Video Prototyping in Human-Robot Interaction: Results from a Qualitative Study

Dag Sverre Syrdal
Adaptive Systems Research Group, School of Computer Science, University of Hertfordshire
College Lane, Hatfield
AL10 9AB
United Kingdom
d.s.syrdal@herts.ac.uk

Nuno Otero
Department of Information Systems, University of Minho
Campus de Azurém
4800-058 Guimarães
Portugal
nuno.otero@dsi.uminho.pt

Kerstin Dautenhahn
Adaptive Systems Research Group, School of Computer Science, University of Hertfordshire
College Lane, Hatfield
AL10 9AB
United Kingdom
k.dautenhahn@herts.ac.uk

ABSTRACT

Motivation - Explore and refine qualitative methods of video prototyping in Human-Robot Interaction in order to evaluate user experience of prototype systems.

Research approach - An exploratory, scenario based study, in which participants were interviewed following some specific guidelines regarding the interviewing technique.

Findings/Design - The results offer insights into how the context of a presented interaction through video impacts on participants' opinions and attitudes towards a particular interaction, and foster a reflection concerning the wider implications of a system.

Take away message - The use of evocation in open-ended interviews regarding user experience of video prototypes is a valuable tool for research.

Keywords - Human-Robot Interaction, video-prototyping, explication interviews, qualitative methods.

INTRODUCTION

This paper describes the methods and results from the use of video prototyping for user evaluations of 3 robotic systems in scenarios of domestic use. Our aim was not only to investigate how useful the recommendations regarding a particular interviewing technique -the explicitation interview -was for tapping into the users' experience but also to gather valuable information to foster the creation of quantitative questionnaires.

Human-Robot Interaction (HRI), particularly in regard to social and domestic robotics, is a comparatively new field . As such, the specificities concerning the methodologies to inform the design of robotic systems from a user centred perspective are still an open issue. Some authors consider that while the nature of the interactions between humans and robots may share some aspects we find when studying human-human, or human-computer, interaction, there are differences between these and human robot interaction that have so far been observed . These differences suggest that HRI research cannot simply apply methodologies from its related field of Human-Computer Interaction, nor those used in the social sciences, in order to automatically assert validity.

Thus, the study of methodologies that are appropriate to a) investigate how potential users evaluate and behave within an interaction situation with a robot, and b) how these interactions will impact on their wider everyday experience once the technology has been implemented, is an important facet of current work in the field of HRI.

The work presented in this paper was developed as part of the research for the European funded project, "The Cognitive Robot Companion" (COGNIRON). Within the Cogniron project the line of investigation reported here concerns the evaluation exercises from an end user perspective to investigate how we fared in improving the interaction exchanges between humans and robots as well as acceptability of robots' behaviour in an ill defined, socially rich and changing environment.

This particular study focuses on how participants evaluated three robotic systems in terms of user experience, after having watched a brief video showing how people were able to interact with each system. However, given the method, third person view of an interaction, i.e. the user experience evaluated/probed is not the experience of the interaction per se, instead it is about the experience of watching the interactions displayed in the videos and be able to, somehow, relate to the situations. In other words, we were inquiring how people project themselves in the situations portrayed in the videos, what their attitudes towards some specific episodes are and what their experience when doing so was.

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BACKGROUND

This section covers two distinct topics: user experience and the use of videos to inform the development of interactive systems from a user centred perspective.

Some notes on user experience

Drawing upon the definition by Preece, Rogers & Sharp, user experience in the context of the present study focuses specifically on the degree in which the participant accepted the interaction models embedded in the robots as portrayed in the videos, and not on specific objective measures connected to the events within the interactions presented.

We are quite aware, though, that defining what one means by user experience is not straightforward. The term has not reached maturity in relation to its distinct dimensions and ways to operationalize them, in part due to its multifarious nature. Hassenzahl and Tractinsky (2006) consider:

"User experience (UX) is a strange phenomenon: readily adopted by the human-computer interaction (HCI) community – practitioners and researchers alike – and at the same time critiqued repeatedly for being vague, elusive, ephemeral." (pag. 91)

Nevertheless, according to Hassenzahl and Tractinsky (2006), the term still gained relevance mainly as a reaction against the mainstream usability paradigm that focused almost exclusively on task and work related issues. Although an in-depth review of the UX concept is clearly beyond the scope of this present paper, two trends regarding the efforts for a definition and practical use can be identified.

Some researchers take the view of the need and possibility to provide a detailed conceptual and methodological framework to account for users' experience by integrating concepts from information design, information architecture and interface design.

McCarthy and Wright take a very distinct stance. They argue that the previous perspective is too constraining in relation to a more philosophical definition of experience. In its place McCarthy and Wright (2004) propose a pragmatic conceptual framework inspired by the work of Dewey in aesthetics and Bahktin in dialogicality. They view experience as an active holistic process of sense making.

McCarthy and Wright (2004) apply their theoretical framework to the accounting of three stories of people's experiences with technology. However, as Light rightly points out, the reader is left unsure about the practicality of such investigative exercise within system's development. The work for sure highlights the pitfalls of pre-assumed, and not explicit, conceptualisations on "what experience is" and shows the complexity of the topic. Nevertheless, one is left with no clear guidance regarding how to systematically investigate user experience and, at the same time, be able to translate the findings into system requirements.

Hassenzahl and Tractinsky , in the Introduction to a special issue dedicated to UX, propose a research agenda for the term. They specifically consider three distinct perspectives:

- Moving beyond the instrumental, which means that researchers and designers should also consider aspects not bound to specific issues related to task completion. As examples, we should pay due attention to user needs like surprise, diversion, intimacy, stimulation, personal growth, identification and evocation (to name a few).
- Attention towards affective and emotional aspects of product design, in particular if directed to a better understanding of the role of affect and emotions before, during and after the actual use of a certain artefact. In other words, to what extent do affects and emotions shape our initial perception of an artefact, influence the actual use and form memory traces that guide future utilization (or acceptance).
- Focus on the human experience dimension and its possible effects on product usage. This dimension highlights the importance of considering the situated nature of artefact use, its temporality. Furthermore, of great importance is the understanding of how people are able to configure their experiences into assessments and, more or less, structured narratives of the things experienced.

Hassenzahl and Tractinsky (2006) also point out the paucity of empirical research in the area and consider it to be a major problem in pushing through the term/concept along firmer grounds. Light (2006, in fact in the same volume) discusses the difficulties of transposing the gulfs between theoretical accounts, the actual operationalization of the concept of UX and the use of appropriate methodologies. In her paper, she proposes the use of a specific interviewing technique termed the *explicitation interview* and discourse analysis in order to tap into people's experiences with technology.

Scenarios and the use of videos in the design of interactive systems

The methodology used in this study was scenario based, drawing upon the extensive body of knowledge from the related field of HCI . Scenarios are stories created about the users and their interactions with artefacts in a specific context (Carroll, 2000, 1995; Dix et al., 2004; Preece et al., 2002). The use of scenarios as a methodology is well-suited for the exploration of needs, interaction and experience within the particulars of a particular setting or situation, which, in turn, is particularly apposite for the embodied, socially situated nature of social robotics. Furthermore, scenarios can have different levels of detail depending on the development stage or need for fresher ideas. In general terms, Carroll (2000) considers that scenarios have the following elements: they presuppose a setting, they include agents, the agents included have goals, scenarios have a plot, including sequences of actions and events.

Videos are a possible form of scenario representation. Video based scenarios have previously been considered

and used when assessing novel technological artefacts . Videos are a possible form of scenario representation. Martin and Gaver (2000) used video scenarios as a developmental tool. They avoided strong narratives leaving the plot underspecified in order to encourage viewers to express their very own interpretations. Interestingly, "... many of the possibilities of our ideas became clear only during the process of finding scenarios to video." (pag. 59). Mackay, Ratzer and Janacek (2000) consider that videos of situations of use are a powerful tool throughout the design process. Videos can be used to: record users' activities in their real settings, stimulate designers to generate ideas, to explore the design space facilitating the creation of prototypes and to evaluate a system.

Newell et al. applied theatrical techniques on the development of videos about situations of use to be shown and evaluated by end-users, in this case, elderly people and professional carers. They wanted to encourage dialogue between users and designers as a way to gain in-depth knowledge regarding users concerns, preferences, emotional reactions and motivations. The video technique was used in the requirements gathering phase.

Videos have already been used specifically in HRI and comparison studies of live and video trials have shown strong similarities in results obtained .

RESEARCH QUESTIONS

Taking into consideration our own belief of going beyond the instrumental when considering robots for home use (an aim of the Cogniron project), the following research questions have been driving our research regarding the framing of the user experience concept, its operationalization and the use of videos for HRI:

- Does the showing of videos of human-robot interactions foster potential users to externalise their opinions and attitudes towards the conveyed interactional episodes in individual interviews? What is the nature of their responses?
- Can insights from interviews inform the development of other methodologies, in particular, more quantitative oriented?

METHODOLOGY

The methodology involved the creation of three distinct videos and conducting individual interviews.

The three different scenarios developed consisted of 2 human-robot teaching scenarios, and a scenario in which a robot demonstrated its capability to navigate and manipulate objects within a human-centred environment.

The participants of this study were interviewed following the guidelines suggested by Light (2006) concerning conducting interviews using the explicitation method. In her paper, the explicitation interview method focuses on *evocation* by cueing and encouraging the participant to revive sensory and perceptual aspects of the viewing. Furthermore, the method also has a strong narrative element in which participants are encouraged to create a narrative to construct the events in.

Our goals for the interviews were twofold: (a) to use a flexible and responsive inquiry method that would allow exploration of possible themes arising from viewing of the videos, and (b) to identify recurring issues driven by the participants' themes that could be utilised for the creation of a quantitative questionnaire.

Participants

Each video was shown to 5 participants recruited through adverts on Studynet.herts.ac.uk, a portal used by students and staff in the University of Hertfordshire. The 15 participants were from a variety of academic backgrounds, ranging from computer science to performing arts. In terms of the procedure, the participants would watch the video, followed by an interview by an experimenter.

Materials

The scripts for our videos were developed in close cooperation with the designers of the systems (Our Cogniron Partners at Fraunhofer IPA, LAAS and EPFL), and were intended to show a possible interaction with the completed system. Furthermore, the scenarios for each script were based on the technological objectives for each system.

Video 1 – 'Moving the Knight'

Set-up: The scene is a living room with a table. On the table is a chessboard with a white and black knight on it.

Actors: There was one person interacting with one humanoid robot. The robot was a HOAP-2.

Figure 1 – Screenshot of the video "Moving the Knight"(Experimental Set-up at EPFL, Switzerland)

The video (see Figure 1 for a picture of the set-up and robot) begins with the human greeting the robot and then putting on a set of motion-capture sensors. The user then verbally indicates that the robot is to be taught how to move a knight in chess. The user points to each of the knights, stating verbally which knight belongs to the robot and which knight belongs to the user. The user then moves the knight forward in the chess knight-pattern. After this initial demonstration, the robot is asked to move its knight. The robot moves the knight, and is successful in reproducing the move. The robot is then asked to move the knight again. This time the robot reaches for the original position of the knight before

replicating the movement, instead of reaching for the knight's new position, and so fails to reproduce the correct move.

The user then attempts to teach the robot through kinaesthetic teaching. The user moves over to the robot and physically moves the arm of the robot, as well as bending it over so that it can more easily reach the piece. The user then asks the robot to move the knight again. The robot this time reproduces the movement of the knight. The user then removes the motion-capture sensors and says goodbye to the robot.

Video 2 – 'Laying the table'

Set-up: The scene is a living room. There is a sofa, as well as a table and a cupboard.

Actors: There are two humans involved in the video, the owner of the robot and a guest, as well as the robot(Care-O-Bot III).

The video (see Figure 2 for a picture of the set-up and the robot) begins with the owner and guest entering the room and sitting down by the table opposite the robot.

Figure 2 – Screenshot of the video concerning the scenario "Laying the table" (Experimental Set-up at Fraunhofer IPA, Germany)

After having a brief conversation about their jobs, the owner shows the robot to the guest, and explains that it is capable of learning new tasks. The owner issues a verbal command to the robot to make it enter learning mode. The robot acknowledges the command by moving its camera up and down.

The owner then shows the robot a series of objects. After having shown the objects the owner then places the objects on the table while the robot watches. Throughout the demonstration, the robot uses the up and down movement of its camera as its means of acknowledgement.

The owner then places the objects on the cupboard before asking the robot to place them on the table in the correct positions. The robot successfully puts the objects on the table in their correct position.

The guest then asks the owner if the robot will be able to place an object it has not learned previously in the correct place. The owner then shows the robot a new object, from a series of different of angles to teach the robot the new object, before placing it on the table. The owner then puts all the objects on the cupboard. The robot then places the objects, including the new object on the table, in their correct position.

Video 3 - 'Curious Robot'

Set-up: A large living room. In the far end is a table, while on the other is a table with two chairs.

Actors: There are two humans involved in this video. The owner of the robot and a guest. Also used in this video was the robot 'Jido'.

Figure 3 – Screenshot of the video concerning the scenario "curious robot"(Experimental Set-up at LAAS, France)

The video (see Figure 3 for a picture of the set-up and the robot) begins with the owner entering the living room. The owner greets the robot and places two bottles on the far table, before leaving the room. After the owner leaves, the robot moves over to the far table and inspects the bottles.

The owner returns with the guest. The owner introduces the guest to the robot, after which the robot tells the guest that it will remember him from now on. The guest then gets a phone call and walks to the side of the room to answer.

While the guests speaks on the phone, the owner sits down on the table and opens her laptop. The robot approaches the owner and asks if she wants it to fetch her a drink. The owner agrees and the robot moves to the table with the bottles while avoiding coming to close to the guest.

The robot returns with a drink, as the guest and the owner starts talking. The robot begins its handing-over movement, but the attention of the owner is now on the guest, so the robot stops and retracts its arm and waits. The owner then turns to the robot and asks the robot to place the bottle on the table.

The robot then approaches the guest and asks if it can fetch him a drink. The owner agrees and the robot moves back to the table to fetch the drink. The robot then returns and hands the bottle over to the guest.

Setting

The participants watched the videos alone. The interviews were conducted in the same room, however, the participants were asked to switch seats.

Procedure

In our adaptation of the interviewing methodology, probing focused primarily on the issues that participants volunteered, but towards the end of the interviews, any issues raised in the creation of the script that was not previously mentioned by the participant would be subject to probing from the interviewer. However, the

wordings of the questions were similar across the videos.

The interviews were all conducted by the same interviewer, who was trained through three pilot interviews which were recorded and watched by other members of the research team in order to give feedback to 'fine-tune' the interviewing technique for these particular interviews.

ANALYSIS AND RESULTS

The interviews were analysed in two main stages. The first stage consisted of identifying salient events (events in the video scenarios, which were referenced by the interviewees), and themes related to these events. These results were used to inform the general outline of quantitative questionnaires for each video (our second goal concerning the use of this methodology referred to above), and focused the further qualitative analysis of the videos.

The second stage of qualitative analysis consisted of a more detailed exploration of how each individual participant referenced the salient events and themes. More specifically, this second stage of the analysis focused on (a) finding commonalities in language and wording used by participant to inform the creation and wording of the quantitative questionnaire, and (b) to explore how the different scenarios elicited different ways of referencing the role of the robot in a wider context than that of the particular interaction. Both stages of the analysis were conducted by two experimenters. The main themes that arose through the analysis were the following.

'Moving the Knight'

There were three salient events referenced by the interviewees: (a) putting on and using the motion-capture sensors to demonstrate the task, (b) using Kinaesthetic teaching and (c) the robot's failure to move the piece correctly.

Motion capture sensors

There was a consensus amongst the participants that the time used to put on the motion sensors was too long in terms of the watching experience. It is likely that the passive watching of this drawn-out event made participants critical of the technology of the motion-capture sensors. Participants would inquire as to the actual function of the sensors as well as suggest alternative technologies for sensing human movement.

When asked to relate the event to their own everyday experience, participants often drew upon cost-benefit reasoning, contrasting the time investment of the teaching with the possible benefits of the robot having this knowledge. An interesting point was that the interviewer was not successful in fully disentangling the method of teaching from the use of the sensors by probing.

Kinaesthetic Teaching

The main theme that emerged when participant described this method of teaching was that of 'naturalness'. The majority of participants would reference experiences of being taught by parents as children or experiences in teaching children. While some participants pointed to the possibility of physical disability being an obstacle to teaching in this way, the consensus amongst the participants was that this way of teaching was conceptually meaningful.

Contrasting the two demonstrating methods

An important point to note when looking at the responses from the participants was that the first teaching demonstration was primarily discussed in terms of utility, while the second was discussed in terms of intrinsic rewards of the interaction itself.

Robot Failure

5 participants offered 5 different explanations to the cause of the robot's failure to move the knight in the correct manner on its second attempt. The sample was equally divided in terms of where the responsibility for this failure was. Some participants highlighted the ambiguity of the instructions given the robot, while others argued the fault lay in the sensors of the robot. A final group pointed to flaws in the robot's learning, in terms of generalisability.

'Laying the Table'

The following salient events were referenced by the interviewees. (a) issues concerning the teaching and focusing on interactional and task aspects and (b) issues related to the robot itself that included its appearance, social role and ability to handle objects.

Teaching – Interaction

Participants described the interaction as highly formalised pointing to the robot explicitly entering exclusive modes of operation, as well as in terms of the verbal communication itself.

Participants also discussed this issue from a practical point of view, contrasting the need to control behaviours that the robot imitates with the added effort of having to actively teach the robot each object and its position.

Also, the robot's means of acknowledging was also addressed by the participants. Some participant stated that the 'nodding' motion was easily understandable across different cultures, while other argued that alternative methods of acknowledgement such as flashing lights or verbal information would be more effective.

Teaching – Task

The main issue to be raised in the interviews were that the teaching process was very slow. While one participant 'defended' the robot, referring to the slowness of humans infants when learning about novel objects, most participants addressed this issue in practical terms. Participants would refer to the teaching within the context of the robot's ability to generalise across tasks, arguing that such a capability would motivate them to teaching the robot. Participants also inquired as to the possibility of the robot having pre-programmed behaviours 'out-of-the-box', as this would lighten the load of teaching in the early stages.

Robot – Appearance

Participants would volunteer their impression of the robot in terms of appearance. This was both from a practical point of view, referring to the size of the robot

and querying its ability to move in a normal-sized home. Some participants would also highlight the mechanical industrial appearance as lowering their expectations regarding its abilities.

Robot – Role

Participants would consistently describe the robot in terms of the tasks it could perform within the household, and if directly asked regarding their impression of its role, would use terms like 'utility robot' or 'servant' when discussing the role of the robot.

Robot – Handling

As with teaching, the participants described the handling of objects by the robot in terms of its slow speed. Some participants related this slowness to the issue of safety however, and argued that the slow handling of objects made the robot's movements seem careful and calculated, reassuring them as to the safety of owning such a robot.

'Curious Robot'

The following salient features were referenced by the interviewees: (a) the inspecting of the bottles by the robot, (b) meeting the owner's friend, (c) robot's approaching distances to the owner and (d) robot's movement and handing over motions.

Inspecting the bottles

This particular behaviour proved controversial within the sample. The main issue to emerge was that the robot acted autonomously and without the knowledge of the owner. Two participants argued that this behaviour was appropriate as the robot acquainting itself with new features of the room in the owners absence, meant that its learning would be unintrusive to the owner, and described it as 'well-mannered'. The majority of participants, however, drew upon the references to trust. This could be either trust in the robot's ability to engage in safe behaviour (for instance, 'what if a robot started poking in a bowl of spaghetti?'), but also trust in terms of the robot potentially violating the privacy of its owner. These concerns were contrasted with the utility of the robot autonomously acquiring knowledge about its environment.

Meeting the Friend

Participants continued to refer to privacy issues when discussing this feature of the video. Participants would also discuss the issue of trust. Participants would agree that such a feature in a robot would be useful both in terms of security, to recognise outsiders, but also in terms of remembering specific interaction histories with specific users. Participant would refer to the perceived role of the robot within the household, the possibility of interaction histories giving it a distinct identity beyond the its functions.

Approaching the owner

Participants tended to make sense of the initiative showed by the robot when asking the owner if she wanted a drink, in terms factors outside of the immediate interaction, primarily by referring to a previous interaction history.

Movement and handing over

Participants did comment on the manner that the robot navigated in terms of avoiding humans in its environment. The participants would also refer to the manner in which the robot stopped its handing over motion when the owner engaged in conversation with the guest. Participants would describe the robot's behaviour both in terms of social appropriateness, but would refer to it in terms of its utility from the perspective of the task itself.

DISCUSSION

The discussion will have the following distinctive parts. First we present an overview of the conceptual issues considered in the paper initially. Second we will highlight our efforts in answering the two research questions set initially.

Generally speaking, our research efforts were clearly aimed at "going beyond the instrumental" as Hassenzahl and Tractinsky (2006) put it. Two of the videos tried to uncover people's attitudes towards distinctive human to robot teaching techniques and opinions about the conveyed and implied social interactions. In the third video the participants were asked to judge to what extent the robot was able to behave in a socially acceptable manner, in terms of its movement and handing of objects, and what were the implications of some of the robot displayed behaviours taking into account the on-going possible relationship between owner and robot. Definitely, the videos were not about task completion per se.

In line with Mackay et al. and Martin and Gaver the creation of videos as instantiations of scenarios of human robot interactions, were very useful as process on itself. Although not really documented here, the writing of the videos scripts, involving both more technically minded teams and HCI experts (us), helped shaping our understanding of the nature of the interactional issues implied in the systems under development. In turn, that helped us frame some of the probes used in the interviews.

In more practical terms, the videos were a good option taking into consideration the very nature of prototypes in HRI. More specifically, the evaluation of robotic prototypes has to take into account that some might not be 100% safe to use in user studies or that some might just too fragile for inexperienced participants.

Let us now turn to the research questions considered in the paper.

Does the showing of videos of human-robot interactions foster potential users to externalise their opinions and attitudes towards the conveyed interactional episodes in individual interviews? What is the nature of their responses?

There was a marked difference between how participants described and considered the role of the robot between the three videos. For the first and second video, the participants focused primarily on how the robot accomplished its tasks and its speed of learning. There was also a marked difference in how they evaluated the robots' performance: participants viewing Video 2 would consider the performance in light of their

own needs and efficacy in using the robot for tasks such as the one presented in the video, while participants viewing video 1, would evaluate its performance within the task itself. For the third video, participants tended to consider the wider implications of the robot in a household on a broader level, offering different types of roles it could fill, as well as implications regarding privacy and trust issues.

These differences occurred despite the similar and neutral wording of the questions from the interviewer, across the videos, and so could not be considered an artefact of differences between the interview schedule.

Another issue was that of the efficacy of using the videos to demonstrate different aspects of technological artefacts. In particular, the heterogeneity of responses regarding the cause of the robot's failure in the 'Moving the Knight' scenario, while interesting from a general Human-Robot Interaction point of view, suggests that for getting feedback regarding specific technological applications video trials may need to incorporate either a detailed explanation of the capabilities of the robot (as in the 'Laying the table' video), or being grounded within a wider scenario to which the participants can relate to their everyday experience (i.e 'Curious Robot').

We believe that the interviews revealed high level motifs and attitudes towards the design of human robot interactions that should be taken into account when considering scenarios similar to the ones we envisioned. Furthermore, the uncovering of high level motifs and attitudes, and not specifics of the interaction per se, leads us to the suggestion that this method can be particularly useful in early stages of the design process or with very novel technologies.

Can insights from interviews inform the development of other methodologies, in particular, more quantitative oriented?

The analysis of the interview proved an invaluable tool when creating the questionnaires used for the quantitative exploration of how potential users evaluated the system. While space constraints do not allow us to detail the questionnaires or their creation, a brief discussion is provided:

The multi-faceted nature of which participants described aspects of the interactions presented allowed us to create items for each salient feature which addressed these aspects, both in terms of purely interactional aspects, as well as in terms of the trade-off between utility and difficulty.

Also, general items for each video could be created by listing motivations, particular preferences and apprehensions that were raised by the interviewees, before integrating them into the questionnaires using both terms and concepts given by the participants rather than the researchers, thus allowing the questionnaire to be more user-focused than it otherwise would have been.

CONCLUSIONS

The results from our study suggest that video prototyping combined with a rigorous qualitative analysis of open-ended interviews are an excellent source of valuable insights regarding user experiences related to the assessment of human and robot interactions. Furthermore, based on the results from the interviews more quantitative inclined methodologies can be designed.

More research is needed to investigate the extent of the complementarities between interviews and derived questionnaires and their insertion in the design cycle of robotic systems. Furthermore, it seems unavoidable to conduct comparative studies to reveal the pros and cons of different interviewing techniques in the pursuit of a method that can tap into people's experiences with technology. For the moment it seems that the interviews we conducted and the materials utilized to ground them, the videos, are particularly useful to initially uncover users' high level needs, motivations and perceived value.

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