C# software API and library.

4. D.I.Y GUIDE

The do-it-yourself guide presents a set of steps required to make the mouse pyjamas. The guide is a simple illustrated step-by-step brochure intended to be easy understandable. The guide takes the reader through the following steps: 1) cut out paper templates, 2) draw the templates on the cloth, 3) cut out the shapes of cloth, 4) sew together the pieces of cloth and add the velcro, 5) snap on the buttons, and 6) insert the mouse. Image 5 shows step 3 from the guide: cutting out the two pieces of cloth that make up the pyjamas body.

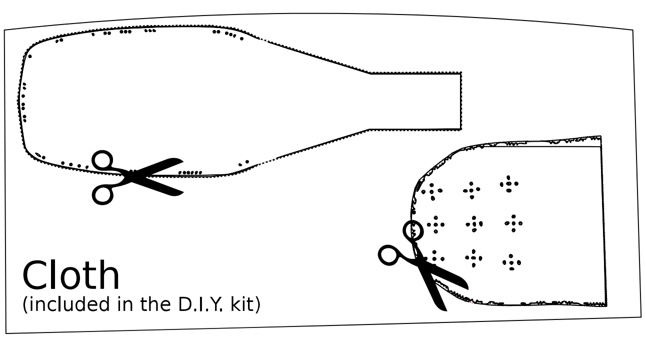

Figure 5: Example step from the DIY guide

As an example, the do-it-yourself guide shows how to make an interactive stuffed toy elephant by using our prototype out-of-the-box toolkit. In addition to a Microsoft Touch Mouse, the toolkit contains the following items: cloth, 9 snap buttons, needle, velcro tape, manual (includes paper pattern), normal and conductive thread. The guide, API, and sample application can be downloaded from the Toki website: http://itu.dk/people/mortenq/loki/.

5. API

The second component of the toolkit is an API that hooks into the mouse and translates the matrix input to a set of events on the 9 predefined zones. Moreover, the API handles calibration and provides mechanisms for recording and playback of interactions with the mouse.

Figure 6: Main components of the Toki API.

Figure 6 shows the main components of the Toki API. The central component is the *TokiManager* class to which the developer registers an object implementing the *ITokiListener* interface. The API is capable of recognizing 4 different *TokiEventType* events from each *TokiZone*: 1) finger down, 2) finger up, 3) tap, and 4) double tap. When any of the events is recognized by the TokiManager the application gets notified via the ITokiListener object. The API will only notify the programmer of events that she explicitly subscribed to.

As mentioned before, the mouse will recognize input signals when wiring is added even though no touches occur. To compensate for this, the API offers a calibration mechanism. Calibration should be performed each time a Toki application is started to ensure maximum precision of the touch detection algorithms. The calibration process is started by inserting the mouse into the pyjamas and invoking the calibration method of the API. The calibration algorithm will detect the average noise at each zone as well as the standard deviation. Once the calibration has finished, these values are saved and now used by the touch detection algorithms. The progress and finishing of the calibration process are notified to the application through the *ITokiCalibrationListener* interface. Signals are now only treated as touches if they exceed the average noise value plus two standard deviations.

Finally, the API provides a mechanism to facilitate the testing of the interactive application: the *TokiRecorder* and the *TokiPlayer*. By using this two objects the application developer can record into a file a series of user interactions with the tangible artifact, and then replay them within the application logic, avoiding the need to constantly manipulate the object for testing.

6. SAMPLE APPLICATION

We tested the toolkit by building an elephant toy and a simple application based around the childrens' game known

Figure 7: The Toki sample application with the elephant puppet and how it is wired to the mouse.

as 'Simon says'. In the example application we have made 6 touchable zones on the elephant: trunk, belly, ears and fore pads; each zone is connected by the conductive thread to the mouse. An image of the toy is shown on the screen, along with instructions on how to play the game: Touch the elephant in the order indicated by the red areas on the image, the green hand icon ( ) means pat gently on the designated area, a finger icon ( ) means tap the area – touch for less than 500ms, and tapx2 icon ( ) means tap the area twice in quick succession. At the start of a game, the player is presented with a sequence of red-colored areas on the image, and is expected to remember the sequence and touch the elephant on the indicated areas using either the patting or the tapping techniques. As the player advances through the levels, they are required to remember longer sequences. Figure 7 shows 1) how the toy is wired to the mouse pyjama, 2) how the mouse+pyjama are hosted inside the toy, and 3-4) screen captures.

7. DISCUSSION

The Toki toolkit provides designers and developers with an easy toolkit for rapid prototyping of tangibles, however it has its limitations. Attaching wire or conductive thread to the mouse will generate noise. While we implemented calibration methods to handle this there's an upper limit as to how long wiring can be. We tested our implementation with conductive thread and found this limit to be around 35 cm, however this may change with the material used. We have limited the number of contact points of the pyjamas to 9, because although it would be possible to add more zones, we expect users to make hand-made pyjamas, and so in order to ensure correct touch-recognition.

In the future we would like to look at other everyday capacitive technologies in their potential for rapid prototyping. Several smart-phones come equipped with capacitive screens and a wide variety of wireless communication capabilities; It seems possible to use these as the center of a DIY prototyping toolkit. Even though our toolkit provides a detailed guide to assemble and program a tangible prototype with Toki, it still requires the developer / programmer to be familiar with the C# programming language. We would like to look in to the possibility of adding visual programming support like for e.g. Scratch[3].

Finally we would like to perform empirical evaluations of the Toki toolkit. The first would be to determine the robustness of the toolkit. This evaluation would include testing it in different applications and with different wiring. The second evaluation should include designer and programmers to evaluate the usefulness and usability of Toki API.

[3]http://scratch.mit.edu/

8. ACKNOWLEDGMENTS

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Revisiting the Practice-Oriented Research Program

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INTRODUCTION

Within HCI and the related research field of CSCW the coupling between technology development and analytical findings based on ethnographic field studies has been under intense scrutiny. The general impression is that this coupling does *not* work properly. A widely quoted source of the impression that there is a problematic divide between ethnographic studies and technology development is an article by Plowman, Rogers and Ramage [13] in which they report on a survey of a large part of the workplace studies that had been published within the CSCW area by 1995. In the article, the authors find "a big discrepancy between accounts of sociality generated by field studies and the way information can be of practical use to system developers" [13, p.321].This proposition has led to concern and continual discussion of the role of ethnography workplace studies in CSCW [e.g. 6, 8, 9, 15, 17, 18]. Despite many attempts to cross 'the great divide' [5], it is still considered a major challenge to combine ethnographic field studies and technology development [7, p.155].

This article is an attempt to account for the relationship between analytical findings based on ethnographic field studies and technology development by revisiting 'the practice-oriented research program in CSCW'. In the process of this revision the following rationale or argument for the practice-oriented research program will be made: The development of technology for cooperative work is ultimately what CSCW is all about. If we accept the notion that 'technology' refers to the use of artifacts in practice, then it becomes clear that understanding human practice is integral to developing technology. Applying the methods of ethnography may afford us insights into practices that we would otherwise be unaware of. This is an important justification in that we cannot know in advance what the relevant features of a certain practice is, let alone how it is relevant for technology development and prospective users. Moreover, analytical findings based on ethnography, in the form of e.g. concepts and conceptual frameworks, may ground the technology development process by providing a framework in which it can be conducted, explored, critiqued and evaluated. Social scientific theory is an apparatus of the mind, a technique of perception and reflection that helps its processors see, discuss and ultimately act on phenomena. In this vein, the conceptual explorations of the practice-oriented research program in CSCW are (partly) intended to ground the technology development process within a context that may make designers sensitive to certain phenomena and provide a vocabulary or conceptual apparatus for thinking about design opportunities and design challenges. In short, analytical findings based on ethnography may be said to 'frame' technology development. As such there is no 'gap' (ideally) between ethnographic work place studies and technology development provided that the role of analytical concepts is taken into consideration.

This formulation is probably too compressed to be illuminating. It presupposes a specific view of the practice-oriented research program in CSCW i.e. views and understandings not least of technology, ethnography and conceptual development that must be brought to light. Below, we will attempt to do so by revisiting the practice-oriented research program in CSCW.

RELATED WORK

This paper relates to the literature on the relationship between ethnographic workplace studies and technology development and it attempts to make a contribution by explicating (as well as prescribing) the systematic connection between ethnographic studies, conceptual development and technology development by revisiting the 'practice-oriented program'. This study both builds and diverges from other contributions. It diverges from e.g. the work of Dourish & Button [9], Dourish[8], and Ackerman [1] since it is rendered *explicit* that the connection between analytical findings based on ethnography and technology development is *conceptual* by nature. This notion is in accord with Schmidt [18].

THE PRACTICE-ORIENTED RESEARCH PROGRAM

We will now revisit (and restate) the 'practice-oriented program' in order to explicate the systematic connection between ethnographic studies, conceptual development and technology development. In doing so, we will account for the nature of technology, the merits of ethnography as well as the role of analytical concepts in the technology development process. We will begin with a description of the aim and scope of the research field, as it was perceived at the field's inception.

The research area of CSCW emerged in the late 1980's[10]. The research field of CSCW can be briefly described as being concerned with the development of computer-based technology in support of cooperative work relations. For the casual observer, perhaps, the notion that CSCW is concerned with the *development of technology* for cooperative work may be conflated with the loose idea that CSCW is ultimately concerned with the *design of collaborative systems*. However, according to Schmidt [18], it is misleading to describe CSCW as a field devoted to the *design* of collaborative *systems*. The term 'system design' usually refers to engineering practices of devising a specific configuration of typically existing and well-known elements, such as software architectures, protocols, modules and interfaces, in order to meet specific requirements in a given setting or for a given type of task. The endeavour of CSCW is often of a different order. CSCW is (partly) a field of research devoted to the development of *technologies* that system designers can apply (along with existing technologies), rather than a branch of practical engineering addressing specific technical issues for specific settings or specific types of tasks [18, p.268].

The looming conflation of technology and system design is rooted in the fallacy that technology belongs to the category of artifact or thing, rather than the broad category of knowledge. The (misleading) claim that what is important about a technology is somehow embodied in the thing itself; that being a clock, a hammer, an electric motor is a position that can be found in George Basalla's *The Evolution of Technology* [3][1]:

"The artifact – not scientific knowledge, nor the technical community, nor social and economic factors – is central to technology and technological changes. […] the final product of innovative technological activities is typically an addition to the made world: a stone hammer, a clock, an electric motor […]" [3, p.30].

The notion that technology is primarily about the thing or artifact is misleading. Of course the artifact plays a pivotal role in the demonstration or application of the technology. But the artifact is only one part of the story. A technological artifact that is not integral to a living practice is merely a heap of junk, or perhaps on exhibit in a museum as a representation of a past technology the use of which is now unknown. That is, technology cannot be reduced to the artifact since the notion of technology refers to use in practice. From their very inception the concepts of technology and practice have been related like 'figure' and 'ground' – you can't have the one without the other [18].

Concepts are institutions that change over time as a result of their distributed use – sometimes coinciding, sometimes contradictory – in everyday activities. In the words of John Austin, 'Our common stock of words embodies all the distinctions that man have found worth drawing, and the connexions they have found worth making, in the life-times of many generations' [2, p. 130].

[1] This is a position that has been influential and widely cited within HCI [18]. See also [18].

In his recent book, following Austin's credo, Kjeld Schmidt [40] tracks the suite of connotations and references associated with the concepts of 'technology' and 'practice'. He emphasises that it will be at our own peril if we ignore the 'baggage' these concepts have. If we do so, we will not know what we are actually saying. A convincing (historical) account leads Schmidt to conclude:

"The concepts of 'technology' and 'practice' were from the birth joined at the hips, with technology as a systematic effort to investigate and transform the techniques applied in the practices of the useful arts. Accordingly, technology is traditionally and usefully defined as *rationalized* or *systematic* knowledge of the useful 'arts' or techniques […]. Development of technology, then, is essentially a systematic conceptual endeavour that results in *technical knowledge, methods, principles, etc.* 'Technology' is an ability-word" [18, p.267, original emphasis].

The notion that 'technology' is an ability word referring to use in practice is pretty far from the idea of technology as essentially a thing or an artifact as proposed by Basalla [3]. Moreover, *if we accept the notion that 'technology' refers to the use of artifacts in practice then it becomes clear that understanding human practice is integral to developing technology.*

We can appropriate an understanding of human practice through: (1) common sense and ordinary life experience and/or (2) analytical findings based on ethnography. The practice-oriented research program in CSCW makes use of the latter approach. Why? We will address this question in the following.

In order to appreciate the role that analytical findings based on ethnography play in the practice-oriented research program in CSCW we will first establish the nature of the enterprise of ethnography and subsequently discuss the role that concepts derived from ethnographic studies may have in the technology development process.

The merits of ethnography

Ethnography is part of the scientific tradition of both anthropology and sociology. The term covers a wide variety of analytical and practical commitments [15]. There is considerable overlap with other labels such as 'qualitative inquiry', 'fieldwork', and 'case study' with similarly fuzzy semantic boundaries [11].

For the purpose of this account, the term ethnography refers to a set of methods that direct the focus on the manner in which a phenomenon is enacted in practice and the way data or ethnographic material is generated through participation, observation, interviews and the collection of artifacts. Ethnographic enquiries can, in principle as well as in practice, be applied to a very large range of subjects including inquiries into kinship structures, customs, exchange relations, power relations, gender relations and technology development to mention but a few. Given this diversity it is hard and potentially misleading to describe ethnography as one unified method. However, we may at a minimum describe ethnography as a naturalistic pursuit that seeks to elicit the world from the point of view of those who live it [15]. We shall elaborate.

Ethnography can be said to be naturalistic in the sense that it is based on ethnographic fieldwork studies of actors in their 'natural' environment [15, p.54], rather than in an 'artificial' environment such as for example a controlled social science experiment or a questionnaire study. Data generated in 'naturally occurring' situations give us an insight into things that we could never imagine. As Sacks puts it, exploring what ordinarily happens in the actor's world 'we can start with things that are not currently imaginable, by showing that they happened' [16, p.420]. Potter [14, p.540] extends Sacks arguments by making a series of related points: (1) 'naturally occurring data' do not flood the research setting with the researcher's own categories (e.g. embedded in questionnaires, experimental setups etc.). (2) It opens up a wide variety of novel issues beyond prior expectations. (3) It may provide a rich record of practice. None of Potter's points deny that e.g. questionnaires or social scientific experiments for that matter can ever be useful or revealing. However, they do suggest that it is these techniques that should be justified, rather than techniques related to 'naturally occurring' settings. As Potter puts it, 'the question is not why should we study natural material, but why should we not?' [14, p.540].

Closely associated with the naturalistic commitment of the ethnographer is the notion that what is pursued is an understanding that seeks to elicit practice from the point of view of the practitioners '[15, p.56]. As Malinowski, one of the pioneers of ethnography put it during his seminal study of Pacific Islanders in the early 20th century, the aim is 'to grasp the native's point of view, his relation to life, to realise his vision of his world' [12]. This credo is very much echoed in today's studies of contemporary work practices [15]. We may note though, that this does *not* necessarily involve accepting what people believe to be true as being just that. That is, aiming to grasp the practitioner's vision of his or her world does not necessarily involve adopting his or her point of view. That is, we should avoid conflating understanding a worldview with adopting it. As Bourdieu and associates hold, the actors' account of their own practices is not necessarily an explanation of that practice; it may often be part of what needs to be explained [4].

In sum, if we accept that 'technology' refers to the use of artifacts in practice, it becomes clear that understanding human practice is integral to developing technology. Applying the methods of ethnography (or ethnomethodology) may give us insights into practice that we would otherwise be unaware of. This is an important justification in that we cannot know in advance what the relevant features of a certain practice is, let alone how it is relevant for technology development and the prospective users [15].

Analytical findings based on ethnography and the technology development process

At first glance making the connection between ethnographic studies of work practice and technology development may seem like a tall order. As described above, ethnographic field studies and design activities are often reported to sit uncomfortably together [see e.g. 13]. However, making the connection may be less problematic than it appears if we consider the role that concept and conceptual development can have in bridging the perceived 'gap'. That is, in the practice-oriented research program of CSCW analytical concepts based on ethnographic work place studies may serve as 'tools' in the technology development process.

According to Schmidt [18], bringing findings from ethnographic studies of cooperative work to bear on technology development may involve conceptual work. That is, coupling ethnographic data to technology development may require the appropriation or production of analytical tools i.e. concepts and conceptual frameworks aimed at technology development. Concepts or conceptual frameworks (however partial and fragmented they may be) can ground design practice by providing a framework for the exploration, comparison, discussion, analysis and evaluation of design. In this perceptive, conceptual frameworks may contribute to design in placing design in a context where it can be discussed in an overt and systematic manner.

Please keep in mind that the alternative to an analytical conceptual framework based on ethnography is a common-sense conceptual framework, rather than no framework at all [4]. That is, if conceptual frameworks based on ethnography (or ethnomethodology) are not positioned to provide a context and a vocabulary for the discussion of design, common-sense frameworks will step in and provide that context. Why is this problematic? This is unfortunate, because 'common sense' conceptual frameworks are, if not closed then at least less open to explicit and systematic critique than their ethnographically and analytically produced counterparts. That is, the schemes used in ethnographically produced explanations are tested (ideally) by being made completely explicit in for example articles and books where (ideally) they are scrutinised in a tradition of methodical and systematic critique. In contrast, the spontaneous sociology of everyday life is not open to the same measure of systematic critique. This is related not least to the lesser degree of explication in relation to many common-sense schemas of understanding [4]. Consequently, analytical findings based on ethnography may provide design practice with a *tested* and *critiqued* conceptual framework (one that spontaneous sociology cannot fully provide) within which design can be explored, compared, analysed and evaluated. Arguably, it is an important justification of analytical work that analytical findings such as concepts and conceptual frameworks can supplant unreflective assumptions about cooperative work.

Furthermore, and this is meant to reiterate a point made above, data generated in 'naturally occurring situations' through e.g. ethnography can give us an insight into things that we could never imagine [16], and these insights may be a great resource in the design process.

None of these points deny that common sense and ordinary life experience could ever be useful in the design process. However, they do suggest that it is design based on common sense alone that should be justified, rather than design related to analytical findings based on ethnography. That is, the question is not why should we carry out design informed by analytical findings based on ethnography, but why should we not?

Furthermore, according to Bourdieu and associates [4], social scientific theory is an apparatus of the mind, a technique of perception and reflection, which helps its processors see, discuss and ultimately act on phenomena. In the spirit of this assertion, we may hold that (ideally) the conceptual foundation of CSCW is intended to ground the technology development process within a context that makes designers sensible to phenomena and provide a vocabulary or conceptual apparatus for thinking about design opportunities and design features. As such, then, there is no 'gap' (ideally) between ethnographic work place studies and technology development provided that the role of analytical concepts is taken into consideration.

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CONCLUSION

The concepts and conceptual frameworks emerging from ethnographic workplace studies may be instrumental in providing, inductively, the conceptual basis for technology development that, ultimately, HCI and CSCW is all about.

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Personas in Co-creation and Co-design

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ABSTRACT

Including users in large participatory innovation projects together with professional innovators such as designers, people from marketing, engineers etc. puts a strain on the user that might not like to be the focus of attention.

With point of departure in two cases, one from business and a student project, the paper illustrates and discusses the use of personas as a mean to get users involved in innovation, how it can address their needs, and at the same time be a platform that gives all participants equal involvement.

Categories and Subject Descriptors

Hm

General Terms

Design

Keywords

Co-design, co-creation, personas, scenarios

1. INTRODUCTION

In the following I will present co-creation from a design perspective and introduce the persona method, in the final part present I will present two co-creation cases. The phrase “Design” covers a wide variety of disciplines, but can be summed up as all processes involved in designing a product.

1.1 Introducing co-design

Co-creation has very different definitions depending on the context it operates in. Co-creation in business views the co-creation process that seeks after the users who are special in that they have high knowledge of a specific area and an interest in changing products within this area e.g. [1] and [2]. A vast amount of time and resources are used to find these lead-users. Co-creation in “design” considers ordinary people to be able to be creative if they are facilitated and encouraged to be so. “Co-designing threatens the existing power structures by requiring that control be relinquished and be given to potential customers, consumers or end-users.” [3].

There is a distinction between co-creation and co-design, but the terms are often used intertwined. Sanders [4] defines co-creation as an act of collective creativity that is experienced and performed jointly by a group of people. Co-design is collective creativity that is applied across the whole span of a design process. This means that co-design is a specific instance of co-creation.

1.2 Co-creation

Co-creation exploits that the users possess knowledge about their own needs and daily life and their ability to be creative. Contrary to participatory design [5] the innovations of co-creation might not lead to artefacts that the participants will use themselves. The user is part of knowledge gathering, idea generation, and concept development. The designer/researcher provides tools for ideation and designs the innovation process. The designer/researcher and the user collaborate on the tools for ideation. Finally the designer/researcher gives form to the ideas.

1.3 Introducing personas

A persona is a fictitious user described with basis in data. The personas method is recognized in IT development within the private sector, but has spread to other areas such as marketing and product development.

The work with personas is about using the everyday experiences of the users and their needs as a starting point when developing new products. The persona method does not include real users but instead representations of the users. This leads to inclusion of the users' perspective in all aspects of the design process.

An example of how the method is used in marketing is the Japanese beer company Asahi Breweries that used personas to strategize the future of its Super Dry beer brand [6]. The most common use of personas is for a design team to use the user description to understand and engage in the user’s world in order to create new interaction forms or products that correlate with the users’ needs and contexts. In this use of personas actual users are present in the data, but not in the design process.

Often the method is perceived as a usability method. But as it will become apparent, personas are more of a design method covering all phases and all aspects of a development project. It has a wider focus than usability. The scientific foundation upon which the method is based is qualitative and based on the entire life-world of the user. The one reading the persona description must be able to understand and get involved in the persona even though it is just a description in text and images. This requires that the information presented can create a level of involvement. Thus, when gathering data we have to not only ask about what kind of work the users do, what their workflow is like, and what the purposes of using the product will be but also ask about their beliefs and attitudes. Always focusing on the area at which the design is targeted.

2. THE TWO CASES

In the following I will present a novel way of using personas together with role-playing for innovation and ideation. This form of ideation process can function as a open-ended process that gives value to both designers and clients.

The workshops described in this paper are based on 10 Steps to Personas [7]:

1. Data is collected
2. You form a hypothesis
3. Approval of the assumption
4. Set out a number
5. You describe personas
6. You create situations
7. Obtain approval from the organization
8. Disseminate knowledge
9. Writing of scenarios
10. Persona descriptions are regularly adjusted

Key to the 10 steps are scenarios that are stories describing the persona's interaction with an interface or product. As a story, the scenario has a main character, a setting, a goal, it has actions that lead to the goal, and it has obstacles that hinder the way to the goal[8].

2.1 The Professional Case

Arla Foods a.m.b.a. wanted to innovate within the, until then unknown area of canteens. For the purpose of creating new products from user knowledge an innovation process was created that consisted of: Scientific data gathering. User data gathering – 4 dynamic focus groups, each video filmed. Data analysis. From the analysis a documentary film lasting 30 minutes and two personas were produced. The material was used in an innovation workshop lasting two days.

The workshop had the following course of events:

- Introduction to data.
- A design game using the documentary and focusing on pain points.
- Presentation of findings in the game.
- Participatory innovation from personas and scenarios.
- Presentation and ranking of best ideas.

The participants that innovated were canteen managers, concept developers, persons from marketing, and engineers. All groups had at least one person from each category. Even though the canteen managers came on the second day of the workshop, they entered the groups without hesitation and got engaged in the creative process. It was easy for them to relate to the persona descriptions and they felt on equal foot with the designers.

2.2 The Student Case

Figure 1: The user explains to the moderator how the persona will act in the given scenario.

The aim of the innovation session was to develop a tool that could support communication between soccer trainers, kids, and parents. Prior to the session, data was gathered from observations and focus groups. From this two personas that had different behavior and media use were created as well as a number of scenarios that varied in situation and context. The participant was asked to go through all the scenarios from the point of view of both personas, with the intention of creating novel solutions.

The participant, a mother to a child who played soccer, had no problem in switching between the two personas even though only one resembled her-self. She was able to drawn on her knowledge of other parents and their preferences and behavior, but when she acted as the persona that resembled her-self, she often commented on the likeness, how she herself would react, and her own needs.

3. DISCUSSION

The two cases show how users 1) are able to act as personas and be as creative as professional designers 2) use their understanding of the area in focus to create scenarios both from the perspective of personas that are similar to them, but also from personas that are different from them, because they are familiar with different behaviors within the given design area.

It also shows how the users immediately are able to role-play thorough the scenarios and do this both alone and together with designers and other project participants.

The use of personas enables project participants to discuss from the same understanding of context and needs and at the same time allows the users to enter the discussion as an expert and relate to the innovation from their knowledge of context and work tasks.

The moderator plays a significant role especially in the case where the user did the innovations alone, both as someone who guides the sessions and someone who asks additional questions to the user.

The two cases shows that the users can be used for much more than validation as in classic HCI, as a UX specialist puts it in an interview about innovation, when presented with the idea:

"I actually was thinking how someone act as a persona would be a useful tool for participatory design. Like you're always having these design meetings between the consultancy and the client, and they will bring in the users for validation. But humans being are appropriating design all the time, they arrange their living, it's not a foreign concept to think about things. Certainly they can't be in charge as specialists. But having sessions that are open-ended like: 'how should we do this?'. I don't think that people understand the value of it." (UX specialist, Canada)

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Using Egocentric Point-of-View Video to Understand Tourist Place Making

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ABSTRACT
The conjecture underpinning this paper is that by drawing upon experiential components of tourist behaviour we might be able to better inspire a process of designing digital tourist technologies for in-situ tourist experiences. The paper works to sensitize researchers and designers of digital and mobile tourism technologies to place-making practices and inspire novel ways of conceptualizing and doing research in the tourist domain.

Keywords
Experience design, tourism, place, video, ethnography.

INTRODUCTION

If, as Bannon and Ciolfi argue (1) (2), the values and assumptions underlying ubiquitous and context aware technologies are unclear, the values and assumptions that underlie ubiquitous and pervasive systems for tourists are arguably even less clear. Some pertinent questions that this paper poses include: What we are designing when we are designing for increasingly mobile and ubiquitously connected tourists? Are we are simply designing more efficient systems to support tourists and the accompanying devices doing "traditional" tourist things, or if we are, in effect, beginning to redefine the ways in which places are "made" by tourists by adding new informational infrastructures and networking services to locations? As Jansson puts it, in reference to the increasing role that different kinds of media play in the tourist experience, media and technologies *"influence perceptions of place, distance, sociality, authenticity, and other pre-understandings that frame tourism"* (3: 1). Understanding this change is a challenge that necessitates a methodically rich, varied and theoretically well-grounded understanding of tourist practices and places.

We argue that tourism and being a tourist is a performative practice. This entails that we understand tourism as a specific approach to being-in and engaging with places rather than as a catch-all term for a specific *product* provided by operational or business agents in tourism. In this paper we understand being a tourist as a multifaceted and complex phenomenon that can be seen to entail a specific sensibility of the world of the part of the tourist. Touristic experiences describes those experiences that are usually associated with being away from home, from the mundane, but at the same time "being away" only partly describes being a tourist. Rather, the tourist experience is characterized by a particular performance and and sensibility towards and engagement in a place. This view on tourism as a situated action is bolstered by Baerenholdt *et al's* critique of the concept of the *destination* (a simulacra for 'place' in the lingua franca of tourism (4), in which they note that, "destinations are geographical images which work at a distance, collapsing in proximity, where place-specific encounters matter" (5): 29). In this sense, tourist places are both "made" and actively consumed and performed by tourists. As Baerenholdt *et al* argue, explaining the performative nature of tourism, "places are not seen as authentic entities with clear boundaries that are just waiting to be visited. Places are intertwined with people through various systems that generate and reproduce performances in and of that place" (Ibid, 139). Human geography inspired approaches to tourism has highlighted the "experience of place" as a key element of tourist experiences (e.g. (6). Place making is the result of performances in place and of activities that include both sensual and cognitive sense-making processes. So, while there are many ways to conceptualize the experience of tourist places, this paper uses the experience of place as a short hand for the holistic or felt experience of "being in place" – the affective, embodied, and cognitive involvement in a particular place.

This work in progress paper provides examples drawn from ethnographically inspired interventions in a tourist location with the aim of uncovering "place-making" practices, ultimately aimed at inspiring design of innovative mobile and context-sensitive technologies and services for tourists. It suggests that *Egocentric Point-of-View* (egoPOV) video can assist in data gathering that would lead to a richer understanding such place-making activities.

TECHNOLOGY IN THE TOURIST SETTING

Primarily explored within proof-of-concept frameworks, typical research on tourist technologies has focused on validation and evaluation of mobile information systems prototypes for different kinds of tourism (e.g. (7). With inspiration from the seminal Cyberguide project (8) and the GUIDE project (9) a project that utilized mobile computers in a variety of settings to design localized and context-sensitive information systems that function as guides or visitor resources, several projects have focused on mobile information guide systems for tourism. Much technical research that ostensibly has to do with travel and tourism treats the geographical displacement and sightseeing information needs as the primary challenges tourist technologies can solve. For example the Cyberguide project (8), using tourism for its primary application area, proposes that, “The long-term goal is an application that knows where the tourist is, what she is looking at, can predict and answer questions she might pose, and provide the ability to interact with other people and the environment” (8). Whilst it is unclear what kinds of interactions with people and the environment the system is designed to afford, the statement that the system should “know where the tourist is, what she is looking at”, would suggest an informational metaphor and a simple sender-receiver relationship underlying the understanding of the tourist and the service environment.

It seems that the application of mobile and ubiquitous technologies in tourist setting has given rise to the import of too simple concepts of tourist behaviour, embodiment and experience. Although early work on mobile guides generated a wide range of insights of a technical nature, it seems that the application area was somewhat incidental, driven primarily by the fact that tourism provided a fitting and recognizable field of practice unto which technological concepts could be projected.

The work of Brown and Chalmers (10), Tussyadiah and Fesenmaier (11) and Axup et al. (12) constitute three useful exceptions from the predominant focus on technical issues, technology acceptance challenges, and the design of useful interpretation technology layers in a tourist context. Brown and Chalmers use an ethnographic study to draw out implications for designing tourist mobile technologies. Tussyadiah and Fesenmaier use “netnography” to analyse and understand spatial patterns of the tourist experience. These studies emphasize the need to approach tourism as a practice that takes place in the interaction with a particular setting rather than a pre-hoc identifiable process. Tourism “takes place” and only becomes “tourism” in the course of doing “touristy” things. Brown and Chalmers focus on the improvised and collaborative problem-solving that tourists typically engage in when at a destination. Typically those associated with planning and navigating while on site. Tussyadiah and Fesenmaier focus on what they tentatively call the “tourist experience”. Both studies emphasize how tourist experiences and practices are mediated or brokered by mobile technologies, and point towards implications for design. In a somewhat similar fashion, Axup et al. propose lo-fi prototyping interventions to explore social practices between backpacker tourists. Particularly focussing on “matchmaking” algorithms on mobile devices, Axup et al study how lo-fidelity prototypes of ubiquitous computing services offering matchmaking and information sharing for tourists can disclose the problem-space of tourist socialising practices to ultimately inform design.

Using egoPOV video

Tourists, by and large, visit places. Being a tourist involves far more than simply transporting oneself to a specified point on the earth's surface. Rather, as Brown (13) describes it, the experience of being a tourist involves "complex engagement of material practices with bodily actions and emotions", albeit this occurs in a manner in which place plays a central role. Place is central not only to interaction but the very notion of being and self. As Casey said, "to be is to be in place" (14), pg. 14). Tourist places are locations that become attributed with affective experience during dialogical interaction and are thus afforded a particular meaningfulness in the context of tourism. The become tourist places, so to speak, through people treating them as tourist places.

Place and place making are key concerns for our design work, as we believe that the concept of place underpins the design of digital technologies that have moved from the desktop to be part of the environment. Indeed, design themes are often grounded in the social, cultural, and material conditions of a specific place (15). However, capturing data that allows an understanding of place making in the wild is difficult and time-consuming. Egocentric point of view (egoPOV) video cameras (mounted in a fixed position on the participant) have been used to depict both the fleeting and temporally ongoing experiences that contribute to creating meaning during spatially embedded interaction (16). The egoPOV method affords the grounding of design themes in the social, cultural, and a material condition of a specific place by becoming a technological site for cultural encounters (17) and thus contributes to the design process with an enhanced understanding of the experience of place-based activities by the participants.

Fig. 1: The Ego-POV hat, mounted with key-fob camera

Egocentric point of view video has previously been used to depict both the fleeting and temporally ongoing experiences that contribute to creating meaning during spatially embedded interaction (18).

The strength of the egoPOV approach lies in the way it provides a relatively unobtrusive means of capturing situations, interactions, and orientations. Mounted on the underside of the peak of a cap, the unobtrusive and lightweight camera quickly ‘disappears’ from view, being ‘absorbed’ into the garment, and does not hinder head movement or interactions. EgoPOV video is relatively undirected compared to other video methods. The researcher can accompany the tourist, and does not have to aim a camera at the participants. The method also serves to produce useful artifacts for contextualizing and understanding the sensory and embodied environment of the participants. As Browning et al. argues, the method "provides a reasonable indication of the participant's gaze temporally consistent with the participant's remarks" (18). An example of this can be seen can be seen in a case where one of the authors are walking down the beach front with Christiane and Paula, a young Danish and a German tourist couple on Magnetic Island, North Queensland, Australia. They are walking with their feet in the shallow water, Christiane wearing the hat with the camera on this hot, calm, and sunny day. It´s 2:00 PM in the afternoon, the sun is beating down. The participant researcher is conducting a think aloud and needs to prompt the participants:

> Researcher: Ah, …could you talk a little about, about what you are thinking about?
>
> Christiane: Yes, we…I actually don't think that much right now (Laughs). Just enjoying.
>
> Researcher: So, when you are thinking something…
>
> Christiane: …yes…(walks, looking down at her feet in the water)
>
> *[9 seconds elapse]*
>
> Christiane: Again, I think it is strange why there isn't any people on the beach here, when they have these summer houses…

This example shows how Christiane's immediate embodied interaction with her surroundings, her feet in the shallow water and the hot sand (which she later mentions) is disturbed by the researcher's prompt for "thoughts" or some representation of what she is experiencing. Quite a substantial interval elapses after the researcher's prompt, and her response seems somewhat unnatural and strained. As researchers, we have been taught to probe, to ask, to interview, and when we have quiet respondents to engage with them, create rapport, provoke responses. However, here, at the beach, at this precise moment Christiane is simply too immersed, fascinated with her own activity, caught up in the pleasure of simply moving her feet through the water, feeling, enjoying. EgoPOV allows us to see and recall those moments, to notice how the participant's attention is engaged, see that while she strolls down the beach, her attention is fixed on her feet, walking in a slow, contemplative and peaceful pace without saying a word. Such interactions with an environment can be very hard to appreciate from e.g. interview data alone, and even from 3rd person (i.e. researcher directed) video recorded data, as the actual posture, kinaesthesia and head orientation can be difficult to capture (18). Thus, egoPOV lends itself to furnish design ethnographic interventions with a richer and more embodied and sensory perspective that supports the kinds of "sensory ethnographies" (19) that we argue are crucial for understanding tourist experiences.

CONCLUDING REMARKS: INFORMING DESIGN?

We argue that a first step in informing the design of new and innovative tourist services and technologies that leverage the power and convenience of spatial and contextual interaction is the understanding of how tourists are involved in "making places". As we have argued, the first step is to conceptually reconsider what it is tourists do. We have argued that going from a "product" based and informational view of tourists who simply consume spaces (and information put in place through a variety of media) according to a predefined topology of services and designs towards an understanding the emphasizes how tourists are actively performing practices so as to make them "touristic". Being a tourist, then, entails entering a temporary particular mindset, doing particular things. The next step is beginning to understand tourist practices from within. Using egoPOV video and "accompanied" tourism we have conducted a series of study of tourists on Magnetic Island, a small island in North Queensland, Australia. Following tourists around and using egoPOV video as artifacts for interpretation, we have been offered a glimpse into tourist activities and possible ways of performing tourism.

Findings from these trips include insights into how "pretty sights" such as beaches and foreshores are transformed (and domesticated) into places of activity and the tying of temporary and ephemeral networks with other tourists. For example, a French tourist couple we followed to a beach on the island became engrossed in the activity of catching coconuts with a "local" Australian couple. Using egoPOV enabled us to see how the different "props" of a location (a beach) were enrolled in the establishment of the contact between the two couples, what things were noticed and returned to by the tourists (e.g. a derelict chair placed on the beach), how distance and intimacy was negotiated, and how the bodily movements and subtle signalling between the interactants was used to facilitate contact. Thus, from the *setting*, a designated and mapped beach "designed" and made available for visitors, a *place* emerged as a network of natural/artificial things and the social environment.

Fig. 2: Walking towards the beach, recorded with EgoPOV video. The van, the Australian couple, and the coconut palms provided

the setting for the negotiation of an ephemeral and shortlived collaboration network centered on getting coconuts from the palms.

From the fieldwork on Magnetic Island we propose that, in the effort of inspiring design of mobile and context sensitive technologies and services, it might be useful to understand the tourist as a networker rather than a (necessarily distanced) sightseer.

So, rather than supporting the tourist in collecting information on sights or aiding her or him in proper interpretation of sights and places, we propose that seeing the tourist as a networker widens the design space of tourist technologies and services dramatically. Relevant scenarios that follow from the understanding of the tourist-as-a-networker could be e.g. making on-site tourist-tourist interactions or tourist-local interactions easier and less intimidating to engage in.

We propose the egoPOV method as a intervention into the "experiencescape" of tourists. Used with participant observation of tourists ("accompanied tourism"), the method enables discrete observations of tourist practices and lends an attentiveness to the embodied participant, an understanding of how movement, sociality, networks and the active body play crucial parts in the performance of tourist places.

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HCI issues in mobile wallet design

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ABSTRACT
This paper presents the processes and products of a design science research project on mobile wallets (m-wallets). M-wallets are virtual versions of the physical wallet that enable cashless payments. Four different user groups consisting of teenagers, young adults, mothers, and businessmen, were involved in the process of identifying, developing and evaluating functional and design properties of m-wallets. Interviews and formative usability evaluations provided data for the construction of the initial conceptual model in the form of sketches, and the subsequent functional model in the form of low-fidelity mock-ups. During the project, knowledge was gained about what properties the users would like the m-wallet to embody. These empirically derived design properties of m-wallets were compared with those of current cashless payment systems. The identified properties have been clustered into 'Functionality properties' and 'Design properties', and are offered as theoretical contributions to the ongoing research on m-wallets.

Keywords
Mobile wallet; design properties; cashless society; digitalization.

1. INTRODUCTION
The digital revolution continues to transform most aspects of our daily life. In particular, the digital revolution has resulted in the vertical convergence of business channel capacities and the horizontal integration of marketing departments [8]. The digital revolution also continues to transform the public sector organizations and services [7] towards an envisioned cashless society [3]. Additionally it is now possible to make purchases on the go with mobile payments transacted through mobile phones. With this comes the need for a personal information system to manage such mobile transactions. Therefore, a potential next step in the digital revolution is the transformation of the time honored traditional physical wallet into the mobile wallet (m-wallet).

There are many mobile payment solutions, but most of them have failed or their adoption rate has been lower than expected [9]. One reason for this is that payment is an institutional act, which cannot be easily changed. Payment is transacted in almost the same way worldwide. Further issues arise when companies additionally develop their own electronic payment systems, such as those for public transportation and retail chains. So, there is a need for standardization of mobile payments [6]. Therefore, it is suggested that technological development of such solutions should be directed towards a closer cooperation with users [2], and that future mobile payment research should focus on usability, as this is an unexplored area of mobile payments [9; 12]. Set within this context, the purpose of this paper is to identify design properties of m-wallets.

2. DESIGN PROPERTIES IN LITERATURE
The literature does not contain much information about the specific properties needed in an m-wallet. That said, some guidelines for the design of an m-wallet were found when examining the literature and existing solutions.

It is argued that electronic payments have several advantages such as accessibility, convenience, speed, privacy and control, and that electronic payments are preferred in simple routine service transactions. It is furthermore emphasized that mobile payments should not imply advanced multi-step procedures; codes are preferred for identification and authentication; and consumers consider mobile payment useful if it is able to constitute several plastic cards [1]. The reasons for using traditional human assistants are security concerns and the opportunity to get help when skills with new technologies are lacked or the system malfunctions. A mobile payment channel should therefore furthermore communicate a high level of security and contain a helpful design that guides the user by means of careful communication, in order to make the user feel as comfortable using the new payment channel, as when using the traditional payment channels [9]. With regard to design properties the results show that mobile payments should be deducted from an already existing account, that payments should be made through another technology other than text messages, and that transactions need to be recorded locally on the mobile phone for documentation matters as well as on the distributed databases [9]. An additional design property identified in the literature is the display of current balance that can be seen before making a transaction [10].

Besides what can be found in the literature, a look at the existing cashless payment systems themselves gives an idea of how they work. In a review of 13 systems (including VISA payWave, MasterCard PayPass, PayPal Mobile, Google Checkout, Paybox, Banxafe, SMS Tickets for mass transit systems, The Travel Card, Oyster Card, Octopus Card, M-PESA, ZAR Card, and SMART Money) 65 different design properties were identified.

3. METHODOLOGY
The choice of method was driven by the research problem, which is the identification of m-wallet properties with focus on the interaction between the user and the artifact. The focus on human-computer interaction leads to issues that are complex and grounded in multiple disciplines. Consequently, questions

frequently arise that have a thin or no theoretical background, and exploring these, is where Design Science Research – exploring by building – proves useful [16; 5].

3.1 The design process

There are several guidelines and approaches on how to conduct design science projects [4; 16]. This project draws upon Takeda et al.'s [16]. model. The choice is motivated by that it was one of the earliest to structure and formalize the process of using Design Science. The model is also applied in recent literature [17].

The process starts with an *Awareness of the Problem* phase, which typically comes from wonder or a problem in current practice that the researcher aims to solve. The output of this phase is a description of the problem and a proposal for researching this problem. The following phase is *Suggestions* for a problem solution, which are drawn from existing knowledge (literature and existing artifacts), followed by an attempt to implement an artifact based on the suggested solution (called the *Development* phase). It is in this *Development* phase that most of the design takes place. The techniques for implementation vary, depending on the artifact to be constructed. The implementation itself can be very ordinary and does not need to involve innovation beyond the state-of-practice for the given artifact; the innovation is in the design, not the construction of the artifact. The output of this phase is findings about the artifact's application and functionality. Afterwards an *Evaluation* of the implementations is made, and finally, a *Conclusion* phase indicates that the design project is finished by deciding that the results are "good enough", and by summarizing what the contributions of the artifact are. The phases *Development*, *Evaluation*, and further *Suggestions* are iterative until the results reach saturation [16].

3.2 User involvement and data collection

The users involved in this project were mainly found at Facebook among peripheral acquaintances and friends of friends, in order to keep prior knowledge of the interviewees to a minimum and minimize biases. A further selection criterion for the interviewees was the degree of use of technology in their everyday lives, as this was estimated to be necessary in order for the interviewees to be able to understand the m-wallet concept. The number of users was 26 for the *Suggestion* phase and 16 for the *Evaluation* phase.

The participants for both phases represented four different user groups: Young Teenagers (YT), Young Adults (YA), Mothers (M) and Business Men (BM). The reason for choosing these four user groups is that they loosely cover the phases of Wells and Gubar's [18] widely used consumer life cycle. Furthermore, one underlying assumption is the need for multiple solutions from different user groups. The interaction time between researcher and user varied from 15 to 60 minutes and were conducted in the autumn of 2010. To avoid the issue of the artificial environment intimidating the interviewees, the interviews were held at a place chosen by them, mainly their residence or work place.

4. THE IDENTIFICATION OF M-WALLET PROPERTIES

4.1 Awareness and Suggestion phase

The starting point of the design process was the identified lack of knowledge about what design properties the user would like an m-wallet to embody.

The work with the *Suggestion* phase took its starting point in interviews with 26 users. Participants were recruited from the four user groups based on the assumption that the groups would differ from each other, regarding their needs and expectations to the wallet. Munck [10] emphasizes the understanding of end-users' behaviors and needs is a success criterion for contactless and mobile payments. This phase involved four steps:

4.1.1 Usability goals and user experience goals

Usability goals are concerned with meeting specific criteria of usability, whereas user experience goals are concerned with developing user experiences [15]. However, as this project only focused on design properties and not on the user experience, the usability was the focal point while user experience goals were not written. Yet, it is important to note, that the two kinds of goals are not clearly separable, since each of the goals is related to the other. The following overarching goals were identified during the first round of interviews:

- *Efficiency*: Carrying out a common task such as paying with the m-wallet, should imply no more than six steps, which is the number of steps it takes to pay with a payment card today (take the card out of the wallet – place it in the payment terminal – type the PIN – click OK – remove the card from the terminal – put it back in the wallet).
- *Safety*: It should not be possible to make a payment by mistake. This goal was chosen since; security is perceived important according to the interviewees.
- *Utility*: The m-wallet should provide an appropriate set of functions that will enable users to carry out their conventional tasks from the physical wallet, in the way they want to do them. This was chosen as a criterion for usability because of the fact that the interviewees had so many different ways of using their wallets.
- *Learnability*: It should be possible for user to work out how to use the m-wallet by exploring the interface. This is important, as people do not like spending a long time learning how to use a new system. Learnability is especially important for interactive products intended for everyday use.

4.1.2 Personas

After having defined the usability goals, four personas were created representing the four user groups. The use of personas was chosen, as it allowed focusing on designing m-wallets to exactly these users, rather than to a whole group of users. Each persona was created as a mixture of an amount of user data, and thus, such descriptions are called fictitious user descriptions [11]. The creation of personas followed the proposed structure in the second phase of The Persona Lifecycle, which focuses on persona conception and gestation [13].

4.1.3 Sketching

Following the personas, the next step was started when the interviewees were asked to draw a sketch of an e- wallet. As Linus Pauling once said: "The best way to get a good idea, is to get lots of ideas". In this process the participants were also asked to show their own physical wallets as inputs for discussion. Thus, the interviewees' ideas ended as sketches for four different wallets; one for each of the user groups. The sketches within each group were then mixed into one composite sketch, i.e. controlled convergence. Besides controlled convergence, which is about discarding ideas or part of ideas, Pugh [14] used another notion, called concept generation. Concept generation is about expanding the scope by adding new ideas.

4.1.4 Scenarios

In this project, the above-mentioned new ideas came from the writing of scenarios that followed the sketching process. Personas and scenarios are inextricably linked, as personas are useless without scenarios [11].

4.2 Development phase

In the *Development* phase, four m-wallet mock-ups were created. A mock-up is often used as a topic for conversation in for example an interview, but the mock-ups in this project were used as prototypes. A prototype is a more or less functional model that enables stakeholders to interact with the imagined product. It is of great help in the design process, because it brings designers to completely new considerations, when they are going to take something from inside their minds and turn it into something physical and/or digital. Figure 1 presents the sketch for the Young Adult's m-wallet and the mock-up that was created, based on this sketch.

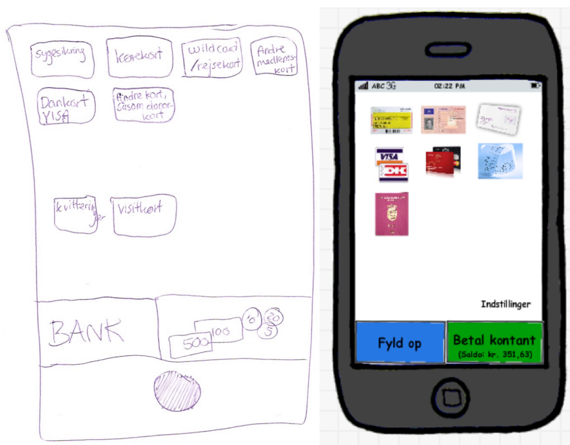

Figure 1. Sketch and mock-up for the Young Adult's m-wallet

4.3 Evaluation phase

The *Evaluation* phase consists of an analysis of the gathered findings and an assessment of to what extent the artifact fills in the imperfections made explicit in the proposal from the *Awareness of Problem* phase. As Hevner et al. [4] explain it: "A design artifact is complete and effective when it satisfies the requirements and constraints of the problem it was meant to solve." Therefore the Evaluation phase focuses on what went good or badly, and decides whether or not an iteration more is needed. This phase involved 15 people to evaluate the design solution. The questions asked were concerned with:

- The users' understanding of the m-wallet's properties
- What impression they got when they first saw the m-wallet
- What they thought about the properties that was specific for the m-wallet compared to the physical wallet
- If they would like to have any other properties in the wallet
- What they liked and disliked about the m-wallet

Based on the user tests, a list of four categories of design properties for the m-wallets was derived: Home Screen, Services, Interaction, and Interface. The design properties for the Home Screen cluster refer to features and aspects that were deemed essential or desired for the starting page of the m-wallet. The Services cluster collects the functional properties. The Interaction cluster consists of navigational aspects. Finally, the interface cluster collects the design properties related to placement, look-and-feel and other user interface aspects.

The Home Screen and Interface clusters contained the highest number of design properties requested by the four user groups. Further, 24 design properties were needed by just one user group.

The Business Man, as it was expected, required the highest number of services and home screen features. On the other hand, the Teenager and the Young Adult placed greater emphasis on the interface design properties. This indicates that while functionality is the critical design consideration for the professional user segment, aesthetic and experiential aspects of design should be prioritized for the teenager and young adult user segments. For the Mother and other user segments with time pressures, a minimalist m-wallet is to be designed.

Comparing the empirically derived design properties with the design properties found in the extant literature and in existing systems, the following design properties were uncovered as being universally required across the four user groups:

- "Settings" button, allowing the user to edit the m-wallet
- Currency conversion
- Purchasing list and total amount
- Headlines facilitating usability
- Advanced, user-group specific properties
- Icon structure in the menu in contrast to the text structures in existing e-payment systems

5. DISCUSSION AND CONCLUSION

A finding that emerged from this design science project is that the way the user tests were conducted, proved to be very useful for this project, as it allowed for explanations when needed. Some of the test users had difficulties grasping the idea of an m-wallet. Those who understood the concept of m-wallets right away, on the other hand had many questions, especially concerning security and other aspects of mobile payments that are still uncertain. The user tests additionally revealed that it is of great importance when testing an innovative product to ask the test users to ignore the question of whether they would use it, as this showed to affect a couple of the tests.

Moreover, the user tests lead to further questions that had not been originally planned and which might not have been asked to all the test users. E.g., if the test users proposed ideas that had not been proposed before, the test users in the subsequent tests were asked about this proposal, in order to have their opinion. This project was, however, an explorative design project, and nothing was given in advance. It was therefore all right to test several ideas. The design expert can be said to be the person who has tested several kinds of solutions, in order to find the right one, and to learn from those who went badly.

Several new ideas were proposed through the last iteration of user tests and others' designs of the m-wallet were still inspiring the user groups. The evaluation results showed that another design iteration is needed and it is concluded that the m-wallet proposed by this project, is not yet ready to be launched. That said, it was neither the purpose nor the scope of this project to design a fully functional m-wallet. Instead, the objective was to document design and functional properties that can help inform further research into m-wallets in particular and mobile payments in general. This has been achieved by proposing the set of design and functional properties for the m-wallet based on user centered design methods and by comparing these empirically derived design properties with those found in the extant literature and existing mobile payment solutions.

A big challenge in the work with the m-wallet was to clarify what functionalities each button should have. There were almost as many opinions as there were test users. Moreover, this project focused on developing different wallets for different user groups. It was from the beginning assumed that a standardized m-wallet would hold many customization options and thereby be confusing to the user. This could lead to a situation where the user would not want to use the m-wallet. However, the evaluation revealed that all the user groups had actually suggested a settings function to be added to the wallet to allow for customization and personalization. Therefore, there is a need to further explore how users would use such a standardized m-wallet with customization and personalization options, For instance, through user tests of functional prototypes allowing them to interact with the m-wallet as an IT artifact.

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TagPad for iPad – Designing a Support Tool for Interview Studies

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ABSTRACT

In this paper we present the iPad app TagPad. The app is designed to support interview studies. It's been designed to fit flexibly with structured and semi-structured interviews for both small and large-scale studies. TagPad can record audio and save text entries and multiple-choice answers. The data can be uploaded to a cloud-based data repository making it simple to access and share data. To get a better understanding of how interview studies are conducted, particularly the data collection phase, we looked into 12 ongoing studies and found that the data collection often is associated with unorganized and complicated processes. We present the results and briefly discuss how TagPad can optimize and support these processes.

INTRODUCTION

We here present and provide and overview of TagPad – an iPad app designed for conducting interview studies. It's intended to support the data collection phase and also offers the possibility to add tags to the interviews for pre-analysis. The idea is to provide a tool that can support research and automat some processes while still offering the researcher flexibility and creativity so it's not the tool dictating the data collection. As Barbour points out qualitative research should not be reduced to a list of technical procedures. It should not be: *"the tail wagging the dog."* [1].

Not only are we interested in developing a usefulness tool. We also wanted to better understand the data collection phase in interview studies and the context in which studies are being conducted. The data collection phase is an area that still needs more investigation. Such knowledge can help determining how collecting data can be made more effective and reliable. Other research has shown that when developing tools for researchers the settings and requirements need to be understood [4]. By examining ongoing studies we investigated how data collections are carried out and in this paper we present the results. Running trials only to determine if an application can be considered a success or not is neither that useful or interesting. It's both difficult to decide when a trial can be labeled as a success and to get a broader understanding of the system and the diversity of the users [2]. Therefore domain knowledge is part of the development process. Not only is this knowledge useful when designing features and interface. The knowledge will also be useful for further studies of TagPad including setting up field trials and to better understand the feedback gained during these trials. When designing and evaluating a research tool it's also about looking into how the tool positively can change existing procedures, deciding on good practices for using the tool, and not least looking into the limitations of the tool. The intention with this paper is to introduce TagPad and provide a summery of the information gained from examining 12 ongoing studies.

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THE TAGPAG APP

TagPad[1] is an iPad app designed for researchers conducting interview studies. The app can be used for qualitative studies or quantitative data collections such as in-person surveys and is designed both for in-person and phone interviews. It's been designed to fit as flexibly as possible with structured and semi-structured interviews. The basic concept is that an interview guide/instrument is loaded into TagPad (See Figure 1.) and different input can be added to the different questions. As input TagPad can record audio, save short text entries and multiple-choice selections. The researcher decides how to combine the input. For example, TagPad can purely be used to record audio, it can be used for only short text entries and/or multiple-choice questions or a combination, so some or all answers can be recorded while some or all questions can be answered with short text entries and/or multiple-choice options. Because of this flexibility TagPad can be considered a multi purpose interview tool suitable for a wide selection of qualitative and quantitative studies. The output generated by TagPad consists of an audio file containing the entire interview and individual audio files for each question. For flexibility audio files are saved in the MP4 format (.mva) recognized by common audio players. Text entries and multiple-choice options are saved in a comma-separated values (CSV) file.

[1] The version described is 1.02. Latest information about TagPad can be found at http://www.tagpad.info

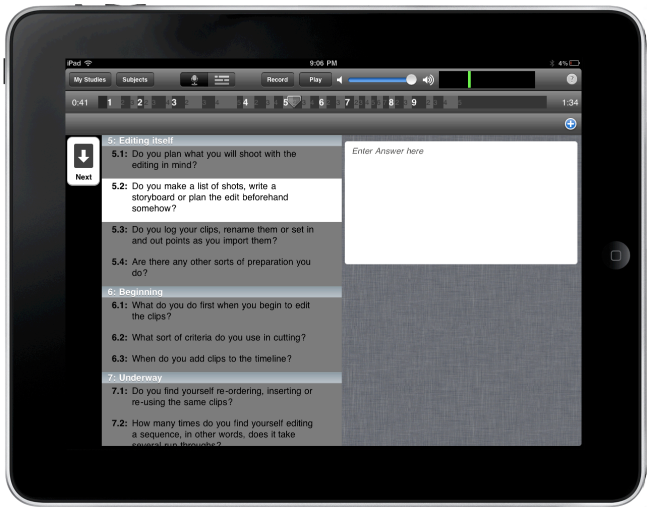

Figure 1: An interview guide is loaded into TagPad. Here question 5.2 is selected. It is possible to audio record the answer and/or type in a short text entry.

Figure 2: This is the analysis view of TagPad. Here it's possible to add custom tags to each interview for pre-analysis.

TagPad has a simple analysis view for quick analysis to support selective transcription etc. (See Figure 2.). Besides having playback capabilities tags are automatically added to the audio timeline for each question so it's possible to locate where in the audio a specific question was asked. Custom tags such as "Good quote" can be added making it easier to navigate, locate and share specific audio segments. Tagging is possible both during and after an interview.

TagPad uses cloud computing for data storage and currently uses the service Dropbox [3]. This file storage service synchronizes files between connected devices such as, desktops, laptops, tablets, and a Web accessible file repository. Dropbox was chosen because it's free, widely used and has some built-in collaborative features including easy file and folder sharing and auto backup. Despite using a cloud-based data repository, Internet access is not needed during interview sessions, as all data also is stored locally.

A vital feature of TagPad is the platform it's running on – the iPad. This tablet computer is partly defining TagPad because it offers the interface and input sensors needed all in a lightweight portable device. This platform was found suitable for the circumstances and environments many studies are conducted under. For example, an iPad can be operated while standing up and is convenient for interview sessions or observations requiring mobility. In comparison to a laptop the iPad is less of a barrier and less intruding during social interaction. In addition the iPad can agilely be prepared for an interview and operates fairly long on battery without the need for an external power source. With TagPad it was an aim was to design a "turnkey" app that easily can be integrated into many different projects and to design an app that does not require a high level of technical expertise to operate. To achieve this we focused on developing an app with a minimal set of features and options and an app producing output in common formats.

EXAMINING THE DATA COLLECTION PHASE

We looked into 12 different ongoing studies to get a better understanding of the data collection phase in interview studies. All studies were either in the study design or data collection phase. A representative for each study explained us the study outline, time frame, and which participants they were looking for. We asked how they would organize the data collection, which methods they would use, by what means they would collect the data and which questions they would ask. To get an authentic picture we requested answers based on actual experiences and not how they ideally wanted to or originally had planed to collect data but how it actually occurred. We looked into both small and large-scale studies, from research teams consisting of only one person conducting 10 – 20 interviews to research teams of 15+ planning to conduct up to 1000+ interviews. Out of the 12 studies eight can be classified as small-scale studies with one to four teams members completing 10 – 25 interviews. Four are considered large-scale studies with five+ team members and 100+ interviews already completed or planed. The studies conducted qualitative interviews, quantitative surveys and observations. A mixed approach was common, for example, in one study observations would be mixed with interviews.

A Closer Look at the Interview Studies

In the small-scale studies the involved researchers would complete all stages, from designing the study, to recruit participants, write the interview guide, conduct the interviews, analyze the data and write a rapport or paper. Occasionally some subtasks such as transcription would be outsourced. In the large-scale studies the research team would consist of several sub-teams. These teams can in general be divided into an executive group that would be in charge of the study and involved in the analysis, a group would collect the data, and a group would be involved in analyzing data chunks. Often there would be overlaps between the different groups, so some data collectors would also be involved in the analysis process etc. To illustrate we here present two studies with very different proportions. The first study presented is a joint project between eight American and Mexican universities. In the second study presented the research team consisted of a single person – a grad student collecting data for her master's thesis.

Large-Scale Study: Mexican Deportees Survey Study

In this project deported Mexican immigrants are asked to participate in a survey regarding their illegal entrance into the US and their deportation back to Mexico. The aim is to get a better understanding about what happens to Mexican deportees. Potentially politicians, think tanks, and activist groups can use this information.

The participants are mainly recruited and interviewed at shelters and immigrant drop-off locations such as bus stations at the border. They are in the age range 18 - ~50 years old and the average age is about 32. Often the participants are in an intermediate stage, using shelters for a short period of time before they will try to reenter the US or move on to other locations. A large majority are Mexican citizens, and the remaining subjects are citizens of other Central and Southern American countries. The goal is to conduct 1000 – 1500 in-person interviews. The paper-based survey consists of about 250 questions, and typically about 170 questions apply to a given participant and takes about 45 minutes to complete. The survey consists of a mix of open-ended and multiple-choice questions. For the open-ended question, answers are written down in one or two short sentences or keywords. Rarely interviews are audio recorded. After completion the paper-based surveys are scanned and forwarded to a team manually typing in the data from the scanned surveys into a spreadsheet. The quantitative data will be statistically analyzed and it's still not clear how the qualitative data will be analyzed. The study is a joint project between eight American and Mexican universities and overall 15+ people are involved in the project. Researchers and in particular grad students are participating for shorter periods and typically grad students will collect data as part of their studies. An executive group is designing and leading the study. The group will in collaboration analyze the data and plan to meet for a series of workshops to coordinate the analysis. It's the plan to repeat the study in a few years for comparison purposes.

Small-Scale Study: Study of Food Habits Among Pacific Islanders Living in San Diego

This study explores the role of traditional foods among the San Diego Pacific Islander community. The project looks at connections between food, health, and identity. An applied anthropologist student using the data for her master's thesis conducted the study. She is the only person involved in the project and will complete all steps of the study from study design to data analysis and final write up. The aim is to complete 20 interviews. All participants are pacific islanders living in San Diego and are in the age rang of ~20 - ~80 years old. Participants are participating in a single session lasting about 45 minutes. Interviews are taking place at different public locations such as cafés and at the beach. The interview guide consists of very open-ended questions and often people will start talking about anything under the sun. Occasionally the researcher will e-mail the participants afterwards for clarifications. The interviews are being audio recorded and she uses a paper-based interview guide. Notes are taken on a piece of paper, for example, spelling of unfamiliar food names etc.

HIGHLIGHTS FROM THE INTERVIEWS

The use of paper-based interview guides/instruments was dominating. Notes were taken on notepaper or laptops (or both) and/or noted in the margin of the interview guide. Researchers recording audio used simple external digital audio recorders. In general recording of audio only applied to the small-scale studies. The interview guide was in most cases very dynamic and would be changed over time, as irrelevant questions would be removed and interesting topics further explored. Using a paper-based interview guide allowed rapid changes during the interviews.

For a large majority of the interviews the researchers would commute to meet with the participants. This is often the case because of practical reasons, for example, when interviewing patients at a hospital, and when the nature of a study requires it such as when doing field observations. This also means that access to Internet and an external power source is not guaranteed.

We found that the processing of the collected data often is complicated, unorganized, and involves several links. In the large-scale studies involving hundreds of in-person interviews or surveys a common approach was to scan the completed paper surveys and then forward the digitalized versions to a team manually processing the data. This process involved several people and is time consuming. Similarly in the small-scale studies processing was done manually including uploading audio files and notes to a computer, organizing the files, and creating a backup. Notes would both be saved and organized in text files and on paper. Particularly the management of notes was very different from study to study.

Simple tools were used for managing the data. For example, word processing software was often used both during the data collecting and the analysis. The use of dedicated Computer Assisted/Aided Qualitative Data Analysis software (CAQDAS) was uncommon. Particularly in the small-scale studies it was common to use whatever software was available and possible to get for free or low cost. Using technology to support the data collection was something our participants was interested in but they had trouble finding applicable software.

Securing collected data was an explicit concern because of the resources needed to collect data and because an observation or interview can be hard to do over again. This was a central reason for using low-tech tools such as pen and paper because they are considered reliable. High-tech solutions were found more risky and stressful to use. When recording audio the quality was often questionable. Often the recordings would contain a lot of background noise. This was particularly an issue when doing phone interviews because the audio was recorded using the phone's loudspeaker resulting in heavily reduced audio quality.

Audio recordings were almost exclusively being transcribed and then not used again during the analysis. It's not uncommon that audio recordings can last an hour or more so navigating and effectively finding the right segments has been pointed out as challenging. Instead the transcription is used to single out interesting and relevant segments.

We found that the strategies for both the data collection and analysis were only prepared on a very general scale. This applied to all aspects of a study from recruiting participants, deciding on interview locations and interview strategies. Mainly a general study design was decided beforehand, all remaining parts would be dealt with ad-hoc.

DISCUSSION

Based on our examination we identified two centrals elements of the data collection phase. One element is the actual collection when a researcher conducts an interview or observation and saves data such as field notes, audio, video etc. Interview studies are conducted using a paper-based interview guide, notepaper or a laptop for field notes, and an audio recorder. The idea with TagPad is to create a tool that combines these tools into one integrated solution while utilizing the features of the iPad. The iPad with TagPad installed provides a powerful IT instrument that can operate without Internet access, has a relative long battery life and has the option to connect to the mobile Internet. As mentioned the format of the iPad itself is an essential factor because it offers the interface and input sensors needed all in a lightweight portable device with a screen size still large enough to be useful. This applies to several levels. First off the size and lightweight is important because researches often commute to meet participants and to conduct field observations. Secondly an iPad blends in well with most settings. For example, recoding audio during observations can feel less obtrusive to the participants because it's not sensed as an explicit audio recorder. During interviews the iPad can be less of a barrier in comparison to a laptop.

Another element of the data collection phase is the processing and management of the data. This includes organizing, storing, archiving, and preparing the data for analysis. This step has several subtasks. For example, digitalizing and transferring the data to a spreadsheet, database, word processor or CAQDAS. This part of the data collection was found to be challenging and time consuming. By automating some of these tasks, such as a simplifying data uploading, a goal with TagPad is to make this part less challenging. Combining TagPad with a cloud-based data repository adds further advantages including the support of auto backup and more options for data sharing and collaboration. Based on our examination we believe both small and large-scale studies can benefit from these advantages. In particular we believe TagPad can support scientific collaboration because the data rapidly can be made available online in common data formats and this can be done with minimal technical skills. In large-scale studies having several people collecting data TagPad can help both streamline the data collection making it more consistent and support a smoother and less complicated uploading process. Because conducting a study is time consuming and complex and often involving people with different backgrounds and skills we have focused on designing a tool that is fast and easy to learn. Our approach was to implement a minimal set of features and automat some processes. It was clear that our participants are anxious to loose data so feeling comfortable with the tools used is absolutely essential.

We also recognize some potential flaws. TagPad can be too inflexible for certain studies. Especially interview guides based on very open-ended questions because the interview guide cannot be modified during an interview. Another issue is that tablet computers not are suitable for all environments, for example, some outdoor conditions such as rain and direct sunlight. Further a tablet computer might not fit into all interview settings and can potentially receive too much attention and focus and act as a barrier between the interviewer and interviewee.

CONCLUSION

We have presented the iPad app TagPad designed to support interview studies and in-person surveys. We have also looked into the data collection phase in both small and large-scale studies. Our goal was to introduce the features and design of TagPad and provide a better understanding of how data collections are conducted in reality. This is both useful for further development of TagPad and to consider how research can be made more reliable and effective. We found that a major challenge was processing the collected data and this was done unstructured and ineffective. With TagPad we believe it will be possible to better streamline the data collection and automate some processes such as uploading data.

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Understanding work practice in Global Software Development

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ABSTRACT
The aim of this research is to understand collaborative work practices in global software development in the industry. I present a preliminary interview based case study and an on going work place study of a mayor Danish Software Company and their collaboration with its outsourcing partner in the Philippines. I have an inductive research approach where the data material shapes the investigation and points of interest will be investigated further. In the end of the paper I introduce two areas of interest from my observations and shortly discuss implications in these areas.

General Terms
Human Factors

Keywords
CSCW, Global Software Development, GSD, Work Practices

1. INTRODUCTION
Global software development (GSD) is the main focus of my research and the initial research question is "*How can we understand collaborative work practices in global software development?*" My current research question is described in fairly broad terms because I use an inductive research approach where the data material shapes my investigation. The strengths of the inductive approach for theory building have been argued to be novelty, testability and empirical validity (Eisenhardt, 1989). However, the aim of the research is to understand the practices involved in GSD work and conceptualize challenges and opportunities when working in a globally distributed setting.

This research is part of an overall research project called "GSD - Next Generation Technology for Global Software Development". This project seeks to develop next generation technologies – infrastructure, tools, and methods – that bridge geographical, temporal, and cultural differences in Global Software Development. In this project I collaborate with a Danish software company, which will be named GlobalSoft for the purpose of this paper. GlobalSoft is my primary research partner, but I am also having contact to other smaller software companies and their activities may also be of interest for my research.

2. RELEVANCE FOR CSCW
I am doing work place studies of global software development where I investigate the work processes needed in the development of software across geographical distance. I specifically research work practices in a global software development companies, which has also been described by Boden, Nett & Volker (2009) and Herbsleb, Paulish & Bass (2005).

I am especially interested in understanding how we can describe the work needed with regard to relation work and knowledge sharing. The importance of these concepts has previously been discussed in the CSCW literature (Newell et al., 2007; Orlikowski, 2002; Cramton, 2001; Jarvenpaa & Leidner, 1999) and my studies contribute with a work place study from the industry of global software development.

3. PROJECT DESCRIPTION
The project has been on going since the beginning of August 2011 and will continue at least until the end of June 2012. The client of the project is a governmental department and the software product involves a large part of the public sector in Denmark. Therefore the impact of this software application has political interest, because it will affect employees in the public sector, private companies and Danish citizens.

GlobalSoft primarily have Danish clients from both the private and public sector. Typically clients will contact GlobalSoft with particular needs for a new IT system, or GlobalSoft will answer to a public call for tender specifying the requirements for the proposed IT system. The initial negotiations of the scope and specific requirements of the project are handled by the Danish side of GlobalSoft together with the client and the negotiation with the client is done with little or no involvement from the outsourcing partners. When the initial scope of the project is defined, the project is spilt into different tasks where some or all of the tasks are send to the Philippine outsourcing department. One of the key documents in this process is the requirement specification, which is developed by GlobalSoft in Denmark in cooperation with the client. The requirement specification is meant to define the product in detail including all the diverse requirements needed in the software product.

3.1 Current research
The initial research began in November 2010 where my colleagues and I held interviews on different organizational levels in GlobalSoft. GlobalSoft is a company with around 1500 employees in different locations around the world. The majority of the employees are located in Denmark, but they also have locations in India, China and the Philippines. Our preliminary study consisted of 14 semi-structured interviews lasting an average of 50 minutes with employees at different organizational

levels (see Table 1), and as such we had the opportunity to compare the cooperative vice president perceptions with the IT-developers perspectives. Our questions were mainly focused on the collaborative tasks and the employee's perceptions of the collaboration with the Philippines. Analyzing the data material we coded and categorized the interview material in order to establish a systematic overview of the data.

Table 1. Data Sources of preliminary research

Job function	Number of Interviews
Cooperate Vice President	1
Vice President	1
Director	1
Manager	3
Team Leader	2
Advanced Project Manager	1
Senior Project Manager	2
Project Manager	1
It-architect	1
Developer	1

Based on this preliminary study, I am now engaged in a work place study conducted in GlobalSoft. Work place studies seek to investigate and observe the world as it is and try to understand how people act in the world (Randall, D., Harper, R. & Rouncefield, M., 2007). I intend to use ethnographic methodology in order to examine the different activities related to the work practice of GSD and gain a deeper understanding of the work processes involved in developing software across geographical distance.

I plan to apply an ethnomethodological approach, where I consistently follow one specific project in the company for four days a week. I have full access to project meetings, documents, mock-ups and I also have my own office space in the project. I will continue these observations for the next four months studying the work practices in both in Denmark and the Philippines, where the developers of the project are located. After the initial four months, I will continue the observations on a smaller scale until the launch of the software product, which according to plan, is in the end of June 2012.

3.2 Initial findings

I am still in the initial phase of my work place study, however, I have already noticed two areas of interest that I hope to investigate further and possibly discuss at the poster presentation.

The first area of interest occurred to me during a meeting in GlobalSoft where I was present as an observer. The attendees were all members of the project and they were really worried about how they could keep track of changes in the requirement specification in order to fulfill the contract. In general then the requirements in the contract is defining the end product. However, they were concerned that the requirements are listed different places such as SharePoint, which has an annoying user interface, so often they export the requirements to Excel and use it there. This creates many different versions of the same document and furthermore, the client and GlobalSoft are having an on-going discussion about how to interpret the requirements, but it is not always clear, what interpretations they agree on.

It seems that there is a serious need for a shared forum where all the change requests are updated and verified by the client to make sure that the client re-sign the changed contract. I feel that this area is important to understand, because there is a lot of articulation work going on that needs to be documented systematically to keep track of the development process.

My second area of interest relates to the communication of shared knowledge. In terms of the requirement specification, the Danish employees often experience that the Philippines misinterpret or misunderstand the intended meaning of the requirement specification. The requirement specification contains all the tasks for a given project, but the descriptions of the tasks are often part of a predefined context. Thus misinterpretations and misunderstandings often is a result of knowledge taken for granted in Denmark. A Danish manager in the GSD Company illustrates the current situation:

"[The Danes] should also have an understanding for them [the Philippines] that they may not recognize everything. That they spend time to talk about what a prescription is. And what a pharmacist is?"

(Manager)

The manager in the above quote is talking about how different understandings of a concept can influence the project. In this example he mentions a prescription and a pharmacist as concepts, which are perceived differently by the Philippines. In Denmark the official authorities govern the pharmacists strictly and all pharmacist have undergone 5 years of University studies. All prescriptions are sorted in IT-systems and are efficiently monitored by the authorities. Doctors authorize the prescriptions after a consultancy and submit it to a general database where all pharmacists have access to it. The patient can then go to the nearest pharmacy and collect the medicine. The manager recognizes that the Philippine employees may not comprehend the applied context of a prescription or a pharmacy in the requirement specification. Therefore it becomes essential to talk about what a prescription or a pharmacist is in order to develop a common understanding of these concepts.

The manager is describing a problem, which cannot necessarily be solved by further detailing the requirement specification. In contrast these challenges are grounded in the taken for granted background assumptions between the Danish and Philippine employees.

4. CONCLUSION

I have presented an outline of my current research and I hope to further discuss my data collection methods and initial findings at the DHRS 2011.

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The Quest for Quality: Usability Testing Assessment

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ABSTRACT

High quality usability testing is not trivial. The author studied professional usability moderators who carried out commercial usability tests. Eight out of nine moderators received serious or even critical notes on their adherence to commonly recognized procedures for usability testing. A key problem was that moderators talk ("babble") too much.

Author Keywords

Usability evaluation, think aloud testing, moderation, quality, quality assurance, certification

INTRODUCTION

The software guru Gerald M. Weinberg has formulated the Zeroth Law of Software Engineering: "If you don't care about quality, you can meet any other requirement." For usability testing this implies for example that as long as we have no quality requirements or we don't follow up on quality requirements, anything will do as a "usability test" and a "usability test report".

Little is known about quality of usability work in general and usability testing in particular. Nørgaard and Hornbæk [5] suggested that think-aloud tests might not get sufficiently analyzed. They saw a tendency that evaluators end up focusing too much on already known problems, and that the questions they ask during a test seem to concern problems that the user expects rather than problems actually experienced during the test.

The Comparative Usability Evaluation (CUE) studies have shown a number of worrying deviations from good practice in the area, for example hidden clues in tasks, unusable usability reports, and unusable recommendations [4]. The CUE studies did not analyze actual moderation.

Until now, usability testing has been considered an art that is beyond traditional quality assessment. However, over the past 30 years the usability community has accumulated extensive experience on what works and what doesn't in usability testing. A number of great textbooks on usability testing have appeared, for example Dumas and Redish [1], Snyder [7], Rubin and Chisnell [6], Dumas and Loring [2], and Krug [3]. Although there are differences in the approaches suggested by these books, there is also a significant overlap. We are slowly arriving at a basis for systematic quality assurance.

Usability testing becomes ever more critical for checking that users have a good experience when they use a website, an intranet or a product. But who checks the checker? Are usability test moderators good enough? Do moderators adhere to recognized good practice in usability testing?

METHOD

During the past 2 years the author has carried out quality assurance (QA) of summative usability tests of e-commerce websites and intranets. The tests were carried out by nine usability test agencies in various countries.

QA checks were ordered by clients who regularly outsource usability activities. Clients were concerned about the reliability of some of the usability results they received. They wanted uniform and state-of-the art usability tests across agencies, including usability tests conducted in languages they did not understand. Clients also wanted to be sure that consistent approaches were used so they could safely make important decisions based on the results. The clients dealt mostly with reputable agencies, and almost all the people involved in these tests had considerable experience, impressive portfolios and relevant exams from renowned universities. In one case, QA was used to screen an agency with limited usability testing experience.

The agencies and the assessed moderators were aware that they were going to be evaluated.

PROCEDURE

Assessments were conducted in the following way:

- The agency recorded 4-8 summative usability test sessions on video. Each session lasted 30 to 60 minutes.
- The agency sent the raw videos together with the test report and any other relevant documentation to the assessor. Ideally, the videos showed what happened from the moment a test participant entered the test room until he or she left. The videos and websites were in several languages; videos and websites that were not in a language that the assessor understood were observed by the assessor together with a hired, professional translator.
- The assessor selected one or two of the videos for closer inspection and analyzed them in accordance with a checklist. The assessment was not limited to the

checklist; the assessor was free to make notes on any deviations from commonly accepted practice in usability testing not covered by the checklist. The website that was tested was accessible to the assessor.

- The assessor wrote a short report that pointed out the strengths and weaknesses in the usability test procedure. The goal was to provide advice that was usable – that is, actionable, comprehensible and in accordance with the state-of-the-art in usability testing. The main goal was to help the agencies involved rather than to point fingers at them.

To keep costs down, assessments were carried out remotely, and the assessor only made spot checks of the videos. If more resources had been available, the assessor could have travelled to the test location and observed all test seesions. Each assessment took 10-20 hours, depending in part on whether the assessor understood the language used in the session; if not, the assessor went through the video together with a translator.

Checklist

The checklist used for the assessments reflects critical issues in usability testing. The list is based on considerable experience from the CUE studies [4], observing large numbers of usability tests, discussions in usability forums, and the previously cited textbooks. The checklist is evolving – at this time it contains 68 checkpoints divided into 8 categories; the list can be adopted to fit specific needs of clients.

Category	Number of checkpoints
Test participants	4
Test tasks	8
Introduction - Welcome and paperwork	4
Pre-test interview	9
Moderation	19
Debriefing	5
Report	16
Efficiency	3

Table 1. Usability testing assessment checklist.

As an example, the following list shows some of the checkpoints for "Moderation":

- Is the test setup realistic?
- Is the test setup ready when the test participant arrives?
- Is the test session affected by a previous session?
  This could happen, for example, if the cache is not cleared properly between sessions, so input suggestions from previous sessions appear.
- Are tasks handed out in properly without any risk for misunderstanding, for example in writing?
- Is the moderator sufficiently curious?
  Does the moderator follow up on any important unclarities?
- Does the moderator appear interested in what the participant is saying and doing?
- Does the moderator say as little as possible while the participant is solving tasks?
- Does the moderator say as little as possible between tasks?

The procedure and checkpoints were fully available to the organizations that were subject to QA because we feel that it's unfair to assess people based on secret criteria.

RESULTS

Until now, nine assessments of usability professionals carrying out summative usability testing have been completed.

The general results were:

- One professional passed with flying colors
- Two professionals had serious deviations but no critical deviations from generally accepted good practice in usability testing
- Four professionals had both critial deviations and serious deviations
- Two professionals did so badly that the assessor recommended that the client should not pay for the service, or that the test should be repeated at no cost for the client.

A "serious deviation" from good practice may skew important results. A "critical deviation" from good practice will skew important test results seriously.

Serious problems found

Moderators deviated from good practice in ways that affected test results. Examples:

- Moderator spent excessive time on unnecessary instructions and smalltalk ("babble")
- Clues from moderator
  For example, during checkout, participants were asked to enter name, address, credit card number, date of birth, etc. Since sessions were recorded, the moderator quite reasonably decided that participants should not use their own information. Instead, the moderator handed them a sheet with artificial data. The labels on the sheet corresponded exactly to the labels on the screen.

- Moderator and note taker findings not coordinated
  A client paid to have both a moderator and a note taker present during test sessions believing that this would increase the quality of the results. QA found that the reported results were based solely on the moderator's notes. No coordination of moderator and note taker notes had occurred. The note taker's observations were lost.
- Key findings were difficult to understand
  A few of the reported usability issues were hard to understand. They were either terse, written in bad English, or broadly formulated without examples.

  Example "Good: participants anticipate to log-in in order to upgrade their [product]"
- Reporting issues that were encountered by only one participant out of 8
  In general, usability issues should be reported only if they are encountered by several participants. If issues that are encountered by only one participant are reported, a detailed justification is required. It was not provided here.
- Issues whose impact was correctly classifed as "minor", were reported as key findings
- Important findings not reported
  The video showed critical problems that were not reported or were reported differently from what the video showed. For example, the report said that some participants had problems finding detailed information about products. The videos showed, however, that participants did not care about detailed information because the website did not help them find the simple, usable and cheap products they wanted.

Some moderator mistakes did not directly affect test results but presented ethical problems or serious quality problems in the documentation of the test:

- Pressured test participant to reveal private data from Gmail
  One test was set up so participants needed to access an email to get a password. The moderator asked participants to use their own email account. In one case, a test participant was clearly hesitant to show the contents of her inbox. The moderator put pressure on her to read the email. When her inbox was displayed, it showed headers of emails from her boyfriend with highly intimate information.
- Unusable audio
  Several of the videos received by quality assurance had a sound level that was so low that it was impossible to find out what was being said. In some cases, noise drowned what the participant was saying. In other cases, the participant came through well but the microphone placement was so unfortunate that the moderator was inaudible.
- No or few positive findings reported

DISCUSSION

We have carried out nine heuristic inspections of co-located moderated usability testing. Further studies are required to determine if similar problems exist for other styles of usability studies, or, indeed, for other activities carried out by usability professionals.

Reactions from moderators and management

This study is controversial. Some of the agencies that we evaluated objected to the publication of this paper. This is why the paper contains few details about the agencies and moderators involved. Clients encouraged the publication of the paper but agreed to omit any details that could identify them in order not to provide clues about the agencies involved.

Moderators are used to evaluating the work of others. Their reactions to others evaluating them is interesting even though only limited feedback from moderators and agencies to our assessments is available.

The available feedback suggests the following reasons for why errors were made by the moderators:

- "My professional opinion is that my approach is OK" (in other words, the moderator suggests that no errors were made)
- "... the participant is quite a special case (why did you [...] pick this particular video, she was one of the only rather strange examples?)"
- "One man's Babble is another man's insightful interview."
- Some considered the study too nitpicking. One quoted Cardinal de Richelieu: "Give me six lines written by the most honorable person alive, and I shall find enough in them to condemn them to the gallows"

Some admitted that there were problems but toned them down:

- "Your feedback [...] acted to confirm our suspicions in many places rather than itself raising anything new"
- One agency assured the client that mature steps had been taken to prevent the problems occurring again - both in terms of methodology improvements and emphasis on moderation best practice. They added that on further analysis the problems were less numerous and severe than the initial reports suggested, and that improvements would take the final quality from good to excellent.

Finally, a few accepted the quality assurance for what it was: Helpful advice on how to improve their usability testing skills. One said

- "I believe that such a precise analysis of the data gathering process will yield further improvements in both study methodology as well as in the study delivery from our side."

Reasons for problems

We speculate as to why the observed problems occurred:

- Lack of training and coaching
- Lack of usable standards for usability testing – that is, short, succinct and generally accepted standards
- Unfamiliarity with commonly occurring problems in usability testing
- An attitude that usability testing is an art rather than an industrial process.

Lessons learned

For everyone:

- Sloppy usability testing actually happens. Our admittedly limited data shows that it could be widespread. It should not be allowed. It undermines our credibility and our profession. If we are ever going to be taken as a serious discipline we have to get the quality under control.
- Usability testing appears simple, but serious and even critical mistakes easily slip in.
- Usability professionals should attend to their own faults, in preference to pointing out the faults of others. In other words, Physician, heal thyself

For practitioners who moderate summative usability tests:

- Be aware of common moderation pitfalls – including the problems discussed in this paper – so you can avoid them.
- Ensure that test time in your usability tests is spent well. Be efficient. Avoid babble.
- Have your usability testing performance assessed once every 2-4 years by a competent and neutral outsider.

For organizations who outsource usability tests:

- Create a short, precise and usable description of how your organization wants usability testing (and other usability activities) to be carried out.
- Follow up on your determinable criteria for usability testing. Remember that what gets measured, gets done – and what gets rewarded, gets done well. In other words: Set standards for what practitioners and subcontractors must deliver – and follow up.

For managers of usability professionals:

- Screen new moderators carefully.
- Regularly check that your experienced moderators do not start using bad practices.

CONCLUSION

Usability testing is slowly and healthily maturing. Thirty-five years ago the first, unsteady usability tests were carried out. About 25 years ago, the first authoritative texts on how to do systematic usability testing started to appear. Today, usability testing is routine practice in some companies. Now we are seeing the first unsteady attempts to measure and control the quality of usability testing.

Usability testing is no longer a work of art. It is developing into an industrial process for which well-defined, measurable criteria exist. Checks of professional, respected agencies show that moderators sometimes deviate from these well-defined criteria.

If usability wants to mature as a discipline, we must get used to working within rigorous standards and being measured.

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User driven development and high fidelity testing

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ABSTRACT
This paper presents how user-driven innovation has been used in designing and developing a prototype for clinical decision support. This prototype has afterwards been assessed in a high fidelity usability test at the IT Experimentarium in The Capital Region of Denmark. The method used was an iterative process consisting of a design game, a mock-up workshop, and prototype simulation all with engaged users as central participants in describing, prioritizing, designing and exploring possible solutions. The iterative design process shows that what might be sought of, as a base level of decision support, is indeed a high level for the clinicians. Integrated information, easy access to data, and easy entries to the systems are the main subjects concerning patient safety. Experiments with mock-ups and prototypes have suggested a workspace center for physicians surrounded by relevant patient information, lab results and medication opportunities when describing drugs.

Categories and Subject Descriptors
H.1.2 [**User/Machine Systems]:** Human factors

H.5.2 [**User Interfaces]:** Ergonomics, Evaluation/methodology, Prototyping, User-centered design

General Terms
Design, Experimentation, Human Factors, Verification.

Keywords
User Driven Design, Human Computer Interface, Full-scale Usability Test, High Fidelity Test, Clinical Decision Support

1. INTRODUCTION
In this paper we describe how user-driven innovation has been used in the design and evaluation of a decision support system for physicians when prescribing drugs. This was part of a European project Patient Safety through Intelligent Procedures in medication (PSIP) [11] [2].

The overall objective for the PSIP project was a "to develop a Contextualized Clinical Decision Support System (Cx-CDSS) for all four main actors in the medication process". In this article we focus on the prescription phase, where the physicians are in charge of the decision making and the ordering stage. The goal is "to design and develop a prototype of a support system for healthcare professionals integrated in the medication workflow". This was done by using a Human Factor Engineering approach to the design of the Cx-CDSS and of its Human Computer Interface (HCI) [3]. Hereby we ensured the usability of the system and prevented that the emergence of new technology would induce negative effects. The objectives for this part of the project was "to support a user centered approach to the design of the Cx-CDSS and of the HCI of the PSIP services for physicians" and "to ensure the usability of the PSIP services for physicians by means of iterative usability evaluation".

This was done by designing and developing a prototype with a user-driven innovation approach. The method used was an iterative process consisting of a design game, a mock-up workshop, and a full-scale prototype simulation all with engaged users as central participants in describing, prioritizing, designing and exploring possible solutions.

One of the core elements was a design game that was developed as the initial step in an iterative development process [8]. Design games have been used for several years within participatory design [6]. The aim is to provoke the development of a shared understanding and to form a basis for dialog. The games help the participants to get a common understanding of the work practice and generate ideas for future design.

The prototype was evaluated in a full-scale simulation at the IT Experimentarium in The Capital Region of Denmark (ITX). Simulation has for many years been used for testing work procedures and IT-systems in the aviation industry. In health care, simulation has mostly been used for training clinicians in clinical skills [4]. In the last few years however it has been more common to use simulation with humans in the loop for testing IT-systems. This makes it possible to test IT-systems in an environment very similar to the real working environments; high fidelity test.

Such tests have been done at ITX for several years and full scale simulation tests are now being used for all new it-systems that might influence the clinical daily work practice. ITX is located at Herlev Hospital and was established in 2007 [5]. It is a full scale hospital ward including operating theatre, intensive wards, delivery room and medicine room, all arranged with ceiling mounted remote controlled cameras that are connected control rooms. This set-up allows for tests of clinical applications in a high fidelity context which involves issues of workflow and organizational settings, as well as usability and usefulness of the application itself.

2. METHOD
The PSIP prototype was designed through several iterations (see Figure 1)

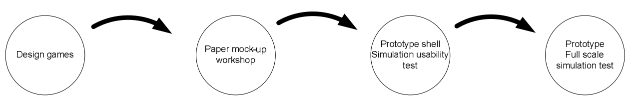

Figure 1. The user-driven design approach

The first iteration was a design game. This was made on a game inspiration from the computer game "The Incredible Machine", theoretical inspiration on electronic decision support, and empirical groundings in scenarios of medical errors. The game was played in a two-hour workshop with six clinician divided in two teams. Each team was presented with a number of scenarios where medication errors occurred. The scenarios were taken from real incidents reported in the Danish adverse incident reporting system. The design game challenged the participants to produce design ideas for IT based decision support that could have prevented the errors from happening. The theoretical basis for the core of the game was founded in four identified levels for electronic decision support; retrieving of relevant information requiring further processing by user, prompts, reminders and alerts, complex consulting advise and finally automated prompts and advice on patient and situation specific issues.

The outcome from the design game was a number of design principles for computerized decision support systems. These principles were implemented in a paper mock-up containing 7 components and presented to the clinicians at a workshop. The 7 components of the mock-up were cut out as separate sheets and placed at a table for the participants to discuss and improve the solution. The results of the workshop were used as input for the further development of a running prototype shell.

The first prototype was tested in an authentic simulation environment to give the users a hand-on experience with a possible realization of their original ideas. Two PSIP researchers played the roles as patients, three researchers where operating the prototype, recording from the control room, supplying technical support and one researcher was in charge of briefing and debriefing the 6 participating clinicians.

When entering the simulation room one by one, they were informed about the diagnoses of the patients and asked to go ward round while using the prototype. They were asked to "think aloud" [13] when interacting with the prototype. After the round the clinicians answered a questionnaire and the simulation ended up in a plenary discussion. The results provided further input for the design and implementation of the final prototype.

Before the final prototype was tested in a high fidelity usability test, it was usability evaluated by applying heuristics in a walkthrough [12], and the majority of the usability errors were hereby corrected.

The full-scale usability test was carried out by ten participating physicians [10]. Each physician performed ward rounds for five patients at two ward-rooms (see Figure 2) and during this process of prescribing medicine they were using the prototype as decision support. The interactions with the prototype were video recorded during the simulation. During the ward round the physicians were assisted by a "nurse", who was able to direct the simulation and to help the physician in using the prototype if needed.

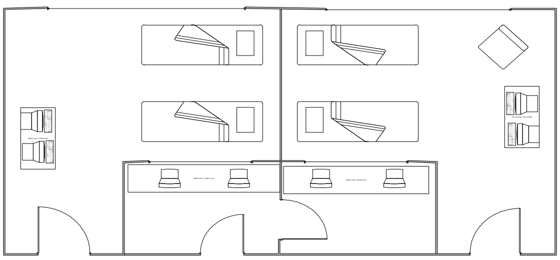

Figure 2. The two simulation rooms and set up.

The scenarios were composed as a ward round for 5 patients at a medical unit in a hospital. The 5 patient cases were real cases taken from the Danish adverse incident reporting system [1] and adapted to the test situation. The cases were further complemented with other relevant data from the patients' records, the computerized order entry system and lab results to ensure that the participating physicians could perform realistically.

The patient roles were played by "real patients"; elderly men who were instructed before and during the simulation. Besides getting help from the assisting nurse, the physicians had the opportunity of calling the senior physician or specialist on duty and thereby get advice. The roles of the nurse and the assisting physician were played by clinicians, who were instructed in use of simulation and the concerned patient cases.

Figure 3. Looking into the bedroom through the one-way mirror from the control room

The physicians were instructed in how the simulation test was going to take place, and were asked to "think aloud" during the simulation. If necessarily the nurse could ask questions during the test, and thereby force the physician to "think aloud". Additionally the physician was instructed to act as if he/she was working at his or hers own department.

A large number of researchers were participating in the test and each one had a particular role regarding data logging, instructing the nurse, video recording or doing the subsequent interview and thereby getting a good overview of the usability problems experienced during the test.

The data analysis was done by a combination of two methods: the Instant Data Analysis method (IDA) [9] and the more traditional Video Data Analysis walk-through of the screen recordings and the interviews. The objective of the IDA technique is to be a tool for identification and ranking of critical usability problems and thereby providing guidelines for re-design and quality improvement of a system.

Combining the two methods enabled us to find also the less critical usability problems, and to both list and rank all the usability problems and to give recommendations for re-design.

3. RESULTS

A very large number of clinicians, researchers and support staff have been engaged in the activities providing input and feedback on human factor issues to the design processes. Clinicians have been involved in the design process as well as in the evaluation studies. Informatics professionals have been actively involved in determining test methodologies and providing input for the planning of the simulations studies. The support staff has been instrumental in performing the concrete tests.

The result of the design games was eight incredible machines for decision support preventing medical errors. These machines presented what the participants found as central foci related to medication errors and decision support, and ended up in the following design recommendations

- Design for integrated information
- Integrated information must be used intelligently
- Design graphical diagrams for visualizing measurements and lab results
- Design for optimizing prescription
- Design for calm working environments when prescribing dispensing and administering medicine
- Design for barcode readings

The paper mock-up were designed with a user-interface where the center of the screen was a workspace supporting decision support; showing the result of new lab results and the effect of the choice of medication and giving the possibility to change and try out different possibilities.

At a following workshop the paper mock-up was being discussed with the clinicians. The overall results were to keep all 7 components but to move them around. The clinicians pointed out that they would always look out for the objects that are most important; like previous medications and lab results. Furthermore they asked for intelligence in form of red markings of lab values, which are not within boundaries and suggestions from the system when searching for alternative drugs.

High fidelity test of the first prototype ended up in a positive list of the features already implemented

- Integration of lab– and diagnose data in the interface
- Workspace for decision support in the center
- Overview of patient information in forms of allergies, diagnoses, lab results and medications
- Choice of graphical presentation of lab results

Two additional recommendations came up during the test

- Design for access to central information sources such as diagnoses, codes, drug information, and instructions
- Design for information about the patient

The evaluation of the human user interface according to standard usability heuristics resulted in 5 minor and 8 major findings; i.e. the use of symbols were not always intuitive, a mixture of standards for decimal marks, and a mixture of old-fashioned GUI (bold and *) and new GUI (mouse over). It also showed that the realized design complied with 4 of the 5 design principles. There was no access to central information sources such as diagnostics codes, guidelines or general drug information.

Full scale usability test resulted in a list with 17 recommendations on how to solve the usability issues the test physicians experienced and a list of 7 ideas from users for further development of the system. Unfortunately the test was afflicted by technical problems and the system broke down during several simulations, which influenced the results.

Furthermore the results from the simulation have emphasized a perspective of several but integrated types of information and interaction [7]. Consequently we conclude on a need for an integrated perspective on design of clinical decision support. Our results point out four principles of interaction for design of CDSS:

- Directed active information where focus is on search. Important is that the user gets an overview; *All in one*
- Undirected active information where focus is on browsing. Users are able to unfold information and browse along in search for knowledge. Important is that information is accessible; *At hand*
- Directed passive information where focus is on monitoring. Important is that the user easily can follow developments; *At a glance*
- Undirected passive information where focus is on awareness. Important is that the system warns the users; *Attention*

4. FIGURES DISCUSSION

The results of the design game are a list of themes related to risk of errors identified by clinicians with a great knowledge of work practice and the possible problems that may occur during the daily work at the hospital. It is not a list of features to implement, but a list, which highlights the recommendations for interfaces between systems and possible problems concerning interruptions, misreading and shortcuts in a high tempo work environment. The use of design games involved the users actively and gave insight in a complex practice and produced ideas for solutions without requiring the users to spend much time in getting there.

A thorough user involvement in the development process as well as in the evaluation has been an important issue for the project. A summation of the quantity of users gives an impression of how the activities are rooted in the clinical community. 25 physicians, 12 nurses and 1 pharmacologist have been involved in the different iterations during design and evaluation activities.

The scenarios and patient cases have been authentic and selected from real cases in the Danish adverse incident reporting system, where optimized decision support may have made a difference. This substantiates the results from the simulation test. A simulation test does not – however – get exactly the same results as daily use at a hospital.

The prototype had some challenges with stability that made it difficult to achieve unambiguous results as some users were more distracted by the instability than others. A unanimous reaction was however, that the great advantage of the prototype was the integration of information from other systems and these features sometimes overshadowed the decision support functions – especially among the older users.

A simulation test performed on a more mature product would probably have achieved richer results for the connection to the users' work context. The absence of this possibility has pulled the evaluation to focus on single screen issues.

5. CONCLUSION

Clinicians participating in design games, mock-up workshops and prototype simulations emphasize the overall importance of designing for decision support. In a design game participating clinicians designed incredible machines to prevent medication errors and prioritizing design solutions and types of decision support.

The results was a list of design principles summing up central themes but it also showed that what might be thought of as a base level of decision support is indeed a high priority for the clinicians. Integrated information, easy accessible data, and easy system entries are the primary features for preventing errors when asking the participating clinicians.

A very large number of clinicians have been engaged in various activities providing input and feedback on human factor issues to design the processes as well as in the evaluation studies. Informatics professionals have been actively involved in discussing test methodologies and providing input for the planning of the simulation studies.

We have described how user-driven innovation has been used in the design and evaluation of a decision support system for physicians when prescribing drugs. Experiments with mock-ups and prototypes have suggested a workspace center for physicians surrounded by relevant patient information, lab results and medication opportunities when describing drugs. We argue that the results would not have been the same with-out the involvement of users

6. ACKNOWLEDGMENTS

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We thank the clinicians from the hospitals in the Capital Region of Denmark and our colleagues from the PSIP project.

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Medication Reminder System using Calm Guidance

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ABSTRACT

We report on work in progress on the Context-Aware Medication Reminder System (CAMS). CAMS aims at improving patient medication adherence levels by using context-aware technology to remind hypertensive patients to take their medication on time. This is done without needlessly intruding on the patients by observing personal preferences and context of the user. We intend to use CAMS in a participatory design process as a proof-of-concept for exploring "calm guidance" as a design concept.

Author Keywords

Medication adherence, medication reminders, adherence aid, context awareness, participatory design, hypertension.

ACM Classification Keywords

J.3 Life and Medical Sciences: [Medical information systems]; H5.2 Information interfaces and presentation: User interfaces—Evaluation/methodology

General Terms

Design, Documentation, Experimentation, Human Factors, Reliability, Verification.

INTRODUCTION

Hypertensive patients require daily and timely medication in order to avoid damage to the cardiovascular system potentially leading to strokes, heart failure, and other blood pressure related conditions. As there are usually no symptoms patients often forget taking their medication. On average, only 43 to 78 percent of patients take their medication on time [1]. A traditional approach to improve medication adherence levels include telephonic follow-ups, which has shown to be effective in enhancing medication adherence [2-3] and reducing the overall costs to the healthcare provider [4]. However, this type of approach is expensive, time consuming, privacy invading, and may be difficult to sustain over time and on a large scale [5].

General-use reminder systems, not specifically designed for medical usage, are commonly available. This includes mobile phones and other information devices. Alarm clocks and calendars enable users to setup scheduled reminders: "take medication at 8:00" associated with an audible alert.

However, these information devices do not have any contextual awareness regarding the users' actions: whether the user has already taken his morning medication, or not. This could potentially cause the user to be reminded of events that have already been complied with, and may lead to double medication. Also, the reminder might be overheard, e.g. if the person is in the bathroom while the cell phone is beeping its alert, or the phone has been muted for the night, or run out of power. Other factors include: the user might have risen earlier than usual that morning, been sleeping at another location than home, or may want to sleep a few hours longer. We may want to have redundancy of reminder devices, in order to be sure that the user is reminded in all situations, on the other hand however, we risk that this may lead to information overload; the user being reminded of the same task on several devices, which might be an annoying element, ultimately causing the user to simply switch off the alarms, perhaps permanently.

Medication reminders have been reported not to provide significant benefits in medication adherence [6-8]. This indicates that existing reminder technology is not always a feasible option, and that we should involve users more deeply in the design of alternative technology.

Our approach aims at creating an alternative medication reminding system that the user will not turn off to avoid getting bothered. A system that the user will perceive and respect as being important, as the system respects the user's time and privacy, and will not intrude needlessly.

We call this approach calm guidance, as inspired by early ubiquitous computing work on calm technology by Weiser [9], as we aim to minimize the intrusion on user awareness.

The aim of this study is to design a system that adapts its medication reminding facility to only remind a patient to take his or her morning medication if the medication has not been taken within a fixed time interval after rising from bed. Also, it should only alert the user if needed, and does so using the relevant communication media in the given user context.

Such a system could be used for future investigations as to whether patients become more compliant in taking their medications when they have a reminder system that is not unnecessarily intruding into their lives, except when actually relevant for patient safety.

SUGGESTED SOLUTION

We suggest utilizing context awareness for creating a non-intrusive and calm experience for the user. The user should only be reminded if the medication is not taken, e.g. within 20 minutes of getting out of bed. The user should not feel that the system is patronizing. Rather, it should be a supportive technology experience, only intruding on the user when necessary, e.g. due to a stressful morning. Only if the user forgets to take his medication should we interact with the user. First giving a friendly reminder – and later – interact with the user with regard to why the medication was not taken. The user might have pre-fetched an extra pill the day before, or even collected a new package from the pharmacy. Here, it is important that we engage the user and ask whether the medication was really forgotten, or whether it was merely a "ubiquitous sensing system breakdown". We must expect that we cannot sense all aspects of a user's life, and we must try not to report unnecessary "false negative" observations.

In addition, if the user is absent from home, we suggest to extend the solution to inform the user on their personal mobile device, and allow the user to simply indicate whether the medication has been taken under these special circumstances.

Ubiquitous design approach

To inform our system design we rely on Weiser's original notion of "calm and invisible computing" [9], in the sense that we need to avoid technology dominating the user, but rather for it to stay in the background. Technology should support and guide the user when, and if, needed. We do not interpret this literally as the system disappearing from the user, but that it will in fact only display itself to the user´s awareness if the user is in real need of assistance, e.g. having forgotten to take the morning medication.

To this purpose, we consider context awareness a useful design concept. Dey defines context awareness as: *"A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task."* [10]. The CAMS system employs context-aware technology to sense the environment in which the user acts to adapt its behavior accordingly, including bed, medication, and location sensors.

METHODS

We have chosen a participatory design approach [11] to inform and guide our design efforts.

We started with a semi-structured exploratory qualitative interview [12] with a 65 year old female hypertensive patient, "Ida", in order to learn how medication was taken and where the potential problems resided. These initial findings were transformed into three "actual" scenarios, illustrating the challenges faced by Ida. We then suggested three "augmented" scenarios, presenting possible solutions to the problem using calm guidance. These were then presented at a workshop with three hypertensive patients, one woman in her early thirties, and a man and woman both in their sixties. Attending the workshop was also a general practioner, an industrial designer and three engineers. As part of the workshop we aimed at discussing the validity of the scenarios and co-design the suggested solution with the participants before starting the technical design process.

RESULTS

Identified usage scenarios

We have defined a range of scenarios to inform the design of the suggested system. They are based on interviews with Ida, who must take her hypertension medication every morning. Ida is retired and only works once a week, Monday afternoon, for three hours, "to keep in contact with the real world". She has an active life, going to gymnastics classes, power-walking, cooking, painting, and visiting family and friends.

We limit our work to three exemplifying scenarios, to shed light on the way most mornings takes place in Ida's life (scenario 1), and sample exceptions to the rule (scenario 2 and 3). These scenarios will be used for verification with Ida and other users on how they perceive the task of taking medication today and to what extent they may need supporting reminders to assist them.

Actual scenario 1: Ida wakes up Tuesday morning, and she is in good time

Ida wakes up at around 9 am. She rises out of bed, showers, dresses, and makes coffee. After breakfast she takes her medication: Spirix and Moxonat. She reads the paper and then turns her attention to the various chores of the day. She almost never forgets taking her medication – but it varies between 7 and 10 am – depending on when she gets up. It does not matter when she gets up, as her routine makes it easy for her to remember when to take the medication.

Actual scenario 2: Ida wakes up Thursday morning, and she is in a rush to go the gym

Ida wakes up at around 8 am. She rises out of bed, showers and dresses. She is in a rush, as the gymnastic lessons are at 9 am, and she doesn't want to be late. She eats a quick breakfast and remembers that she promised her husband to post a letter for him. The postbox is on the way to the gym hall, so this is not a problem. But, the letter has gone missing somewhere. She spends 20 minutes searching for the letter before finally finding it. Now, she is no longer in good time. She grabs the bag with gymnastics clothes, and heads for the door. The car keys are nowhere to be found. Slowly she panics while searching for the keys. The keys are found, 10 minutes later, and she is now officially 5 minutes late for gym class. Ida hates being late. She speeds off to the gym and has forgotten - to take her medication. Due to the eventful morning, she does not remember to take the medication later in the day either, and as there are no physical symptoms to hypertension, nothing physical different she will feel, her hypertension remains untreated for the day, posing a potential risk.

Actual scenario 3: Ida wakes up in a hotel room, while on holiday

Ida wakes up at 10 am in a hotel in Cancun. She is on vacation for one week with her husband. Ida loves being on holiday, but being away from home messes up her usual routines. The medication is not placed the usual place, and so, as Ida leaves the Hotel room for a day-on-the-beach, she forgets to take her medicine. This happens three days in a row. Again, Ida feels no physical symptoms.

Augmented scenario 1: Ida wakes up Tuesday morning, and she is in good time

Ida wakes up at around 9 am. She rises out of bed, showers, dresses, and makes coffee. CAMS senses her getting out of bed (using the bed context-monitor) and signals the CAMS reminder agent that Ida is up. The reminder agent starts a timer. Ida now has 20 minutes to take her medication before anything further happens. After breakfast she takes her medication. The CAMS medication-box context service senses that she has taken her medicine, and signals the reminder agent that this has occurred. The reminder agent logs with her personal healthcare record that medication has been taken on time, and decides not to intrude on Ida. Therefore, Ida does not notice that the CAMS system has watched out for her. Ida reads the paper and then turns to the various chores of the day. She almost never forgets taking her medication – but it varies between 7 and 10 am – depending on when she gets up. If she sleeps to 10 am, the bed context monitor helps ensure that she is not woken up by the reminder agent, as the timer sequence first starts when she rises from bed.

Augmented scenario 2: Ida wakes up Thursday morning and is in a rush to go the gym

Ida wakes up at around 8 am. She rises out of bed, showers and dresses. CAMS sensed her getting out of bed and signals the CAMS reminder agent that Ida is up. The reminder agent starts a timer. She is in a rush, as the gymnastic lessons are at 9 am, and she doesn't want to be late. She eats a quick breakfast and remembers that she promised her husband to post a letter for him. The postbox is on route to the gym hall, so this is not a problem. But the letter has gone missing somewhere. She spends 20 minutes searching for it before finally finding it. While she is searching the reminder agent times out (she should have taken the medication 20 minutes after rising). It therefore checks whether there is movement in the home using the room-occupancy context-monitor, and sensing her being home, it starts the reminder client, on the home wall touch screen computer. For the first 2 minutes a pure ambient graphical flashing, later followed by a sound alert slowly increasing in volume. Ida is now no longer in good time and misses the initial non-audible flashing. She grabs the bag with gymnastics clothes, and heads for the door. The car keys are nowhere to be found. Now she hears the reminder alert, walks to her bedroom, sees the notification and confirms that she will take her medication now. She takes her medication. The CAMS medication-box context service senses that she has now taken her medicine, and signals the reminder agent that this has occurred. The reminder agent notifies her personal healthcare record that medication has been taken. Still, Ida is slowly starting to panic while searching for the keys. The keys are found, 10 minutes later, and she is now officially 5 minutes late for gym class. Ida hates being late. She speeds off to the gym – late again - but at least she has not forgotten to take her medication.

Augmented scenario 3: Ida wakes up in a Hotel room while on holiday

Ida wakes up at 10 am in a hotel in Cancun. She is on vacation for one week with her husband. Ida loves being on holiday, but being gone from home messes up her usual routines. The medication is not placed the usual place, and so, as Ida leaves the Hotel room for a day on the beach, she forgets to take her medicine. As the CAMS system is impractical to bring on holiday (due to sensor and touch screen infrastructure) the system is not looking out for her. However, the system continues to run at home. As it can sense, that Ida is in fact currently not using her bed, it assumes that she is away. It therefore signals the CAMS mobile extension device asking for a status at 10. The CAMS mobile extension device reports back – that Ida is in fact not at home (as it cannot see the usual GSM cells). Also, it infers that Ida is not up by looking at the phones accelerometer. The reminder agent decides that Ida must be away, and that she needs to be reminded manually of her medication, the next time she is using the phone. This happens while Ida grabs the phone at 10.30 am, thereby activating the phones accelerometer sensor. The phone presents Ida with a reminder-alert, while also asking Ida to confirm whether she has taken the medication.

Workshop Findings

All workshop participants expressed that the three actual scenarios were relevant to them. They also agreed that the augmented scenarios appeared relevant as a way of overcoming the challenges. One participant stated that she practically never forgot taking her medication, but "that it would not hurt to have such a system". The presented CAMS prototype was well received by both physician and patients, while also resulting in suggestions for several design improvements. One participant used a 7-day medication box for keeping track of her medication. She stated that CAMS should be able support this medication delivery method to be of relevance to her. Due to work-related and extensive travel activity she did not find the rather cumbersome construction of the CAMS system (as a suit case system) feasible for her purposes and would require another and more light weight construction to suit her needs, e.g. using a smart phone solution. The other two however appeared interested in the solution for home use volunteering as test-subjects for future in situ evaluation. Neither of the patients wanted a medical looking device. It should not display their illness to visitors and family. The physician confirmed that medication adherence was a prevalent problem, and that he had no way of knowing the actual medication adherence levels of his patients. Getting precise information on when medication was actually taken by his patients was deemed very relevant, and "one of the biggest challenges to general practioners today".

DISCUSSION

With the suggested solution we are able to detect whenever a patient is getting up or entering the bed, which initially allow us to activate all our augmented scenarios. However, we are only able to detect whether the user has removed the pill box from the container, not whether any medication was taken, or the quantity. Previous work has investigated the feasibility of constructing such advanced medication containers and reminder systems [13-16] and commercial systems are available [17-18]. We chose to build our own medication sensors, rather than integrate commercial products. We do not aim at creating more precise medication delivery technology, but rather to explore the feasibility of calm guidance as a concept for medication reminder systems. In this respect, we argue that the concept appears feasible. This was supported by the findings from our participatory design process. However, these findings are limited due to the qualitative nature of participatory design projects, and more work is needed.

An in situ user study is required in order to gain relevant user feedback on the perceived feasibility and usability of the system. Initially, a small qualitative user pilot study appears relevant, before turning to large scale, randomized clinical comparative trials, for evidence-based evaluation of the usefulness of the concept.

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Human Work Interaction Design (HWID) and sensor based prototyping for interactive climate management

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ABSTRACT

Internet- and sensor based ICT systems for climate management in greenhouses presents challenges for the understanding of how technology mediates the interaction between humans and specific work contexts, which is the topic of the field of Human Work Interaction Design (HWID). In this paper, we will analyze and discuss how to combine empirical work analysis with interaction design techniques, with a focus on sensor-based prototypes. The proposed method is action research that will use a combination of theory from usability, work analysis, and prototyping techniques. We wish to investigate possibilities for designing, using and evaluating interactive sensor based prototypes for designing systems, learning key skills, and enhancing current training methods, all of this in a work context.

Author Keywords

Human Work Interaction Design, sensor-based prototypes, usability, work analysis.

INTRODUCTION

Internet- and sensor based ICT systems for climate management in greenhouses presents challenges for the understanding of how technology mediates the interaction between humans and specific work contexts, which is the topic of the field of Human Work Interaction Design (HWID) [1]. Currently greenhouse growers spend several hours daily with the computer, working with the greenhouse climate management systems. What are they doing? Is it all functional, rational problem solving? Is it process control? Is it learning? Is it enjoyment, pure fun? What are the social, cultural, organizational and technical contexts of the computerized climate management? Insight into the needs and reasons for spending much time on a certain task using a computer can help in planning future software systems for the needs of the growers and to contribute to reducing unnecessary work time and stress while increasing time for pleasure, eventually increasing work efficiency and reducing labour costs.

Human Work Interaction Design (HWID)

This paper contributes to the field of Human Computer Interaction and in particular to Human Work Interaction Design (HWID) which is the topic of IFIP (international federation for information processing) WG (working group) 13.6 on HWID. HWID is concerned with how technology mediates the interaction between humans and specific work contexts, and touches upon topics such as; e.g. cross-cultural usability testing, user personas, usability evaluation method in medical context, usable techniques for hand-writing recognition, mobile application for construction workers, promoting usability in large enterprises, design conversations, social usability in second life for distance learning students, interactive kiosks for museums and more [2]. The research advances and supports international usability research, including mobile usability, usability in safety critical domains, aesthetic approaches to usability and user experience, user innovation, and empirical studies of usability. These research areas are complemented with the research presented in this paper and its proposed focus on usability in contexts.

A note on material hermeneutics and human-technology-world relations of the HWID approach

Human work interaction design has hardly been conceptualized in HCI. We suggest basing the HWID approach philosophically on ideas from design and technology philosophy; in particular the material hermeneutics and human-technology-world relations developed by postphenomenologists Ihde [12] and Verbeek [13]. In HCI, a few researchers, with ties to Swedish HCI research, have introduced the postphenomenological approach to HCI. Fallman [14] suggests that new pervasive technologies have made it increasingly hard to grasp what is a 'good' user experience, how to distinguish a good user experience from any other kind of experience, and, seen in the light of all the artifacts with computational power, what is a 'user'. To meet these challenges, he suggest, we need to import concepts (with their related richness and context) from philosophy of technology. In particular, he suggests while citing Borgman [15] and Ihde [12], technology is not neutral. Rather technology often induces people to certain perceptions and actions so strongly that they appear not to be able to refrain or refuse it, i.e. the technology shape our lives in ethical and moral ways. This challenges what is a 'good' user experience.

In another line of research that combines HCI and philosophy of technology, Stolterman (like Fallman with a relation to Umeå in Sweden) and colleagues, e.g. [16-19], have for years build on the work by Verbeek. They selected Verbeek because his philosophy of technology is design-oriented [13], and his work could be used to develop criteria for design that inspires a high degree of attachment, by being based on choices of material qualities in design and material awareness. For example, [17], by relying on the work by Verbeek, have developed a framework of function (what an object does), symbolism (what an object means) and material qualities (what an object is made of and its appeal). Using these as descriptors of the Human-technology relation, they studied qualitatively 32 Americans' relations to objects, and found four types of general human-technology relations: engagement (does the object invite to engagement?), histories (does the object preserve memories), augmentation (has the object been augmented to the extent of becoming a symbol of its owner?), and perceived durability (does the object's owner regards it as long lasting?).

Thus if we try to see HCI from a philosophy of technology design point of view, HCI (including HWID) is about how technology in a non-neutral way mediates the relation between the human (the I) and the world, in ways that require the designer to (also) apply material awareness and sense of ethics. The HWID approach studies these relations with a strong focus on the domain, be it leisure, learning or human work domains.

Domain knowledge: Climate management

Near stress conditions can be identified and characterized in relation to different plant species in a greenhouse under dynamic climate conditions. This e.g. includes effect of high or low humidity that might often be associated with energy saving conditions and cause disease problems. Combining the different technical possibilities of measuring microclimate, enable the application of crop specific models for a large range of climate management purposes. Plants can be established under standard growth conditions and subjected to a desired degree of dynamic temperature, humidity and light conditions combined with different screen conditions and light use. For example, different greenhouse crops have very different needs for climate control. Among them are year round roses, cucumbers, seasonal poinsettia. However, they have the common denominator of large energy requirement both in terms of temperature and light. The management of a dynamic climate may induce physiological changes, and characterization and quantification of these may have importance for the interaction design of the systems for climate management. In a sense, climate management situations are comparable to well-known types of safety critical, emergency and disaster situations, by the urgency of reactions, the disastrous long term consequences, and the decision making aspects of the situations. In this paper, we will analyse and discuss how to combine empirical work analysis with interaction design techniques, with a focus on sensor-based prototypes. In particular we want to discuss the pedagogical aspects of allowing users to train themselves on key scenarios for climate management. The paper is thus narrowly focused on climate management in greenhouses, but takes up the broad discussion of how people adapt and learn to act in new (often extreme) situations. Online worlds (which include simulations, virtual environments, augmented reality, and massive multiplayer games) have potential to aid in training staff to deal with crisis situations. In our paper we focus on a new type of online world that we call sensor based prototypes. We wish to investigate possibilities for designing, using and evaluating interactive sensor based prototypes for learning key skills and enhancing current training methods.

Sensor-based interaction design prototypes

One of the challenges we are faced with when talking about sensor-based prototypes are how to actually do the *physical* modelling. In example, it is difficult to create and test a real sensor-based prototype. Some of the reasons for this are that it requires a different skill set than other prototyping efforts such as Internet programming or standard GUI design. In terms of creating/visualizing a normal user interface intended for a PC, we can usually resort to a drag and drop editor, which are already part of a programming language integrated development environment (IDE). This holds true for languages found in the Microsoft .NET suite and the Java programming language. In the latter case, the popular Eclipse programming environment provides a visual editor. It forms an easily approachable and inexpensive prototyping platform.

In a sensor-based environment, we are not so fortunate. If the requirement is that the sensor-based prototype is dynamic/responsive in any way, then we are required to connect the sensors to each other and to the intended management console. In order to do so, we would need the skillset of electronic engineers and/or mechanical engineers. The electronics and sensors have to be wired, and prototyping boards will be manufactured. It is possible to do so, but at an additional cost (both in terms of time and money) than purely software based prototyping.

A second option is to settle for a modular prototyping platform such as Lego Mindstorms. It features the Lego construction that many is already familiar with. Moreover, it is a candidate for sensor-based prototyping because the Lego Mindstorms NXT ships with various sensors. There are ongoing efforts to provide this platform as a prototyping platform for languages such as C and Java (see http://nxtgcc.sf.net).

Evaluation of sensor-based prototypes

A key element in evaluation the use of prototypes - also prototypes of online worlds - is usability and user experience measures [3]. International standards define quality in the use of ICT systems in terms of a single concept „usability" with three aspects: effectiveness, efficiency, and satisfaction, achieved in a specified context of use [4]. The idea that usability can be treated as a unified concept „u", analogous to Spearman's „g" for general intelligence, has found support in reviews of usability test practice in major US companies [5]. In contrast to this idea, theoretical work has shown that many really different images of usability appear to be relevant [6]: 1) Universal usability, i.e. the systems can be used by everybody, 2) Situational usability, i.e. quality-in-use of a system in a specified situation with its users, tasks, and wider context of use, 3) Perceived usability, i.e. the user"s attitude towards a system based on his or her interaction with it, 4) Hedonic usability i.e. joy of use, 5) Organizational usability, i.e. groups of people collaborating in an organizational setting, 6) Cultural usability, i.e. different meanings depending on the users' cultural background.

Analyzing usability in context is important for connecting empirical work analysis and interaction design of the ICT system to explain how technology mediates the interaction between humans and specific work contexts. Industrial techniques [7] often give - seemingly - similar results when applied in diverse social, cultural, organizational and technical settings, but experience shows that we need a deep understanding of the different contexts to interpret the results, and to transform it into interaction design. Empirical work analysis offers such deep understanding by studying closely the work, how it does (or does nor) follow plans and procedures, what great and small troubles that people run into during their work, what those who really know the work can tell us about it, and where the work actually is done in our mobilized world [8]. A promising approach in combining empirical work analysis and interaction design is the use of throwaway (rapidly made, easily discarded), sensor-based prototypes. First, prototypes are low-cost and flexible constructions, which allows for evaluating a number of different setups that with the use of sensors can include more contexts. Secondly, there is an advantage about reproducibility; namely that such prototypes can be reconstructed from simple and clear building instructions, making the evaluations of the prototypes more easily verifiable by other researchers [9, 10]. Specifically, the focus will be set on the three questions:

1. Is there a measure „u" of usability, i.e. is there a single, unified concept of usability that can capture the relation between the human and the computer across the different social, cultural, technical and organizational contexts of an ICT system?

2. How do empirical work analysis (studies of work and the workplace) inform and interact with paper design sketches and functional prototypes?

3. What are the benefits of using sensor based prototypes in ICT user interface design?

METHOD

To answer the research questions, we suggest an action research based approach where researchers work closely with greenhouse growers and consultancy houses, and with software developing vendors that are specialized in systems for climate management. These parties will together have to perform a full iteration of user inter-face development activities on the different components (e.g., climate control, decision support, communication platform) of a greenhouse management system. The iteration will 1) be based on an agile interaction design lifecycle model with usability evaluation as the central element [11] to ensure useful user interface designs will be a results, and 2) be overlaid with extensive data collection and systematic reflection on findings, including reflective exercises with stakeholders, to ensure answers to the research questions. Existing systems and modules will firstly be evaluated one for one. Based on that, improvement will be worked out and sketches and prototypes created for each part of the system. To ensure a complete working system, where the complimentary sub-systems are embedded, the researchers may take the lead and create a guideline, and, in cooperation with the industry partners, give suggestions for a complete system house style that ensures a high usability, good user experience, and a clear common style, keeping however the separate functions of each sub-system apart.

EXPECTED RESULTS

The researchers will, in collaboration with the industry partners, be responsible for delivering different research products:

1. Usability and user experience specifications for the primary target user groups.

a. diary study with ten greenhouse growers, two weeks, elicitation diary
b. work observation, two greenhouse growers, onsite, six weeks, participating as an apprentice, following the growers around, screen capture of climate management computer use
c. repeated individual interview, primary stakeholders: 4 growers, 4 advisors
d. online community, e.g. internet based communication and knowledge sharing tool, establishing a user community

2. Analysis of the climate management task, based on:

a. hierarchical task analysis, ten interviews with experts from consultancy houses
b. persona creation, one person per target user group (e.g., small/large, flower/vegetable nurseries), use of existing marketing statistical data, if necessary questionnaires
c. scenario writing, usage scenarios, two focus groups with four-five growers in each

3. Evaluation of effectiveness, efficiency and aesthetics of prototype through:

a. think aloud usability testing, repeated four times, five participants each time
b. heuristic aesthetic evaluation, repeated four times, focus group interviews,
c. task time performance prediction

4. Conceptual design of the interaction between gardener and system by:

a. sketches, post-it note, at least ten different sketches, animated sketches

5. Prototypes that demonstrate key aspects of the interaction between the software users (typically the growers) and system:

a. horizontal, flat, broad functionality, paper, html, java or similar, more than 4 prototypes
b. sensor based vertical throwaway prototypes, a series of at least five experiments with simulated sensor based climate management with useful functions and a basic set of sen-sors, using Lego Mindstorm programmed in Java, with two group of participants (10 expert users (greenhouse growers), 100 novice users (university students))

6. Implementation user evaluation:

a. work observation of the grower‟s work with the new climate management system
b. diary study with four growers, two X one week, feedback diary

DISCUSSION

The idea that we can use Lego Mindstorm sensor based vertical throwaway prototypes to do interaction design will hopefully be versatile. Other research in reflective physical prototyping through integrated design, test, and analysis have shown that, after an initial period of learning the prototyping tool's interface, participants will spend the major parts of their time doing design thinking, i.e. thinking and talking about how the interaction design should be from the user's point of view, instead of wondering about how to implement a particular behavior in the user interface [3]. What is currently less clear is how explorative and sketch-like such sensor-based prototypes will be. Sketches support different kinds of design thinking [20].

An interactive, sensor-based prototype may be used as a greenhouse environment simulator, e.g., in the form of a scaled down version of greenhouse including real-time monitoring control systems [21]. Greenhouse environment simulators have been designed to be used as educational tools for e.g. demonstrating the physics and biology of greenhouse systems and environmental control principles [22-24]. For example, scenarios can be simulated to show how a specific greenhouse design would respond environmentally for different climate conditions (e.g., four seasons of the year, or four geographical locations), and to evaluate how system designs work for achieving the desired environmental conditions [22, 25].

The user is one of the key factors in successful climate management, due to the need for leaving part of the decision freedom in the hands of the grower. Current approaches for user accepted climate management rely on a concept of division of responsibilities, where the short-term effects, e.g., photosynthesis and evapo-transpiration, are controlled by automated systems, while the long-term effects are left to the grower working with flexible decision support system based on crop models [26]. The measures of usability will thus have to be able to accommodate these kinds of two-levels supervisory control activity models. As data from the different metrics will provide insights into different aspects [27], this will provide challenges to the idea of an integrated usability concept.

While the HWID research is concerned with how technology mediates the interaction between humans and specific work contexts, it is not clear what concept turns out to be central or the cases studied. Recent studies of work psychology and design suggest that socio-cultural concepts such as processes of trust-building, social identification and community-based learning may be highly important [28].

CONCLUSION

The expected results of HWID research include application of HWID in a new domain, green-house horticulture, and how the combination of empirical work analysis and interaction design theories and techniques function in this domain. This includes the results on the benefit of using sensor based prototypes in interaction design.

The idea of developing a single, unified metric for usability across different software platforms, functionalities and user groups is controversial; some studies show that there is a high correlation between the different measures of usability, e.g. effectiveness, efficiency, satisfaction, while other studies show a low correlation between such measures. Thus the evidence for and against this idea that we will gain from the proposed research will enter a current debate in the international research community.

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Interactive motion tracing for Rowing Training

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Abstract

This paper studies motion tracking and team coordination for the training of rowers. The design research is drawn upon the division of contribution between the designers input and the user input in a design process. We built a training system that can record and show the action of a rower's hand. Designer proposed solutions for both a fundamental problem and a very advanced problem. Users guided the design direction, and spoke what they expected or what they disliked. As the result, our design provided a real-time recording tool for rowers and coaches to discuss and analyze the motion. The coach can correct the path immediately and save the corrected path for the rower to try to imitate and train. The members in a rowing team train with the same path from to coordinate and synchronize their actions for the best performance. The training system was developed through a user-centered design process with Danske Studenters Roklub. It was designed in iterations to provide a new experience for rowing sport training by coaching in real-time, training interactively, and perceiving directly.

Keywords

Motion tracing, rowing training, team coordinate.

1. introduction

The right action and gesture take an important part in rowing training. A coach needs to demonstrate and correct rowing techniques in person. Currently, there are several systems that help for rowing training. These systems adopted different methods and processes including motion capture, virtual trainer, real sense feedback, and video analysis. [6,8,11]. There are also some researches focused on indoor rowing training [1,12]. But less system provides a friendly environment for the interaction between coach and rower. This paper describes a project that aims for providing a real-time indoor coaching system for a rowing team. This project is working with Danske Studenters Roklub (DSR) for improving their training experience. During our research and communication with DSR, we found that training is a communication between the coach and the rower, and we decided to focus on the movement of hand and paddle. We believe that the training system should provide useful information for both coach and rower to analyze and learn. To reduce the misunderstanding and to build better communication, the information should be more direct and clearer, and people can interact with it to help them communicate. Self-learning and team coordination are also in our consideration in this system, and that is very necessary for lowering the cost of coaching.

2. The Research

The target user of our research is DSR. They have both outdoor training and indoor training facilities. As user input, the coach shows us his process and techniques of coaching. The main approach is video analysis. When they train outdoors, the coach drives a motorboat and uses a video camera to record the rowing boat. After they get back to the training HQ, the coach analyzes and explains action by action the earlier training on a screen. There are two main issues that perplex the coach. At first, the correction is not in a real-time. There is much time difference between video recording and correction. For dealing with this issue, the rowing team adopts a world famous indoor rowing simulation machine, concept2. [4] The coach can see and correct rower's action indoor and in real-time. But rower can only follow the right action when the coach is beside him. When they train individually or rowing outdoors, they will have a hard time remembering the right action. The second issue is that the video recording can't show the motions directly and accurately. The coach tries some motion tracing technologies that are installed on the boat with wires. But the rowers feel that the device adds additional burden on the boat and changes the feel and sensation of rowing. The collected data will be analyzed after outdoor training, and software will redraw the motion of the rower. The path is accurate, but it is not for real-time coaching, neither. These dilemma and obstacle are the initial users' input.

We have more research on indoor training with the rowing machine Concept 2. Concept2 has an ergometer with monitor. It can show a graphic of the velocity, the distance, and the force. The coach rows first, and the monitor lists the history of the motion as graphics. The rower needs to remember which history the coach records, and then the rower is needs to perform an action that gives a similar graphical pattern as the coach's pattern. Actually it is a behavior of imitating and matching. But the machine doesn't provide a user friendly way. This investigation inspires us to design a similar way to show information to the user. Based on the investigation and previous experience, the design concept is a part of designer's input. We also investigate virtual reality. Actually, Alessandro et.al built a training system with VR, and their focus is on machinists and the view from a rower's eye. [12] Lindholm Høje Museum in Aalborg exhibits an interactive rowing game with VR to demonstrate how ancient Vikings rowed there the ships. We take these suggestions back to our users. We all think it is a nice way to get a fantastic rowing experience for indoor training, but it would not help to demonstrate the right motion and rhythm, the coach still needs to analyze video clips.

During a discussion with DSR, we list out the new ideas and the old training methods to find a balance and connection. Because the old training methods are reliable and the fact that we are not just developing a game for fun we need to find a way to incorporate users input that is critical to evaluate to what extend the new ideas can be accepted for a practical training. The designer's input is investigation, results, new concepts, and analysis diagram. We find out that the rowing team needs a new idea of real-time correction and direct motion capture, meanwhile, they want to keep the traditional way of training with the Concept 2. To combine these 2 points, we designed a system that can recode the motion path and show it on the wall in front of the rower. The coach could point on the visible path and explain the right or wrong of an action. It provides a direct approach for analyzing, communicating, imitating, and training. We show our prototype to the rowing team. The coach and the rowers give us feedback. They could try to use any technology to record the motion, but none of them could help them to correct the motion. As the goal of training is to perform a right action, our users need a way to correct the wrong action. We can also see the same need from daily sport training. [10] Therefore, we decide to integrate a correction function into the next version. In the later iteration, more and more functions are added in to the system. People have suggestions and needs from varied perspectives. Lead user and common user have different ways to use our system and get different information. Finally in our system, it includes three steps for rowing training: The recording, the correction, and the matching. Each function represents a level of cognition.

3. Motion Path Recording

Human friendly design needs understandable information. As above-mentioned, we are going to recode the motion path and to show it on a screen or on a wall. Therefore we study the rowing process and got a research question: "What is an easier and more understandable way to show the motion path?" During our research, the coach is always trying his best to explain by simple and clear way. He catches the key points and emphasis, and tries to use easy and direct way to teach rowers. He proposes requirement and expectation to our training tools. On the one hand, the coach hopes our sports training tools can capture a motion as real as possible; on the other hand, he needs to make the rower understand the right motion easily. The coach told us he mainly focuses on some key position of a rower's hand. These positions can be connected one by one, and form a motion path. He draws this path on whiteboard or paper to explain the right position and motion. Following this traditional way of communication, we use accelerometer sensors to instead of the coach's eye, and use screen and projector to instead of whiteboard and paper. The position sensor provides a more accurate and original motion data. The screen and projector draw and refresh motion path in real-time. The important is that a computer will generate an understandable path by filter out complicated and useless raw data and provides a recordable history. Moreover, when the rower reviews the recorded motion paths and studies deeper his/her actual action, the simplicity of these paths information becomes more vital to the rower. Try to imagine, dozens to hundreds paths include thickly dotted potions. That is nearly impossible to process and analyze. As Figure 3-1 shows, the path looks smooth, but it is hard to catch the key point. The learner cannot performance another path exactly like this. In addition, this information cannot show time and speed different by an obvious way.

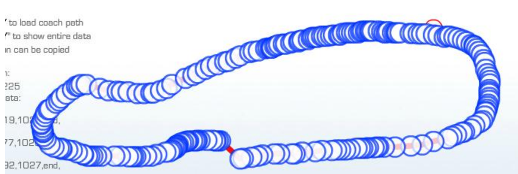

Figure 3-1 complicated path information

4. Build the System

The system that we build includes a mechanical paddle, motion capture sensor and hardware, and a laptop that is connected to both the hardware and a projector. The system shows as Figure Figure 4-1.

Figure 4-1Systems settings

The sensor capture is based on an electronics prototyping platform called Arduino. [7] We use an accelerometer to capture the motion of one end of the paddle in 2 directions. It represents the movement of up and down, or front and back. These 2 directions are represented by X and Y-axis on the computer screen and projected on the wall. The signal is generated by accelerometer and captured by an A/D convertor on Arduino, and sent to computer by a USB connection. This USB connection is treated as a COM port in the in PC. Following the guide on Arduino Playground, [7] we deployed a serial port convertor programs called SerialServer to transfer data from COM port to TCP/IP port. In my system, we used Adobe Flash as a user interaction program. Flash can get data from TCP/IP port, process the data, and use the data for animation and user interaction. When the capture starts, Ardurino will give a signal that the frequency is 25 per seconds. It is just enough for making an animation for human eyes. In the Flash programming, the system also set a threshold to filter the captured data when every two points have a distance of 40 pixels. In this way, the captured point becomes clear and understandable, by showing the difference of both time and position. User can change the threshold. We provide a handle for adjusting the capturing distance. (Figure 4-2).

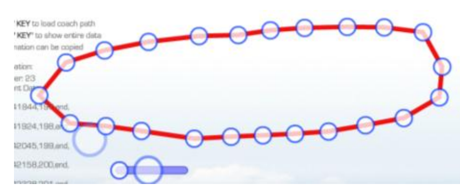

Figure 4-2 **Capture distance changing handle**

This handle design was part of designer's reflection-in-action. It is an obvious need of our designer. The same as Schön mentioned, "The project would talk back to practitioner what the conflict and problems are and where he has opportunity to solve the problems"[9] (p239). An efficient and effective reflection-in-action should be based on the interview and study with user. Basically, it is dangerous to pretend that a designer himself as the user to decide all the design solution. Thus get rich knowledge from user, and keep interaction with user during design process is the way to keep the design in the safe range. The rich information from user relies on the interviews and every discussion. In another words, designer's input rely on user's input. Designer translates user's idea, and combines his own recognition to make detailed design decision, and directly forms the product. After that, a cycle starts, user gives feedback and gets inspiration to generate the next user input, then the designer gets inspiration from user input, and combines them with his reflection-in-action to generate next designer input again.(Figure 4-3) From this iterative process, designer gets closer to user, and understands user's way of ideation better and better. The reflection of the designer will be more accurate to match user's need.

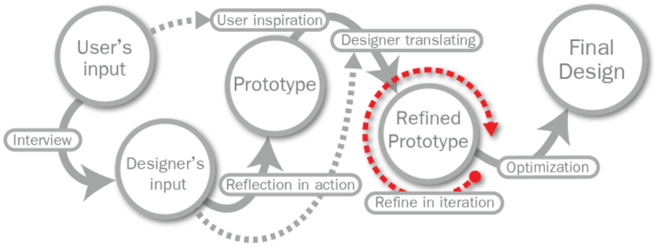

Figure 4-3 **design input and user input to design result**

User has a vague vision about what they need, [13] but can't speak out the exactly form of the design. Designers help users form their idea, and the very important is that designer sees the essential and core of the user's need, but not just one idea on the surface. Moreover, designer knows what resource they can use to reach a practical way that can realize user's expectation. The result of this interpretive work may have bias from user's original purpose. As I mentioned above, it will be closer to user's vision along with more iterations done, but the bias still exists. At this point, User's feedback is not only the inspiration for new ideas and new function, but also includes what the wrong or unnecessary design they saw from the bias. The feedback reduces and eliminates the bias step by step. Thus the designer can predict more accurately during later reflection-in-action. The coach has responsibilities to train several rowers. But it cost lots of energy and time for correcting everyone's motion and path. We purpose a solution to use computer to recode the coach path. Firstly, the coach performs several good motions, then he chooses the best one and save it in the system. Later on, he can load it as training standard or as a reference. The rower will study the coach path, and practice by matching it without the supervision of the coach. This approach allows the coach prepare an elaborative motion with deeper thoughts and put it into a visible format. Another coaching function is correction. The coach tells us, it is often to see that a rower has a customary motion. It may include a mistake or a core problem at a certain key-point. Thus the coach would like to correct this key-point with keeping other point. This way can make rower easier understand where the motion problem is, and how to correct it. (Figure 4-4) For performing this correction, the coach can use either the paddle or the mouse to drag the key-point. He can also move the cursor to an expected position first, and then push a key to automatically find out the nearest key-point. (Figure 4-4)

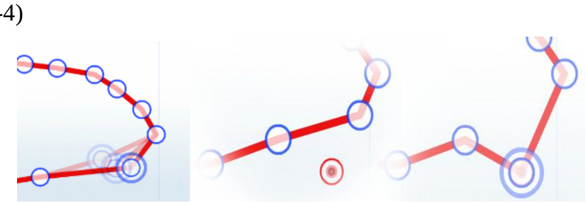

Figure 4-4 **correction functions**

Based on the individual training, and going along with the iteration of getting deeper and deeper, the coach hopes the system can also fit for team coordination training. As we know the rowing sport may need up to 8 or more people to row on one boat. The same rhythm and motion path are critical to the success of the coordination. As I mentioned above, the coach can save a perfect and adjusted motion path to support rower training. The same coach path is studied and matched by all members in a rowing team. No needs to gather the all members, everyone can train separately by referring to the same path. The system will show the rower's path and the coach path at the same time. (Figure 4-5)

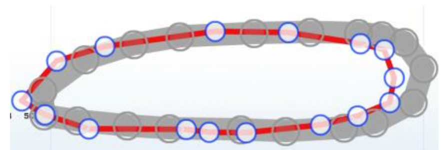

Figure 4-5 comparing rower path and coach path

5. Test procedure

After several iterations and communication with DSR, we take the whole system to them for an observation of using a relatively completed system. It is different from previous test and iteration. It is not for developing more functions, but for testing the feasibility. We gather a rower, the coach, the interaction designer, and the mechanical designer together to observe the usability. Following the process we designed, the coach makes a standard coach path, and the rower tries to match it. However we find that the rower feels hard to match both rhythm and path at the same time, and the number of key-point is also different between each path. Moreover, the coach finds out, because the size of rowers is different, the rower path may have different scale. The most important is not matching the position of a coach path, but is the rhythm and the shape of a coach path. Therefore, we decide to collect some objective data from a traditional way of coaching. The coach is correcting the rower without use our system, meanwhile, the system records rower's motion path and rhythm. Until the rower gets a satisfied motion, we stop recording. We also record several coach paths that the coach feels satisfy. Later on, we analyze the basic feature of these rowing data, such as cycle time, the number of key-point, and the proportion of width to height for each path. We analyze three groups of data: the rower's original rowing path data, the corrected rower's path data, and the coach path data. The table Figure 5-1 indicates that the coach path has average about 18 key-points in each path, the proposition of the shape is approximately 5, and the cycle time is about 1.5 seconds. Comparing with the coach path, the rower's original data has about 15 key points, the proposition is 3.8, and the cycle time is about 1 second. All these three aspects are higher than rower's. After manually correction by the coach (without using our system), the corrected rower's path is higher than the original. The corrected path has 16 key-points, the proposition is 4.25, and cycle time is 1.4 second. That means the shape of the path should be wider, and the rower should be more careful about the detail of a movement rather than a fast cycle. This point is also proofed by a following test with a common user, and based on it, when the rower uses our system to study a coach's path, he will put focus on wider shape, more key-points, and average about 1.5 second a cycle.

	Rower Orignial Path						Coach Corrected Rower's Path						Coach Path					
		x/w	y/h	No.	Time	W/H		x/w	y/h	No.	Time	W/H		x/w	y/h	No.	Time	W/H
Path 10	max	1040	491.7	13	3.58	1055	max	988.8	512.35	17	3.93	1437	max	1168.3	492.8	21	4.15	1721
	min	443.8	325.25				min	262.2	327.45				min	296.95	282.85			
	dist	596.15	166.45				dist	726.7	184.9				dist	871.35	209.95			
				15	3.81	1073				16.1	4.25	1431				18.2	5.1	1528.3
Average				15	3.81	1073				16.1	4.25	1431				18.2	5.1	1528

Figure 5-1 **three groups of rowing data**

We take the same rowing system to Sønderborg local rowing club (SRC) without any modification to see the feedback from common user. The SRC is lower level than DSR as they are not aiming for the Olympic games. But they are far more professional than an individual amateur user. As I mentioned above, the DSR is the lead user in the rowing field, and they represent the highest need of rowers. Because the system was developed with DSR step by step, it should fit most needs of the common user. The test with SRC is held in a rowing training exhibition (Figure 5-2). Some friends and rowing amateurs also come. The members of SRC have similar comments as the DSR. They care more about the cycle time and the shape of a path, and they don't need to match accurate positions of the coach's path, (actually our system didn't have an evaluation function for matching). They also said that the training system is very good to them to use in a direct visible way to compare between any different rowing paths. Some of the amateur likes the matching idea very much. They like studying by following the coach's path completely. They trust this is a faster and necessary way for training a right motion from the very beginning. From these comments we can see that our system provide information from different aspects, a user has his own way to use the system and get focus on different aspects of the information.

Figure 5-2 **rowing training exhibition**

6. Conclusion

Through our research I would like to conclude that, Sports training is a communication between coaches and athletes. The training tool is to help a coach organize information and explain certain aspects. An intuitive, direct, and real-time way with interactive graphical information gives more efficiency to the communication and reduces the misunderstanding. Motion training is one of the most important parts in Sports training. To help athletes do a right motion, the training tool is necessary to have ability to record the motion, and present it in an easier and more understandable way. Moreover, the recorded motion can be used for individual training without a coach, and for team training with coordinating to the same motion. The correction function is also necessary, because it gives a solution for explaining the wrong or right motion for a personal case.

We also get experience on implementing User Centered Design as a system development. We can conclude that, User Centered Design is a combination between designer's input and user's input. Users know special information in his area where he is a specialist, and the designer translates the information in to practical tools. On an ongoing project the designer would get closer and closer to the user's ideation, and can more easily see himself as a real user based on the rich information they get from user. This process grants the final design many functions to generate information. The different users can find out their own way to use such a product by selecting useful functions and getting information from different aspects.

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