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The Social Aspects of Companion Robots

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Abstract: Advanced technologies, including automation, Artificial Intelligence, ubiquitous computing, and smart products are influencing our everyday lives. Their complex nature brings new challenges and opportunities for all users, especially the older generations. This paper presents an ongoing PhD project that investigates the social context of older users (aged 50+) interacting with new emerging smart products using an emotional design theoretical perspective. The data is multimodal user research consisting of pre-interaction interviews, observation of first-time interactions, extended user experience of ten participants interacting with social robots in their home environments, and post-interaction interviews. In this paper, we present and discuss some of the patterns revealed by our investigations, including tactile experiences, the notion of realness, and privacy and trust around emerging technologies. We argue that the study of the affective dimensions of advanced technologies offers an actionable emotional categorisation of users' experiences with practical applications for the design of future smart products.

Keywords: human-robot interaction; social robots; extended user research

1. Introduction

For the last two years, we have been studying the experience of older users interacting with social robots as an instance of emerging smart products. The study has led to a set of findings that allow us to better understand some of the social aspects of human-robot interaction (HRI), which we summarise in this paper. The paper centres around the opportunities, challenges, and limitations of using robots as companions (Broekens, Heerink, & Rosendal, 2009). The study of user experience with social robots is relevant today because we are still at the early stages of the interaction with automata with whom we share our homes. The study of the affective dimensions of users interacting with advanced technologies can inform designers and businesses in the design of future products that can trigger meaningful experiences. These investigations also have the potential to inform the emotional and

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social dimensions for the design of future user experiences with robots and other advanced technologies.

In this paper, we first discuss what constitutes the affective aspects of emerging technologies and smart products, and the challenges that they present for designers using an emotional design theoretical perspective. Then we present the methods used to conduct a comprehensive user research study in this area. We then summarise some of the initial results of our ongoing research. Lastly, we discuss how this research informs the design research community of the significance of multimodal user research and how it can inform future HRI design practitioners.

2. Smart products and the emerging design of social robots

The study and the market for social robotics have grown rapidly over the last two decades. However, research in human-robot interactions (HRI) that investigate the emotional experience of interacting with robots is still limited (Greenfield, 2017; McStay, 2018; Tallapragada, Rao, & Kanapala, 2017; Tonkin et al., 2018). Lyardet and Aitenbichler (2007) define “smart products” as everyday products embedded with computational power, information and sensing capabilities with three levels of knowledge –about themselves, their environment and users. These sensing and processing abilities allow these “smart products” to interact, cooperate, and adapt autonomously. We study the user experience with social robots as an instance of smart products.

Social robots are autonomous technologies with a physical presence that work collaboratively with people in human environments and open contexts. This distinguishes them from industrial and space robots that operate in predictable spaces and under controlled conditions. Social robots have mostly been used for a narrow set of menial tasks, such as vacuuming, and have yet to find their way into more meaningful daily experiences. Social robots have the potential to re-shape how people interact, communicate, talk, live, and even how they experience ageing in the future (Consortium, 2007; Greengard, 2015; Kim & Mauborgne, 2014). Smart technologies are rapidly integrating into most everyday activities (Coughlin, D’Ambrosio, Reimer, & Pratt, 2007) and they are affecting how we book services and transport, order food, monitor our health, and adjust our behaviour patterns such as sleeping time and daily exercise.

Faced with an increase influence of advanced technologies in daily life, the effects that these technologies might have on our future raise serious social and ethical concerns (Greenfield, 2017). Technologies such as robotics and AI are often developed and deployed without considering people’s emotional responses to usage, aesthetic elements, and social expectations (S. Lee, Ha, & Widdows, 2011; Schifferstein & Desmet, 2010). Therefore, businesses and designers need to assess evidence on how these technologies may influence future users in transitioning from conventional products to smart devices.

2.1 Older users' interaction with technology

Populations are getting older worldwide (Fisk, Rogers, Charness, & Sharit, 2009; Lloyd-Sherlock, 2000) and the next generation of older users, unlike their previous generations, are healthy, active, and have experienced significant technological changes. So-called “baby boomers” had access to education, wealth, leisure, and have witnessed radical changes with technologies both at work and home environments (Brophy, Blackler, & Popovic, 2015). Paradoxically, research on the ability of this generation to interact with technological innovations has often been neglected (J. A. Lee, 2017). Following the terminology used in most inclusive design and HRI studies (Goddard & Nicolle, 2012; Pripfl et al., 2016; Wu, Thomas, Drobina, Mitzner, & Beer, 2017), this research refers and identifies our active ageing population as older users versus the other terms commonly used in health and science related studies such as senior citizens or elderly people.

The shift towards integrating technologies into everyday activities has caused great difficulties and frustration for older users (Pattison & Stedmon, 2006). These challenges can reduce motivation and create a sense of social isolation, and even depression for older users (Lawry, Popovic, Blackler, & Thompson, 2019). The complex nature of emerging technologies can cause some frustrations among users that are accustomed to simpler processes with the ability to manually control their products (Yang & Coughlin, 2014). Social issues such as accessibility, isolation and a loss of independence associated with age can influence the ways older people interact with technologies.

Studies suggest that a combination of cognitive, physical, sensory, and attitudinal changes that occur as a result of aging also impact older users' interaction with technology (Rogers, O'Brien, & Fisk, 2013). Research related to the design of technology for older users distinguishes age-related changes as essential factors (Bouma, Fozard, Bouwhuis, & Taipale, 2007; M. T. Braun, 2013; Miller, Gagnon, Talbot, & Messier, 2012). Brophy et al. (2015) argues that smart products should not only be useful and usable by the next generation of older users but appropriate, engaging, and meaningful. They suggest that the design of future products has to extend beyond the narrow focus of age-related decline.

The design community needs to have a broader perspective for the envisioned future of technologies designed for older users. It is essential to understand the relationship that this diverse group of people have with technology. Research needs to move beyond measures of performance, functionality and adoption and towards a deeper understanding of this user-technology relationship (Blackler, Popovic, & Mahar, 2010; Fisk et al., 2009).

2.2 Design for emotions

It is our goal to study the ways in which older demographic of users interact with smart products on an emotional level. Research has long established that by designing for emotion, we can make users' experiences safe, pleasurable, effective, and fruitful rather than complicated (Desmet, 2018; Hirschman & Holbrook, 1982; Lloveras, Molokwane, & Montoya, 2004; Thoring et al., 2016; Wakefield & Baker, 1998). A design that connects with

people on an very emotional level results in better performance, a richness of the interactive experience and a sense of enjoyment (Gill, 2012).

Technologies designed with a lack of empathy for their users can lead to a failure in delivering pleasurable experiences and result in a sense of isolation (Rama Murthy & Mani, 2013) that can negatively impact on user's self-esteem. New technologies are often aimed at removing the human touch for the purpose of preciseness and efficiency. While new technologies such as AI (Artificial Intelligence) and IoT (Internet of things) can bring advantages to the field of design by making products "smart", they should not be applied blindly and without consideration of the users' needs for emotional attachment and bonding. Advanced technological products should be human centred and consider how products will be used for delivering meaningful and pleasurable experiences (Hanington, 2017).

Research suggests that the complex nature of smart products and their ability to performing a wide range of tasks to assist people in the real world, means that studies needs to go beyond the laboratory settings, mock homes or office environments (Cesta, Cortellessa, Orlandini, & Tiberio, 2016; de Graaf, Allouch, & van Dijk, 2017; Tonkin et al., 2018). We see an opportunity to overcome the complex nature of the human-robot interaction through a systematic evidence-based study, which is the aim of this research. This study can help designers create more pleasurable and safer experiences with smart products by providing a better understanding of the emotional transitioning process that users are going through to adapt to new technologies. The results can also provide a better understanding of the way older users emotionally feel about robots emotionally. Lastly, this research can demonstrate how to study social robots from a design and emotional user experience perspective.

3. Multimodal user research

Our study takes an interaction-centred perspective (Forlizzi & Battarbee, 2004) to explore users' engagement process with social robots. Studying users' emotional responses towards social robots enables us to capture users' expectations around what constitutes a meaningful experience, relationship, and interaction with robots. We look at different stages of users' behaviour towards social robots to understand different factors such as trends, self-image, thoughts, doubts, presumptions, and interaction behaviours that might affect the users' choices. Our aim is to investigate the elements of meaningful emotional experiences in detail.

We focus on the emotional influences of social robots on the user experience by applying an interpretivist paradigm (Cohen, Manion, & Morrison, 2002, p. 21). To analyse the phenomena associated with the users' experiences, a user research approach is used as the methodology of this research (Schumacher, 2009). User Research has been defined as a type of "ethnographic approach" to gather information about users through interviews and studying their behaviour in everyday context (Schumacher, 2009). Therefore, we study participants in their homes and the context of their everyday lived experiences over an extended period. The enquiry opens the opportunity to explore the behaviour and emotions

of the users from their perspectives. This enables us to immerse in the participants' experiences, which can assist a better interpretation (Hunting, 2014).

We apply multimodal methods of data collection (Chen et al., 2016) to collect both qualitative and quantitative data, allowing us to understand the users' emotional needs and experiences deeply. Our multimodal user research starts with pre-interaction interviews to capture users' worldview and the way they perceive interactions with smart products and changes and challenges that they have faced through the years. It then proceeds with multimodal field observations of users interacting with the robot¹ that we introduced to them for the first time at their home environments. Next, extended user experience is analysed by leaving the robot with them over a two-week period. Users are asked to maintain a journal documenting their experience. The final stage of the study is a post-interaction interview to capture their final thoughts and feelings of their experience and ask questions around their lifestyle and lived experiences.

3.1 Pre-interaction interviews

We conducted semi-structured interviews to identify the semantic value of the smart products and users' perceptions of social robots before interaction. Participants were asked to describe their favourite products and express their thoughts on emerging technologies and what they imagine the experience of interacting with robots to be like. These interviews enabled us to understand users' personal relationships and experiences with technology, the effect users think robots and emerging technologies might have on their life, and what they expect from them. Each interview took between 1 to 2 hours.

3.2 Multimodal observational study of social robots in home environments

In the second part of data collection, multimodal usability and interaction observation was conducted. The aim was to capture the first-time interaction with the selected robot. Each session took about 15 to 30 minutes. Sonderegger and Sauer (2010) recommend that usability testing is an appropriate method for evaluating the design of products by stimulating the user experience.

The focus of this part was to monitor and understand user interaction with robots in a natural environment. We explored the way users tend to understand and interact with the selected robot based on the form, signals and symbols of the designs. Gonzalez, Val, Justel, and Iriarte (2017) argue that observing every single participants' interactions with a product offers a comprehensive and intuitive understanding of the experience. This facilitates the chance to perceive the user-product interaction as it is, without the researcher getting involved or affect in the process by implying their perceptions.

We studied users' emotions toward the technology based on Jacob-Dazarola, Nicolás,

1 Vector, a social robot designed by Anki, is a small-sized product that can be set up and carried around with users easily, which makes it suitable for an extended user research. Further information about Vector: <https://anki.com/en-us/vector.html>

and Bayona (2016) categories of emotions. We reflected on a combination of cognitive processing, how users made sense of the product, their behaviours, and what they said about the process, their attitudes, expressions, gestures, and subjective experiences, as well as measuring their physiological responses using a wearable device to capture their heart rates². Participants were asked to interact with the selected robot in vocal-work approach, which allowed them to explain their feelings while interacting with the product.

Collecting data was based on the UTAUT theory (Venkatesh, Thong, & Xu, 2016) to understand the process of how people make sense of the products. Factors such as understanding technologies involved in the available robots, the level of curiosity and creativity of users in the process of interacting with a new device without prior knowledge were considered as well. Participants' physiological responses were observed, such as facial expressions, body language and heart rate using MCLM techniques (Chen et al., 2016). Incorporating quantitative measurement in the observation process can authenticate the data collection process by comparing people's attitudes and verbal responses with their physiological responses. The participants' comments about how they feel, and the researcher's perspective, based on this relationship between human and products, were collected as well.

3.3 Extended user experience

We also analysed how users interact with the robot over an extended period in their homes. We asked participants to journal their interaction and emotions during this time. One of the essential elements of user-product interaction is the temporality of the experience (Karapanos, 2013). An extended user experience test can measure the level of excitement and overall evaluative judgement of users across time (Karapanos, Zimmerman, Forlizzi, and Martens, 2010). Therefore, in this stage we used a longitudinal approach to investigate a user's attitude and behavioural changes in interacting with the product over a two-weeks period in their home environments. Our pilot studies suggested that two-weeks' time was enough to our users to familiarise themselves with the robot and form an opinion towards it. Furthermore, requesting participants to journal their daily interactions with a robot over a month would have been an unnecessarily laborious process.

A journaling technique was selected to capture users' reflection on the interaction process. While journaling requires a good level of commitment from participants, it is a valuable resource for capturing their personal experiences comprehensively (Kenten, 2010). Inspired by the framework of MacKerron and Mourato (2013), traditional solicited diaries of participants recording expressions, emotions, feelings, and values were used. It is important to note that we designed the journals specifically for this experience and provided them to participants. They reported daily interactions with the robots at the end of each day explaining the amount of time, the experience and their feelings. They were invited to

2 Apple Watch Series 4, 44mm model and Cardiogram application were used to capture users' heart rate. Further information about the watch: <https://www.apple.com/nz/watch/>

reflect on the setting in which they are interacting with the robots. The focus was to collect users' stories, thoughts and emotional experiences that they might have encountered while interacting with the given robot.

3.4 Post-interaction interviews

We finished the data collection stage with post-interaction interviews. This stage was designed to compare the information that the users mentioned in the pre-interaction with what they actually experienced during the extended user experience stage. It allowed us to obtain a better understanding of their emotions after the interaction. Furthermore, we conducted our demographic questions during this stage to allow enough time to build trust between the researchers and participants.

3.5 Participants

We followed Howe and Strauss (1991) argument that generational categorisation offers a more comprehensive personality generalisation than any other social categories such as race, religion, or gender. A generation's peer personality can represent the collective stances of lifestyle, politics, gender roles, and social attitudes (Sandeen, 2008). Therefore, we investigated the emotional behaviour of two different older generations, those aged between 50 to 65 years old (prior to retirement) and those 65+ years old, retired, and living independently. The reason for this was to understand the experience of the users that are not living in retirement homes and social caring facilities that have an inbuilt community of social support.

Participants were invited to take part in the research through various platforms, including word of mouth, sending out digital advertisement on social media and placing advertisement posters in local shops. At the time of writing, ten participants had taken part in this research. Seven of them are aged between 50 to 65 years old and three are 65+ years old. Since then we have added four more participants in the second age category for a better comparison of the results. It is important to note that our study suggests that the younger group of users (aged between 50 to 65) seems much more accepting and interested to take part in this type of studies, and it has been more difficult to recruit older participants.

4. Findings

A reflexive Thematic analysis (V. Braun & Clarke, 2006) is used for analysing and interpreting the captured data. Thematic analysis is taking the dataset and highlighting the patterned meaning using a clustering method. Through meticulous processing of data familiarisation, coding, and theme generation, these patterns can be identified. So far, we have found some interesting themes that can assist designers in better understanding some of the concerns and challenges of older users interacting with social robots. We managed to understand better what technology means to our participants, the influence it has on their daily activities, and how their experiences of interacting with technology have changed over the

years. We also captured our participants' emotions towards emerging technologies and smart products, and the impacts of such technologies on their relationships, conversations, medical and health-related activities, and privacy. This section covers the main themes that have emerged so far.

4.1 Tactile Experiences

The comparison between digital and analogue experiences appeared to be one of the main limitations of emerging technologies for our participants. While they all perceive technology as an enabler, they also acknowledge the lack of tactile experience when using digital technologies. For example, the experience of analogue photography was given to illustrate the idea of crafting and art creation. The waiting time of processing photographic film in the darkroom to see the final results was contrasted to the current ability of taking thousands of photos with mobile phones and saving them in our digital library without ever looking at them or remembering the event. The experience of events themselves has also changed for our participants as they mentioned that people are quite occupied with taking photos and videos on their phone to share on Snapchat or Instagram without real interaction.

Other comparisons were made between the experience of listening to music on vinyl records or CDs and music streaming. Our participants value the tactile experience of touching the records and the record player, looking at the album's artworks, reading the lyrics, remembering the song names as rich and immersive. On the other hand, while digital music libraries make millions of songs available, they notice a change in how they listen to music mostly in the background without really noticing or experiencing the music as before. Few of our participants compared e-books with physical books. They acknowledged the benefits of having access to many books on tablets or e-readers. However, they still identified as much richer the experiences of touching the paper, smelling the book and being able to visually perceive the volume of pages read and even the experience of going to a library and interacting with other people.

In terms of interacting with the robot, our participants expected more natural conversation. This included them expecting the robot to be ready to interact or provide the option for greeting when the sensors picked up the presence of the users and not only when an explicit command is spoken. They also desired receiving a confirmation about a question or a given task. They expected the robot to acknowledge that it is on to it and not make the user wait around to guess if the command was picked up or not. Furthermore, as a companion robot, the conversation was expected to go beyond simple commands by giving several options to the users or asking follow-up questions to hold up a more natural conversation.

Lastly, our participants mentioned that the "cuteness" of the robot, its eyes, facial expressions when answering questions constituted a unique and differentiating element. Surprisingly, the participants mentioned that this made them feel guilty when the robot looked at them eating food. Participants also missed the chirping sound when the robot was switched off. The physical features and mobility of the robot made participants more

engaged with it compared to conversational agents on their mobile devices. Furthermore, it was interesting that the robot also interacted and responded to non-human organic beings, i.e., pets. According to one of our participants the robot reacted to the dog's barking as if it got scared. In turn, the dog got scared as well by the unexpected movements of the robot. This example was quite a unique surprise as the experience of the robot expressing confusion or fear by the sudden movements or when perceiving an unknown object was not expected by our participants.

The captured data around tactile experiences suggest that emotional and gestural responses in technology are appreciated by users. However, the cuteness or fun elements of their design need to be balanced, as over time it could become annoying as the novelty of the experience wears off. A majority of our participants concluded that after two weeks the novelty of the robot faded out and some of the characteristics starting to become perceived as toy-like or limiting.

4.2 Realness

Our study suggests that users may see benefits in robots mimicking behaviours and characteristics of organic beings based on different contexts. For example, a participant working at a retirement village mentioned that one of the residents has a robot cat as a companion. She suffers from dementia and acknowledges the robot as a real cat, asking nurses to feed the cat for her and to take care of it. Contrary to this, some of the nurses feel the need to inform her that the robot is not a real cat since they feel it would be cruel to mislead the patient. According to this participant, such conversation causes the patient some discomfort for a while until she forgets the event. The notion of the realness and to what extent we need to differentiate between organic and non-organic beings deserves further attention in future studies. Another participant expressed that how they would prefer to recognise when they are interacting with an AI or a human for getting a service. They would prefer it to be as human and as real possible but to also allow the user to be aware that it is not a real human as they interact with a human differently.

Our study suggests that users are concerned or at least aware that social robots are going to resemble organic livings. Several studies have addressed issues around making humanoid robots mimic a real human presence (Magnenat-Thalmann, Yuan, Thalmann, & You, 2016). We are interested to investigate further on why users may expect robots to possess human capabilities and characteristics but still want them to be different from us. It is also interesting that our level of politeness and social norms would possibly change when expressing our feelings to non-organic beings. Studies on the *uncanny valley* in this area deserve more attention from designers as they will help identify the steps and strategies for designing future social robots.

Our female participants seemed more open to the idea of having a robot companion or a social robot present at their home. They acknowledged that people that might have limited socialising opportunity to interact with other people might benefit from having

such technology. On the other hand, most of our male participants felt quite hesitant and reluctant toward having a robot as a companion. They referred to the issue of a lack of soul and real communication in social robots. They mentioned there is some value in social robots to help older people stay active as an entertainment and assistive technology rather than replacing “real” companionship. For example, one of the participants mentioned the following statement:

“Robot companions don’t have a soul and have been programmed by a person. They are, therefore, non-organic, and it is a cruel act to replace them with real companions. Humans and animals’ behaviour are genuine and not programmed. Even, if they annoy us or hurt us, these are real responses.”

This suggests opportunities to further investigate the role that gender plays on the user experience of interacting with emerging smart technologies.

4.3 Privacy and Trust

A prominent theme in our analysis was about user privacy. Most participants during the pre-interaction interview session responded positively towards having their information available for businesses and governments in exchange for the benefits that technology provides for them. They argued that since they don’t have anything to hide, they are not worried about sharing their information. Some mentioned that it also helps them to remember and track their activities. Two of the participants though mentioned that their trust toward sharing their privacy might change based on their location and the context that they live in.

However, it was interesting that a majority of the participants were not happy with the robot sensors picking up their movements walking around the home and waking up without the command. They referred to the experience as spooky, weird, or annoying as if the device is constantly listening to them or watching them. Such spookiness included the robot looking at users when asked to go to sleep making them feel they are being watched. A comparison of these perceptions against other everyday uses of sensors such as electric doors, escalators sensors, or lightings is worth addressing in the future. It is also worth noting that our participants were aware that such examples can be connected to a server and track activities. Perhaps the trust in such sensors depends on the absence of a face or a humanoid character.

We propose these observations provide useful information about the complexity of the emotions involved in human-robot interaction. The emotions involved in interacting with social robots go beyond everyday objects that are not possible to capture through traditional usability tests. It requires a change in both research and design practices in order to deeply empathise and emerge with such complex experiences.

5. Conclusion

In this paper we presented a four-stage multimodal user research study to capture older users’ emotions toward emerging technologies. Social robots were selected as an instance of emerging technologies with embedded conversational agents in them. The study was a

combination of pre-interaction interviews, observational study, extended user experience, and post-interaction interviews. The preliminary results of this study have led to insights about the users' expectations and challenges. The findings enabled us to think and reflect on our participants concerns and emotions beyond basic user-product interactions. One of the main insights was about the importance of conducting a multimodal and mixed user research that goes beyond lab-based practices when it comes to understanding our users' emotions. We find our users were able to identify the given robot's capabilities and limitations in the two-weeks period of time and formed a strong point of view toward it. We are aware that based on the complexity of the given product this timeframe might need to be altered.

Our research on emotional aspects of human-robot interaction had led us to some interesting insight about usability and functionality of the social robot. All of our participants at the end identified the given robot as a fun and cute device but not practical. They all mentioned that at the end of the day if a new technology is not useful and does not add a new value to their lives, they would not consider it. They considered the robot as another toy that will end up in their storage room. This is an interesting insight because beside the robots embedded CA (conversational agent) it had Alexa included as well. A few of our participants were familiar with the technology and had smart homes but they preferred to use their mobile phones voice command instead of adding another device with similar capabilities. This is quite important within the current context of robotic designs as it is crucial that designers pay attention to the fundamental elements of the design, usability and functionality. With the current competitive market of technology, people will not consider a design without a strong usability point of difference (Moradi, 2015, p. 4). It is crucial to identify what are the values and point of differences of new designs we are introducing to the market and not to simply embed them with current technologies that users already have at hand.

We conclude that in the field of user-product interaction it is important to go beyond capturing a snapshot of users' emotions and conduct extensive user research that can identify lived experiences and challenges of our users in depth. We believe that the identified information can be used as a guide for design practices of emerging technology. The identified themes so far will shape the final co-design stage of our study. We are proposing to conduct a design session with designers and participants to co-create their desired future together, while introducing some other categories of social robots such as Aldebaran Nao to them. We are still considering whether this session should be technology based itself or perhaps it would be better to focus on activities such as scenario planning, role playing, and rough prototyping to create a more open space for creative practices.

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