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SYSTEM REPRESENTATIONS FORMATS AND THEIR INFLUENCE ON USER EXPERIENCE EVALUATIONS

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ABSTRACT

Knowledge is lacking on the choice and use of representations in a design process when seeking to investigate user experiences. Two types of representations (a storyboard and an interactive prototype) of the same system were used in a user experience evaluation involving 24 participants to investigate how different representation formats influence participants' responses to interactive systems. Data from a questionnaire and individual interviews were compared. Very few differences in questionnaire responses were found. However, the interactive prototype gave rise to more design proposals as well as more personal reflections on experiences although with a focus on interface design details. The storyboard elicited more responses on the core ideas of the concept, but less grounded in reflections on personal use. The differences are attributed to how each representation managed to convey interactivity and context, resulting in differences in experienced agency. It is therefore suggested that there is a need for further research, but with less focus on the type of system representation and more focus on how the content and affordances of system representations can be designed to elicit rich and personal reflections on user experience in early design phases.

KEYWORDS

Prototyping, User Experience, Storyboard; Infotainment, Representations, User Study

1. INTRODUCTION

User Experience (UX) has evolved from traditional usability to include also aesthetics (Alben, 1996), hedonic qualities such as stimulation, identification and evocation (Hassenzahl, 2004) as well as contextual (in terms of place), social and temporal aspects of use (Bargas-Avila & Hornbaek, 2011; Forlizzi & Battarbee, 2004; Hassenzahl & Tractinsky, 2006; Pettersson,

2016). At the same time as this creates opportunities for innovative design it also leads to methodological challenges when planning and conducting studies to generate in-depth understanding of users' needs and requirements as well as when choosing the methodology to evaluate designs from a UX perspective. Several studies have found that both academics and practitioners face difficulties when addressing UX evaluations (e.g., Kashfi et al., 2016; Law, 2011; Vermeeren et al., 2010) in particular in early design phases (e.g., Roto et al., 2009; Vermeeren et al., 2010). Challenges include the choice of data collection methods (e.g. interviews, questionnaires, etc.), participants (e.g. end users, experts, individuals, groups) but also how to represent the concept to be evaluated (e.g. scenarios, sketches, paper, interactive prototypes, etc.). However, whereas a number of studies has investigated how the choice of product or system representations impacts the outcome of usability trials (e.g., Kim et al., 2006; Sauer et al., 2010; Sefelin et al., 2003; Virzi et al., 1996), systematic comparisons are scarce of the influence of representations used in evaluations with a user experience focus. As user experience reaches beyond traditional usability and functionality aspects and as UX evaluations must not only address pragmatic but also, for example hedonic, social and temporal aspects, the choice of system representation in UX evaluation studies is a methodological challenge that requires further consideration.

One exception from the hitherto prevailing focus on usability evaluation is Diefenbach et al. (2010), who explored differences in participants' responses to two innovative lamp concepts represented in forms of text, text+pictures, text+video, and text+real interaction (with functional prototype). Participants were assigned to one of the two concepts, each presented in one of the four different representation conditions. In this case, neither global evaluation (i.e., goodness) or high-level product perceptions (i.e., pragmatic or hedonic quality) were significantly influenced by the representation of the respective concept.

With the intention to investigate the effect of visual quality and medium on users' understanding and appreciation of a design concept, as well as of the nature of any feedback provided, Özcelik-Buskermolen et al. (2015) presented a concept for an adaptive patient room, manipulating the representation medium (a series of stills vs. an animation) and visual quality ('sketchy' vs. 'refined'). They found that whereas medium and visual quality had no effect on the participants' comprehension of the concept, or on their judgements of hedonic quality or appeal, sketchy representations provided more elaborate feedback and design suggestions as well as more grounded feedback in past experiences.

A third example is a study by Sellen et al. (2009) in which users' experiences in relation to the design of in-home technology for eldercare were investigated. The participants were randomly assigned to either viewing a video or reading a storyboard describing the design. In this case, an analysis of valence (i.e. number of positive, negative or neutral comments regarding the design idea), references to material (number of references to explain an idea etc.) and self-references (i.e. the number of times participants referred to personal preferences, traits or mention of the self) formed the basis for the comparison. No difference in valence could be noted but the study revealed that participants' responses varied based on the format of the prototype they were presented with. Storyboards elicited more self-references than videos and thus lead to more information about the participants' subjective experiences.

Given the limited number of studies of the influence of system representations in user studies of UX, there is a need to develop further knowledge to support the choice and use of representations in a design process when seeking to investigate user experiences, that is hedonic, contextual, temporal and subjective experiences.

2. AIM

The overall aim of the present study was to further the knowledge on how different types of system representations influence the outcome of a UX evaluation. In the particular case, the aim was to investigate what information on experiential aspects on a design was triggered by two different types representations of the same system: a non-interactive representation – a storyboard – and an interactive prototype. Which representation conveys the intended user experiences most effectively? Is there any difference in how participants respond to the idea? Considering that UX is highly subjective and contextual, is there a difference in how participants respond and expresses emotions, contextual use and personal reflections? and as both storyboards and interactive prototypes are often used in formative stages of the design process, how do the representations differ in terms of elicited suggestions and reflections on design improvements?

3. STUDY DESIGN

In order to address the questions, a user study was completed. Most UX studies encompass the collection of both qualitative and quantitative data (e.g. Bargas-Avila & Hornbaek, 2011). In the present study individual, structured interviews targeted overall personal experience, daily contextual use as well as design proposals. Questionnaires were included to collect quantitative data on participants' actual experience compared to the one intended. By compiling the quantitative data and by analysing the qualitative data by means of a thematic analysis, the intention was to discern differences in responses in addressing the contextual, emotional and subjective aspects of user experience, as well as the ability to provide formative feedback.

3.1 The System

3.1.1 System Description

A novel, inter-connected, automotive infotainment system (containing entertainment functionality, navigation and vehicle settings) was employed as case study. The system was design with the intention to help users stay socially connected to others during the drive, with simplified interactions for phone calls or checking social media when standing still in a queue. The system could furthermore suggest activities and solutions to problems, taking the individual user's habits and the use context into consideration, for example propose navigation routes based on travel habits or send a mail to colleagues if the user is delayed to a meeting. The users' identification with the system as well as stimulation through use were intended to be supported by the system's ability of sensing and adapting to personal needs. In addition, the system had a knob, a "zen control", that could increase or reduce the level of information in the display. This meant that the user could change information level depending upon need and situation, for example choose to get more information in a queue situation. The concept was developed during a joint research project between industry and academia, building on research of what constitutes valuable, positive experiences in cars. The development process is further described in the following section.

3.1.2 System Development

An initial user study was completed as a basis for the development of the concept (see also 18) (see also Gkouskos et al., 2015). In total 16 participants (7 women and 9 men, with a median age of 48 years) were involved in the study in which contextual interviews (cf. Beyer & Holzblatt, 1997) complemented with reflexive photography (Harrington & Lindy, 1998) and a simplified version of the UX curve (Kujala et al., 2011) in order to access the subjective experiences of the respective participants through multiple entry points, and to stimulate a deeper conversation around lived experiences in cars. The participants were asked to take photos of what they perceived as significant for them about their car, prior to the interview. The photographs were then used to draw attention to areas that the participants found significant enough to photograph. The next step of the study was the contextual, semi-structured interview with the participants that took place in their home or office as well as in their cars. Being in the use context with the user was an important aspect of the interview, as topics could be followed up more thoroughly, avoiding misconceptions and spurring conversation. The UX curve method was integrated into the interview and the participants were asked to draw a curve along a vertical timeline to describe how the use experience had changed over time. The UX curve method was employed for two reasons: firstly, for gaining insights of experience as it changed over time and secondly, as a conversation mediator. Each session lasted approximately 1,5 hours.

A qualitative data analysis was conducted of the interview data (cf. Denzin & Lincoln, 1998) with open coding of emerging experiential themes. Four distinct key areas of experiences were deducted for experiencing infotainment systems:

- (mental) transition; e.g., using the in-vehicle system to transition into work-mode by placing work calls in the car during the morning commute, relaxing with music on the commute home;
- relatedness to others; e.g., using the systems to connect to others by routine calls to family members, or jointly making music playlists on holiday driving,
- stimulation; e.g., discovering and enjoying new functionality in the vehicle,
- caretaking; e.g., enjoying and finding security in the car looking out for one's best.

The user study was followed by a series of ideation workshops with interaction designers from the automotive industry, where the insights were used as starting points for creating new concepts. After evaluating and prioritizing the emerging design ideas, the ideas that best appeared to target the needs of caretaking and relatedness to were selected to be further developed into representations of a final product, able to look out for the user's well-being, and simplifying the user's daily life.

3.1.3 System Representation

Two representations were developed: a storyboard (Figures 1-2) and an interactive prototype. The storyboard was presented in an A3 format, the main features of the concept narrated by a user named Susan; a middle-aged manager with husband and two teenage children, engaging in the system on the way to work.

Figure 1. Full storyboard representation of the system, narrating the drive to work for "Susan"

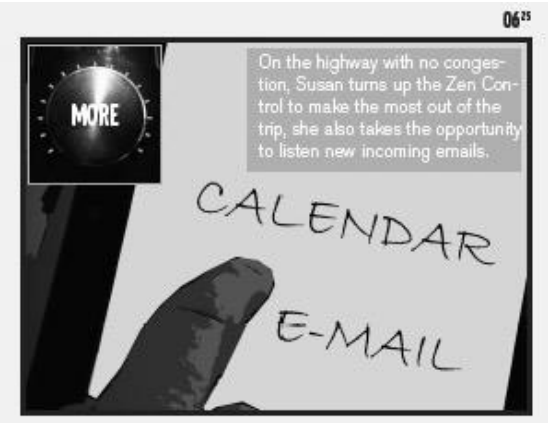

Figure 2. Part of the storyboard, illustrating the user's interaction with the system

The interactive prototype was a touch tablet combined with a haptic rotary wheel – the zen knob (Figure 3). A number of interactions were possible to perform, such as checking mail, placing phone calls, receiving reminders, selecting suggested radio shows etc. (Figure 4).

Figure 3. The interactive prototype and the haptic rotary wheel

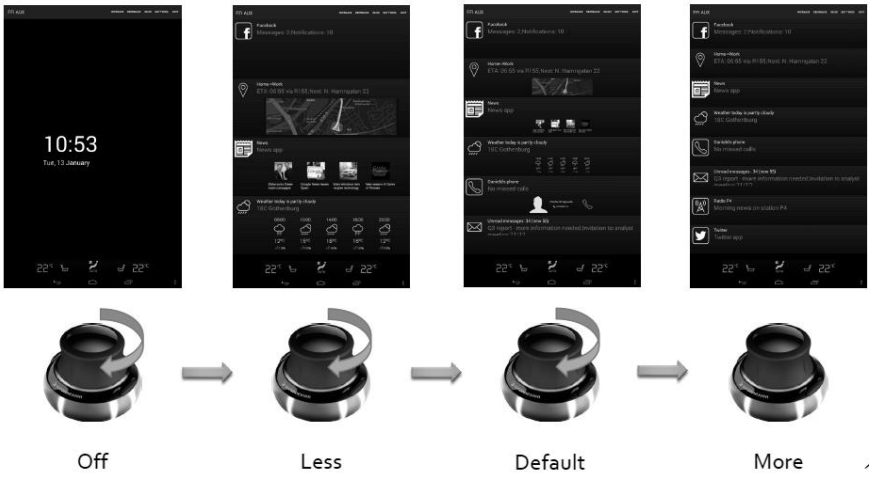

Figure 4. The zen-knob

3.2 Participants

The study encompassed altogether 24 participants, 12 men and 12 women. Their ages ranged from 24 to 53 years (average age=37). Inclusion criteria were that they had experience of car commuting and were possible adopters of the technology due to their interest in (new) technology (their self-estimated technology interest averaged 4 on a scale ranging from 1=low to 5=high).

The participants were assigned to one of two groups (group A or group B) taking into consideration age and gender (see Table 1).

Table 1. Participants in Group A and Group B

	Group A	**Group B**
Type of representation	Storyboard	Interactive prototype
Mean age (span)	39 (24-53)	36 (24-53)
Gender (M/F)	7/5	5/7

3.3 Procedure

The evaluation sessions took place in an office environment and lasted approximately 45 minutes each. In order to form a common basis for all participants, the basic functions of the system and how it could be manipulated were first explained. The participant was then instructed to independently read the storyboard (Group A) or explore the interactive prototype (Group B) for as long as he/she desired. Typically, this took a few minutes, and a few clarifying questions were usually asked by the participant. The participants were welcome to ask questions until they felt that they had become familiarized with the system.

A questionnaire was then handed to the participant. The questionnaire contained eight Likert-statements to which the participants had to indicate their level of agreement. The scales ranged from 1=completely disagree to 5=completely agree. Three of the items were adopted from the UX curve method (Kujala et al., 2011) with the intent to cover generic elements of user experience, namely attractiveness, ease of use and utility. An additional five items were added to capture the intended specific user experiences, i.e. the process of preparing activities next in life, simplifying daily routines, being socially connected, identification with the system and perceived stimulation from using the system.

In the structured interview that followed, the same questions were posed in the same order to each participant. These questions concerned valence, i.e. the participants' impressions of the concept (positive and negative), how the participant imagined it would be like to use the system, if it would support them in daily activities, and if it fit their self-image. In addition, the participants were asked if there was anything that they would like to change about the system and its design. With the approval of participants, the sessions were audio-recorded.

3.4 Analysis

The quantitative data were compiled, average values calculated per item and a test of statistically significant differences between the ratings of Group A and Group B was performed. The recorded interviews were transcribed and a qualitative data analysis was performed (cf. Miles and Huberman, 1984) by the first author. This meant that the material was coded and sorted in a top-down approach into themes (i.e. contextual aspects, emotions, reflections on personal aspects, design proposals) as well as according to the specific experiences that were the intention of the concept (i.e., simplifying the daily life and routines).

4. RESULTS

For the questionnaires, the concept as described by the storyboard (SB) was given consistently lower ratings than the concept represented by the interactive prototype (IP) for all aspects except ‘ease of use’ (see Table 2). However, no statistically significant difference could be found except but for one item; "I feel that this concept would make me feel more in contact with those people who are important in my life".

Table 2. The responses to the questionnaire by group a (storyboard) and group b (interactive prototype) respectively, average and p-value

Question	**A**	**B**	**p-value**
I feel that this concept would make me feel more in contact with those people who are important in my life.	2	2,5	0,04*)
I feel that this concept would help me prepare for activities that follow after the drive	3.5	4	0.53
I feel that this concept would help me enjoy my time in my car more	4	4.5	0.27
I feel that this concept would support me in everyday tasks	3	4	0.64
I feel that the concept is attractive and interesting	3.5	4	0.43
I feel that the concept appears easy and effortless to use	4	4	0.75
I feel that the concept has an important function for me	2.5	3,5	0.06**)
I would like to have the concept in my car	3.5	4	0.27

*) statistically significant difference, $p<0.05$
**) trend, $p<0.10$

According to the analysis of the qualitative data from the interviews, the storyboard resulted in stronger emotional and overall more negative reactions to the concept whereas the interactive prototype resulted in a more positive response. Comparing the two representations, considerably more design proposals were made for the interactive prototype. More reflections on contextual use were made in regard of the storyboard, but more personal reflections were made in relation to the interactive prototype (see Figure 5).

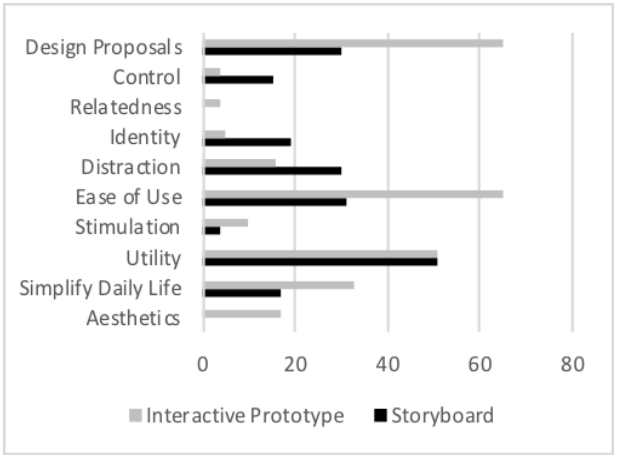

Figure 5. Number of quotes for each user experience aspect

4.1 Group A - Storyboard

The storyboard (SB) appeared to direct the participants' attention to the core ideas of the concept as the system's suggestions for activities and the "zen" device, controlling the level of display information, were extensively discussed.

The overall perception of the system was negative and there was a general scepticism to the system detecting the user's habits and making suggestions based on these patterns. By and large, the emotional reactions were fairly strong, questioning what was perceived as an intrusiveness of the system. A typical claim was that the system would be too interfering and a loss of control was anticipated; *"It's like that Microsoft clip - annoying. I tend to like to control the interface myself"* (SB9). The participants were anxious of actions taken by the system without their control which was expected to lead to stressful situations. The described system was commonly perceived as a stressor, where the pace of interactions would be decided by the system, and not the user: *"I would be stressed by it. I mean, the vehicle suggests I should do this and that… I can decide that for myself "*(SB1). That the system was not only detecting the habits of the user but also habits of family members, resulted in the system being perceived as too intrusive: *"I'm not sure I'd like the car to tell me to check on my son… It would feel strange to have a voice in the car to tell me that!"* (SB8). Thus, the design ideas that were supposed to be an aid in the user's everyday life, were instead perceived as interfering and invasive.

The distractions that could be caused by the system during driving were frequently mentioned in the interviews. The concept was generally considered as a possible traffic safety risk, as it was perceived to potentially lure users into dangerous behaviours: *"The brain of this CEO is not focused. Maybe the system is so smart it knows what's safe... but what does it do to her? Is she able to do wise, informed decisions?"* (SB11). However, any apprehension typically concerned other people using the system, not the participant's own use; *"I'm not sure that it should show so much information. Is it a good idea to show Facebook when driving, even when in a queue? I think it might encourage people to look at Facebook…"* (SB7). Overall, even though stories on other people's use of the system were verbalised, most participants did not appear to consider themselves as target customers for the evaluated system: *"I don't see myself as the target customer, I'm not that interested … I don't want to be fed with info all the time. I want time for reflection."* (SB2). In summary, the storyboard respondents were less prone to see themselves as protagonists in the story and referred more to how others might use the system.

However, the storyboard evoked also positive responses and sparked reflections on, for example stimulation through use over time; *"I would play with it a bit in the beginning, to learn and to understand the system, how it talks to you and how it works …"* (SB3). Positive comments were found in relation to the "Zen control" functionality that could control the different levels of information and therefore was perceived to increase the ease-of-use of the system. The idea of a simple turn of a knob to enable a 'calm environment' in the car was appreciated, in contrast to the stress believed to be caused by system functionality.

The design proposals that were verbalised concerned primarily the inclusion or exclusion of certain functionality, mainly referring to the distraction issues of the system. Even though the storyboard contained descriptions of many and rather detailed interactions, the design proposals were generally on a high level of functionality; *"...I would remove it (the system) but maybe if you could project it on a head-up display in front of me and have more voice*

interaction …" (SB8). Often, design proposals concerned introducing limitations of functionality in certain situations, for example when driving over a set speed limit, certain information would be made inaccessible for users. A few proposals addressed the choice of interaction modality to reduce distraction.

4.2 Group B – Interactive Prototype

For group B using the interactive prototype, the visual aesthetics of and interactions with the system formed the main bulk of comments. Examples of such comments are; "*It's quite easy to use. It's not so many steps." (*IP11) and "*It is not very intuitive to have the notification only like this in the top very small, it should appear bigger" (IP9).*

A considerable number of design proposals was put forward, describing overall rather incremental but very detailed modifications. The interactive prototype respondents reflected extensively on issues such as layout, symbols used and text size. Graphic design was, for instance an often-mentioned topic: "*You should be able to make it more personal, like a personal background*"(IP4) and "*I would add information to each tile when there are fewer tiles instead of more tiles. And only allow 4 tiles maximum at the same time. 6 and 8 tiles are too much"* (IP5). Other common proposals concerned changes in input modality; *"(I'd like to see) more of the voice interactions and less of the visuals. You could have audio information about traffic jams."* (SB1).

Very little information regarding possible personal identification with the system was elicited, but if mentioned, the comments were overall positive "*I would like it very much. For me, I'm a salesman and I use my cell phone, my computer, my tablet all the time so it would fit me very good. It would fit my image"* (IP4). The participants saw themselves as the 'actors' of and with the system and did typically not refer to how others might use the system. Previous personal experiences were reflected in relation to the system's design in terms of how it would be like to interact with the system in typical driving situations; *"This would take too long time to read while I'm driving in high speed. I had a bad experience when I was driving, may years ago, I had a phone call and I tried to get my phone out...it's not easy to get it out of the back pocket so I hit the pedestrian pavement, and that really scared me. After this experience, I started to care about these behaviours…I think for this concept, I really like this that's I can switch between the levels (shows level 3 and 4) and reduce information…"* (IP10). Temporal issues, such as getting to know the system and using it over a longer period of time, were however not addressed. Comments made involved momentary aspects of interacting with and using the system.

As earlier mentioned, many participants referred to their own previous experiences when assessing the concept, but the lack of context in the test set-up was experienced as difficult to oversee by some participants, as reflected in this comment; *"It's difficult to see how it will work in a car. I would get another impression if I would be in car and interact with it, I don't have any traffic now. It's difficult to know how easy it is to see the information and react on it, when you don't have the traffic situation"* (IP11).

Distraction was only mentioned by a few of the participants, and then in connection to how this could be affected by the design of the interface, including the choice of modality; "*I would take away this part (the knob); I would only use the screen. It's easier to only use the touchscreen when you're driving. I would have fewer applications to choose from to make it easier to use when driving. I just want to focus on driving, I don't want to many options"* (IP7). Control was addressed in relation to direct interactions with the systems, and on an ease-of-use level more than by questioning the system's suggestions based on user habits.

5. DISCUSSION

Even though the questionnaire data did not indicate differences in the participants' evaluation of the system (at least not statistically significant), the interview data two substantial differences in how the new system. First, there were different UX factors that surfaced in the participants' narratives in response to the respective representation; the storyboard narratives addressed mostly temporal, contextualized issues, while the interactive prototype narratives focused mostly on personal, visual and interaction issues. Second, the overall impression of the system differed; the system represented in the interactive prototype was received more positively than that in the storyboard. These differences are argued to originate from the system representation, an issue found in previous relevant work by for example Söderman (2001) and later by Diefenback et al. (2010). This has serious consequences for UX design and must be considered in order to plan successful UX evaluations, i.e. design teams that aim to evaluate the UX of a design artifact must pay special attention to how the design is represented in the evaluation. As user experience is a rich, complex and diverse topic, it is unlikely that one evaluation method can cover all of it in early design phases when no "real" contextual experience of the product is possible. Therefore, a meticulous decision must be made regarding which UX factors that would be the priority in an early evaluation. This calls for awareness of that some UX factors will be in the background and other in the foreground as the choice of representation in itself will filter out some aspects and emphasize others.

On the one hand, the interactive prototype allowed the participants to physically interact with the interface, i.e. to make choices, perform actions, receive multi-sensory input (visual, haptic, and audio), and react accordingly. As a consequence, the participants' responses focused on visual aesthetics and interaction properties of the prototype, instead of addressing more holistic UX aspects. The evaluation was centred around momentary experience and first impressions, rather than experience over time. However, the interactive prototype effectively elicited participants' personal reflections. The participants were able picture themselves as the user interacting with the system, and this had a direct effect on the richness of elicited user experience data as they were able to draw upon, and share, previous personal experiences that they deemed relevant. However, the participants were not sufficiently able to address contextualized use over time, in order to envision a whole experience with the (future) system.

On the other hand, the storyboard provided participants with a complete story that included context, assumed benefits, and a specified user. As a consequence, the participants focused their comments on these factors – but they did not appear to be able to identify themselves as an intended user. These results contradict previous findings that storyboards enable "... *the viewer to experience the interactions through empathizing with the character and/or the situation and reflect on the visualized situation through his/her own everyday expertise*" (van der Lelie, 2006). However, van der Lelie (2006) also argued that storyboards "*allow users to withdraw from the experience and look at the unfolding event from the outside*" which seems to have been the case for the majority of the participants in the storyboard group. The storyboard directed the participants' focus to the story, and the system's functions and interactivity were filtered through the lens of the persona's needs and actions. Hence suggestions for modifications primarily concerned these matters.

Several other studies have found differences when investigating users' more general responses to different design representations and often argue for less detailed, more 'sketchy' representations as preferred tools to elicit more user feedback, whereas more advanced

representations tend to be accepted 'as is' (e.g. Özcelik-Buskermolen et al., 2015; van der Lelie, 2006). If the storyboard in this study is to be considered the less detailed, the present study does not confirm earlier research; indeed, fewer design proposals were made by the storyboard group compared to the group that were allowed to interact with the interactive prototype. However, the main ideas of the concept were addressed and challenged in the participants' narratives, as compared to the more low-level comments on the interactive prototype.

Furthermore, the findings support the notion that the choice of representation is not only a matter of choosing the type of representation deemed appropriate to a certain stage of design process, but careful consideration must be paid to details in how the representation is designed, for example what content is included (cf. Söderman 2001) and what is not, and what the representation allows to user to do and what it does not. In the case of designing storyboards for instance, Truong et al. (2006) have earlier observed that the outcome of an evaluation will be affected by the background provided, that the use of words can bias a user's response to a design and, furthermore, that the inclusion of human actors can result in a focus on the experience of application, whereas showing only the interface will result in a focus on smaller details. In the study presented here, negative reactions were noted towards the actions of the storyboard persona, and participants had difficulties to imagine themselves using the system the way the persona used the system, whereas they could envision other people doing so. This indicates that it is important to construct storyboards that allow for a greater sense of agency for participants in user studies.

No matter the representation, eliciting more in-depth data of user experience is challenging. The analysis of the interviews shows that the greater part of data concerned the traditional usability aspects, such as utility and ease-of-use, an issue confirmed in previous UX research (Arhippainen, 2009). Even though usability is fundamental to system design, to be able to evaluate UX in terms also of, for example aesthetic experiences, stimulation, identification, as well as contextual, social and temporal aspects of use, there is need for more directed means to elicit UX data, not only by system representation but also by other mediating objects that can support the study participants to reflect on, for example contextual and emotional factors. Examples of this can be visual (cf. McDonagh et al., 2002) or sensory (cf. Isbister et al., 2007) means of expressing experiences in user studies.

Furthermore, the interview data that were collected (primarily in Group A) directed attention to experiential qualities (i.e. distraction, feeling of control) that were not revealed by the questionnaire but found to be fundamental for the participants' evaluation of the concept. In using only data from the type of questionnaire used in the study, there is an apparent risk to miss out on aspects that are highly relevant for design decisions (cf. Diefenbach et al., 2010), for understanding the reasons behind ratings, for eliciting suggestions for modifications, as well as for sparking new design ideas (cf. Buskermolen et al., 2015; Kashfi et al., 2016). There is also a risk of not reaching more in-depth understanding of the effects of how the system is represented.

In conclusion, designers that wish to evaluate UX early in a design process must be aware of which factors can be addressed as a consequence of different methodological choices, including the choice of product representation form, and be ready and willing to combine different representations in order to cover the broader aspects of UX, or at least UX factors that deemed particularly important to the design problem at hand. In the study presented here, neither of the two representations provided responses on the "whole" experience, something that is difficult to reproduce before the experience is actually lived by the final users. The

representations can, thus, only be “rehearsals” where, in each rehearsal, different aspects of experience are highlighted and conversely other aspects are muted and fade into the background. In this study, the storyboard appeared to surface general reflections on temporal and contextual factors, whereas the interactive prototype gave rise to more personal reflections, however mostly on design details.

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