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Sharing a life with Harvey: Exploring the acceptance of and relationship-building with a social robot

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ABSTRACT

Social robots will become ubiquitous in our everyday environments. These robots could potentially extend life expectancy, and improve the health and quality of life of an aging population. A long-term explorative study has been conducted by installing a social robot for health promotion in elderly people's own homes. Content analysis of interviews provided an in-depth understanding of the factors that influence the acceptance of and relationship-building with social robots in domestic environments. The permanent presence of a robot in users' own homes yields the vital challenges social robots encounter to be successfully accepted by their users. These vital acceptance challenges are unlikely to be revealed in one-day laboratory human-robot interaction studies or even in multiple observations of short interactions between humans and robots.

1. Introduction

Social robots are expected to increasingly enter our everyday environments. Social robots are characterized by understanding and communicating in a humanlike way, allowing them to behave as social actors and be understood as such by their users (Breazeal, 2002). Triggered by aging populations in many advanced economies, artificial companions in the form of social robots are gradually becoming part of people's environments. Social robots are hypothesized to aid the elderly to live in their homes autonomously for longer and therefore to decrease the burden on our social and healthcare systems. Helping people to live independently and in good health for longer will enable them to extend their active and positive contributions to society (World Health Organization, 2010). Social robots potentially hold the promise of extending life expectancies and improving health and quality of life for all people as they age by: (1) letting elderly people live autonomously for longer in their own homes; (2) helping elderly people feel less lonely; and (3) helping elderly people to stay fit, thus improving their health (Broadbent, Stafford, & MacDonald, 2009). To profit from these positive outcomes of social robot use, elderly people need to accept these robots into their home environments. Moreover, it is important to study the user acceptance of these types of robots at an early stage of their development process, so that future social robots can be adapted to the desires and requirements of elderly people. For a successful introduction of social robots, underlying reasons need to be revealed where upon people their perceptions of use these robots.

One way of understanding how people perceive social robots is by studying the reasons why people accept or reject such robots in their natural environments (Young, Hawkins, Sharlin, & Igarashi, 2009), for example in their own homes. Although previous research studying the user acceptance of social robots have used various methods, long-term studies are still scarce as almost all studies are usually no longer than one day (e.g. Bartneck, Reichenbach, & Carpenter, 2008; Bartneck, van der Hoek, Mubin, & Al Mahmud, 2007; Heerink, Kröse, Evers, & Wielinga, 2007; Nomura, Kanda, Suziki, & Kato, 2008; Wada & Shibata, 2006). As a consequence, not much is yet known about the factors that influence the acceptance and continued use of social robots in everyday life (Oydele, Hong, & Minor, 2007). Yet, people's perceptions of technologies are likely to change over time as they develop experiences with that technologies and their usage skills develop (Fink, Bauwens, Kaplan, & Dillenbourg, 2013; Sung, Christensen, & Grinter, 2009; Venkatesh & Davis, 2000). Thus, longitudinal studies are necessary to investigate how users' perceptions towards robots, their behaviors and their experiences change over time. Although domestic uses in long-term studies are recently starting to receive more attention in robotics research (Leite, Martinho, & Paiva, 2013), still, more insight is necessary to fully understand why and how people are

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willing to continue to use a robot after initial interactions. The goal of this paper is to explore the acceptance of social robots in domestic environments by observing how older adults use and perceive a social robot for health purposes.

2. Theoretical background

2.1. Robots as social actors

The acceptance of social robots is presumed to differ from the acceptance of other technical innovations, because these robots are not always perceived by their users as technologies (Lee, Park, & Song, 2005; Young et al., 2009). It might be that the interaction of social robots is more in line with the principles of human–human communication than with human–machine communication (Heerink et al., 2007; Krämer, von der Pütten, & Eimler, 2012). Just as humans and other living beings differ from each other in terms of internal and external characteristics, social robots also have their autonomous individuality displayed through their design and behavioral configuration (Libin & Libin, 2003). With a minimum of social cues, technological objects can be evaluated as social entities; a theory known as the media equation (Reeves & Nass, 1996), which has also been successfully applied to the field of robotics (Kahn et al., 2007; Lee et al., 2005). Although a study on behavioral analysis suggests that the robotic dog AIBO is a poor substitute for a living dog, nonetheless, all children and adults from that study did engage with the robotic dog as if it were a social partner to some extent (Kerepesi, Kubinyi, Jonsson, Magnusson, & Miklosi, 2006). Another study on the evaluation online forum posts (Melson, Kahn, Beck, & Friedman, 2009) shows that both children and adults recognize AIBO as a product or technology. However, they still grant the robotic dog with many attributes of a living dog, by regarding it as having a mental life and treating it as a social companion. More recently, a study revealed that people show increased physiological arousal, report more negative and less positive emotions and expressed empathic concern when watching a video in which the baby dinosaur robot Pleo is being tortured (Rosenthal-von der Pütten, Krämer, Hoffmann, Sobieraj, & Eimler, 2013). However, these social effects might decrease when the novelty effect wears off. Fernaeus, Håkansson, Jacobsson, and Ljungblad (2010) reported on a study evaluating the robotic baby dinosaur Pleo with six families over two to six months (each family was allowed to stop using the robot at their own terms). Initially the families regarded the robot as a real pet (e.g., petting it, giving it a name and displaying emotions towards it), but the disappointing interaction capabilities of the robot resulted in it being treated as a regular pet. Still, when investigating the user acceptance of social robots in the home, it is important to consider the effect of these possible social reaction towards the technology and how this might affect the process of long-term acceptance.

For the acceptance of social robots, the above described differences in the user's perception of social robots need to be taken into account and the dual perception by their users need to be acknowledged. On the one hand, social robots can be perceived as utilitarian systems; they are able to perform tasks such as housekeeping. On the other hand, social robots are recognized as hedonic systems; they offer sociable interaction opportunities to be able to build long-term relationships with their users (Kidd, Taggart, & Turkle, 2006; Reeves & Nass, 1996; Shibata, Wada, Ikeda, & Sabanovic, 2008). Previous research thus indicates that in addition to the utilitarian factors of usefulness and ease of use (Davis, Bagozzi, & Warshaw, 1992), the hedonic factors of enjoyment (Heerink, Kröse, Evers, & Wielinga, 2010) and anthropomorphism (Bartneck, van der Hoek, et al., 2007; Ben Allouch, Klamer, & de Graaf, 2011; de Graaf & Ben Allouch, 2013; Friedman, Kahn, & Hagman, 2003; Klamer, Ben Allouch, & Heylen, 2010) also seem to play a role in the user evaluations and acceptance of social robots. People who perceive higher levels of anthropomorphism tend to be more positive in the general evaluation of a social robot, perceive higher enjoyment when engaging with it and are more likely to see the robot as a companion (Lee, Jung, Kim, & Kim, 2006). People, who enjoy the use of a robot, also think that robot is more easy to use (Heerink et al., 2010). This effect becomes stronger when users gain more direct experience with a technological system (Venkatesh, 2000), indicating that previous experiences mediate and strengthen the effect of enjoyment on ease of use. Elderly people tend to accept social robots more readily because they enjoy the interactions more than younger people (Heerink et al., 2010). Thus, our study will incorporate both the utilitarian and hedonic usage aspects of social robots into account.

In addition to the general usage factors, the social reactions social robots evoke from their users, we will also investigate the possible relationships people might build with these robotic systems. As computer technology interacts with us through increasingly complex and humanlike interfaces, the psychological aspects of our relationships with them comprise an ever more important role (Bickmore, 2005). Moreover, it is expected that the media equation effect (Reeves & Nass, 1996) may even magnify with embodied agents that interact socially using natural language and non-verbal behaviors. Indeed, many studies show the existence of relationships between humans and social robots (Fujita, 2004; Kanda, Sata, Saiwaki, & Ishiguro, 2007; Kidd et al., 2006; Robins, Dautenhahn, Boekhorst, & Billard, 2004; Turkle, 2011), whether this occurs consciously or subconsciously. Users who feel involved when interacting with a social robot tend to conceptualize it in terms of agency, social standing and life-like attributes (Friedman et al., 2003). People seem to respond to robots in one of two ways: either humans love and nurture social robots and build relationships with them, or humans see social robots as artificial, as machines. In the studies of Turkle (2011), an elderly man interacted with a robotic doll as if it was his ex-wife and loved and nurtured the robotic doll, while another elderly man saw the robotic doll as an interesting artefact and he slapped it just to see what would happen. Using imagination and empathy, people are able to anthropomorphize the objects in the world. This reasoning makes it plausible for people to develop a relationship with a social robot even when its cognitive, behavioral and interactive capabilities are simpler than those of other living creatures. When users perceive social robots as companions and build a relationship with them, they are more likely to continue interacting with these robots. However, not establishing a relationship with these robots results in discontinuing the use of social robots (Kanda et al., 2007). The ability to build a relationship with a robot will thus have an effect on the long-term process of user acceptance and will therefore be included in this study as a factor of technology acceptance.

Together, the utilitarian and hedonic usage aspects provide a more holistic view on the user acceptance of social robots in domestic environments. However, these aspects originate from static models of technology adoption, such as the technology acceptance model (Davis, 1989), and do not include the social context of technology use which becomes more important when technology is used for a longer period of time. In the next section, we will introduce the social context of the home in which the technology use and long-term acceptance process of the robot will be investigated.

2.2. Domestic use of robots

An alternative view on user acceptance to the commonly used adoption models in the technology acceptance literature is pro-

vided by social constructivist theories. These theories imply that meanings of technologies are shaped through the interactions between designers, social groups and policy makers (Bijker, Hughes, & Pinch, 1987; Fulk, 1993). Explorative field studies conducted with this view consider the acceptance of technologies in a broader, social and situational context, namely domestic environments. Studies that use a 'mutual shaping of technology' approach provide rich, qualitative descriptions of the design, introduction and use of technologies, because they study technologies from various points of focus (Boczkowski, 1999). In our study, the focus will be on the use and gradual acceptance (or rejection) of social robots in domestic settings. The domestication theory is one of the social constructivist theories and is very suitable for our aim to study the long-term acceptance of social robots in people's own homes. It involves the user in the process of appropriation by taking technology into their own domestic environments and making technology acceptable to themselves by giving it a place in everyday life. In their article, Silverstone and Haddon (1996) distinguish three dimensions of consumption: commodification, appropriation and conversion. *Commodification* involves the design phase of a technology. *Appropriation* happens when people are starting to use the technology. The process of acceptance is gradual in that users can continue the use (adoption) or choose to stop using the technology (rejection) during the process of appropriation. Incorporation, as part of the appropriation phase, occurs when the technology is used and incorporated into the routines of the user's everyday life. *Conversion* reconnects the domestic environment with public values where the technology can become a tool for making status claims and for projecting a specific lifestyle to family, friends, and neighbours. It appears that the actual use of the technology feeds back to the commodification stage again, so that designers can learn about how people use the technology in their domestic environment. In that way, designers have the option to improve the technology and adapt the users' desires and requirements. As the focus of this study lies on the domestic use of the robot, only the dimensions of *appropriation* and *conversion* will be taken into account.

Based upon the domestication theory, in addition to factors regarding the social robot itself, also factors involving the context of use could play a role in the acceptance of these robots. Earlier research learned us that there are two types of contextual factors that influence user acceptance, namely factors from the social usage context and the psychological usage context. The social usage context contains the several dispositions people hold towards their general behavior. It includes the dispositions and rules a group of people uses for appropriate and inappropriate values, beliefs, attitudes and behaviors. Above all, people are influenced by the opinions of other people in their social network. The effect of social influence on technology acceptance behavior has been widely acknowledged. However, its precise effects on other factors in the technology adoption process remain unclear (Lee, Kozar, & Larsen, 2003). Therefore, researchers have expressed the need to further articulate the link between social influence and technology acceptance (Karahanna & Limayem, 2000). Another factor of the social context, a normative one, is privacy. When robots enter the domestic environment, people can feel that they are being watched, i.e. perceiving the presence of the social robot (Klamer et al., 2010). Another privacy aspect of robots lies in the possibility for robot to monitor, deliver messages, and remind people of things or the factor that robots could be integrated with other home-sensing and monitoring systems, e.g. smart homes (Sharkey & Sharkey, 2010). This could raise questions such as: what information about the user does a social robot collect and with what databases is it sharing this information? However, privacy invasion could also be sensed with a robot asking private questions or speaking of private matters when visitors are in the house. People would feel comfortable with the idea of a robot storing user information, however, this "necessary evil" would only be tolerated in case of a clear, perceptible benefit for the user (Syrdal, Walters, Otero, Koay, & Dautenhahn, 2007). Another social normative issue in the acceptance of technology is trust. Trust seems to have an influence on a user's attitude towards use and intention to use during the technology adoption process (Ben Allouch, Van Dijk, & Peters, 2009; Yu, Ha, Choi, & Rho, 2005). It appears that robots need to earn the participants' trust and allow its users to feel safe. Users need to know that there are security measures in place to protect the information that the robot has collected about them from being accessible to others (Koay, Syrdal, Walters, & Dautenhahn, 2007). In the psychological usage context, people's behaviors are influenced by their own evaluation of a certain behavior. This factor is called perceived behavioral control, defined as "an individual's perceived ease or difficulty of performing the particular behavior" (Ajzen, 1991). An earlier study on smart home technologies states that technologies making autonomous decisions cause feelings of loss of control for users (Ben Allouch et al., 2009). Since social robots are autonomous systems, we presume that these findings could also be applied to the field of robotics. Previous research on perceived behavioral control have indicated positive effects of perceived behavioral control on ease of use and usefulness (Karahanna & Limayem, 2000; Venkatesh, 2000), attitude towards robots (Bartneck, Suzuki, Kanda, & Nomura, 2007), and enjoyment (Libin & Libin, 2003). As earlier studies indicate that both the social and psychological usage context are affecting the process of technology acceptance, these will also be taken into account in the analysis of this study.

As robots might be perceived as social actors, both the utilitarian (e.g., usefulness) and the hedonic (e.g., social interactions) aspects of robots need to be taken into account when investigating their acceptance. Moreover, as the focus of our research is on domestic use, we also pay attention to the social (e.g., social influence) and personal (e.g., privacy) usage context.

3. Method

An explorative, in-depth approach was chosen to study the long-term acceptance of social robots. Specifically, the main focus in our study was to achieve a better understanding of older adults' acceptance of social robots over a longer period of time. A secondary goal was to investigate to which extend the participants experienced the sociability of the robot and whether they were showing signs of a human-robot relationship. Previous studies that have looked into the acceptance and use of social robots have used various methods but almost all have in common that their observation duration is rather short; usually no longer than one day (Bartneck, van der Hoek, et al., 2007; Bartneck et al., 2008; Heerink et al., 2007; Nomura et al., 2008; Wada & Shibata, 2006). The EU project SERA (Social Engagement with Robots and Agents) accepted this challenge by setting up a long-term field study. The primary goal of the SERA project was not system development, but exploratory research to reveal in-depth insight into the user acceptance of social robots in people's domestic environments to inspire subsequent directions for future research. Moreover, the SERA project followed a new multi-methodological approach to installing social robots in homes of older adults and observed their interactions with such social robots in three usage phases of ten days each, collecting real field data to gain insight into the factors that play a role in the acceptance of and relationship-building with social robots in domestic environments. The research questions are formulated as follows:

(1) What factors play a role in the long-term user acceptance of social robots in domestic environments?

(2) What kind of relationship do people build with social robots and how does this influence the acceptance of these robots by their users?

In the following sections, we will further elaborate on the type of robots chosen for this study, the procedure that was applied, the older adults who have participated in the study, what kind of data that was collected and the interview scheme that was used.

3.1. Social robot

The zoomorphic social robot used in this study is the Violet's Nabaztag (now called Karotz, see http://www.karotz.com), which is a 30 cm high bunny shaped WiFi enabled ambient electronic device with movable ears, blinking LED's in its "belly" with different colors. Furthermore, the social robot had an infrared motion sensor (PIR), a micro switch on a key hook that tracked whether the keys were taken away or were hung back, an array microphone and a webcam which recorded the interaction on a voluntary basis. Nabaztag was placed on a wooden column with a hidden desktop computer with broad-band internet connection (See Fig. 1). Nabaztag was designed to initiate at least three interactions per day. The dialog system covered the following topics: good morning dialog (including a weather report, advice on activity level, and weighing of the participants; initiated by first appearance in the morning), going out and coming home dialog (initiated by the key hook switch), evaluation of the day's activities (initiated by PIR sensor after the last scheduled activity), information about the system (initiated by user) and read out messages from the researchers. Also, the system was supplemented by the SALT(E) (Sleeping, Alert, Listening, Talking, Engaged) interaction manager which distinguishes between three states at the top level. The system is either: (1) sleeping, not seeing or hearing anything (indicated by horizontal ear position); (2) alert, 'attending to' the person (indicated by vertical ear position); or (3) engaged, it is committed to a conversation, either listening or talking (indicated by vertical ear position, with the right ear slightly further forward than the left). The participants were provided with RFID cards recognized by the social robot which enabled the participants to respond to the closed questions of the social robot via 20 different RFID cards, which were divided in four different, color coded, topics: (1) general interaction: smiley-, neutral- and frown face, repeat; (2) topics: weather, add to log, summary, message and system info, (3) rating numbers from 1 to 5; and (4) numbers for adding/altering the amount of exercise time of the participants in the log (10–60 min).

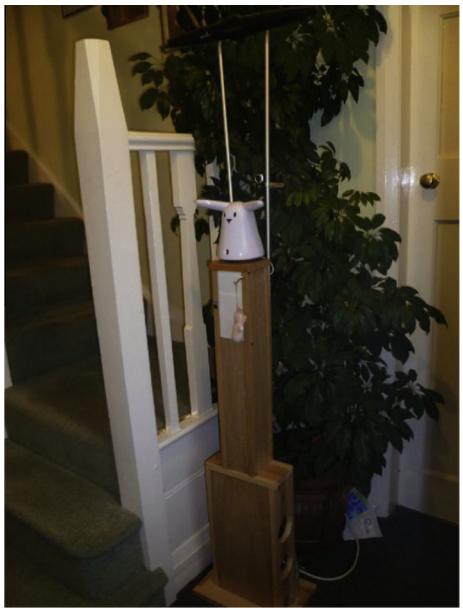

Fig. 1. Set-up of the social robot.

3.2. Procedure

The social robot was installed at the participants' homes for a period of 10 days per usage phase. The participants were told that the goal of the study was to improve their health. Therefore the function of the social robot was to ask the participants if they were adhering to their activity plan, to ask them to reflect on their feelings after a day that had involved some activity, and to ask them to weigh themselves to keep track of their own weight as an indication of their long-term health and fitness. The social robot could also provide the participants with a weather report and recommendations for local events. At the beginning of each interaction the social robot asked participants to agree upon being videotaped letting them press a button.

3.3. Participants

Participants were recruited via the Sheffield 50+ targeted mailing list. The initial recruitment criteria were that the participants had to be over 50 years of age and healthy with no known pre-existing conditions which placed restrictions on doing exercise. The participants were representative for the people on the mailing list. The participants recruited for the project are shown in Table 1 along with their demographic details and in which usage phases they were involved.

The education of the participants differed from a participant with formal education until 16 years of age to a participant with a Bachelor's degree and three participants with a Master's degree. Two participants were retired, while the other three participants had a job. One participant was visually impaired. They received an initial visit to provide detailed information on the study, get consent and to receive their activity plan which was then input into the system. The positioning of the social robot was based on the participant's preference but placing the Nabaztag in the participants' hallway was advised, to allow reasonable functioning of the set-up as storage for the house keys, and to ensure frequent passage but less sustained presence maximizing privacy for the participants, the other people who lived in the house and any visitors. Participants received a compensation of £20 for energy costs made during the study. During the second visit, the social robot was installed and the participants received instructions to its functions.

3.4. Data collection and analysis

During the three usage phases interaction with the social robot data was collected via individual video recording of users' interactions with the social robot in participants' homes. Video data was only stored when participants gave consent by pressing the video button. During this time, 22 videos per person on average were recorded. The video data was used in this study as a way to support

Table 1
Participant information.

Participant	Sex	Age	Lives alone?	Usage phase
P1	F	65	Yes	1,2,3
P2	F	50+	No, with one other	1,2,3
P3	F	60	Yes	1,2,3
P4	F	50+	No, with one other	1,2
P5	M	76	No, with one other	1,2
P6	M	71	No, with one other	1

the results of the interview data. In this paper we only occasionally refer to the video data results. For an extensive analysis of the video data, see the study of von der Pütten, Krämer, and Eimler (2011). The main conclusions were that there are massive inter-individual differences with regard to all categories of behavior. Whereas verbal behavior was stable for some participants, this changed over time with other participants. However, a pattern of decreased amount of smiling was observed among the participants who used the robot for more than one phase.

After each of the ten-day interaction periods, three in total, experiences of participants were evaluated via a semi-structured interview at the participants' homes. The interviews were recorded with the participants' approval and the recordings of the interviews were transcribed verbatim. Based on the transcriptions of the interviews key concepts were identified and were translated into a coding scheme. The interviews were shown to one primary and three secondary coders. For each interview section, the coders were instructed to independently apply at least one code from the coding scheme to each section. Intercoder reliability, which involves testing the extent to which the independent coders agree on the application of the codes to the different interview sections, has found to be satisfactory with a Cohen's Kappa of .60. In the results, from every interview transcript, 'striking' or 'typical' quotes (Hansen, Cottle, Negrine, & Newbold, 1998) were selected which illustrated, confirmed or enhanced our understanding of the experiences of the participants with the social robot as explained through the emerged key concepts from the coding scheme.

3.5. Interview scheme

After the each usage phase a semi-structured interview was conducted to evaluate the user's experiences with the social robot. Questions were asked about the following topics: evaluation of the device (e.g., Can you describe some advantages/disadvantages of the device?), evaluation of the interaction experiences (e.g., What is your opinion about the interaction between you and the device? How is this different from interacting with another person?), evaluation of the health exercises and logging (e.g., Can you tell me anything about your exercises during the last 10 days using the device?), context of use (e.g., Can you describe a typical day using the device? Did you talk with other people about the device and what did they say?) and relationship development with the social robot (e.g., Can you describe how you perceived the device? What is the device for you?).

4. Results

The analysis of the interviews induced several interesting themes which will be outlined below and categorized as utilitarian and hedonic factors of the robot, the usage context, user characteristics, domestication, and ideas for improvement. For each of the themes, the progress through the usage phases are described and supported with quotes from the interviews.

4.1. Utilitarian factors

Utilitarian factors concern the practical features of the usability of the device. Based on the analysis of the interviews from a theoretical perspective, we found four factors belonging to this category: usefulness, ease of use, adaptability and intelligence.

4.1.1. Usefulness

In all interviews, participants talked most about the usefulness of the robot as compared to other utilitarian factors. Most participants made it clear that a specific usage purpose is essential for the success of future robots. During the first usage phase the participants were still indifferent about whether or not they find the robot a useful device. One reason given was that the conversations of the robot were limited to the activity plan. Although all participants liked the ability to log their exercises and the weather reports the robot provided, some other participants were not able to find a purpose for the robot yet.

"It did not really discuss [my activities] in any grade."– P3: phase 1.
"[The robot] probably needs to be more sophisticated if it's going to be a useful source of information for me really."– P5: phase 1.

This indifference about the usefulness of the robot did not change much during the second phase. However, in the interviews after the third phase most participants revealed that they did find the robot a useful tool for general information and health stimulation.

"[The robot] knows that I have been and done my exercise. [. . .] The robot stopped me from over-exercising." – P1: phase 3.
"Subsequently, when I went past, which was useful, she [the robot] asked me how I was." – P2: phase 3.
"Really, I think, as with any machine, it is a matter of does it [the robot] do the job. And if it does, it is fine." – P3: phase 3.

4.1.2. Ease of use

The topic of ease of use was much less discussed by the participants as compared to the topic of usefulness of the robot. After the first usage phase, all participants, being either positive or negative, talked about how easy or difficult it was to use the robot.

"Yes, yes, [the buttons] were quite easy and simple to use." – P1: phase 1.
"Sometimes it was like, oh which stock of cards do I need?" – P2: phase 2.
"It was quite tricky sometimes to persuade [the robot to accept two times the 60 min cards]." – P3: phase 2.

Over time, and especially after the third usage phase, the topic of ease of use was discussed even less by the participants. Now only those participants who did not find it easy to interact with the robot spoke about this topic, and the longer use of the robot did not change their opinions about the ease of use of the robot.

4.1.3. Adaptability

The participants did think it was important that the robot enables personalization and for it to adapt to personal needs. Their perception of the robot's adaptability became more positively with every usage phase.

"So [the programmed diary] was a nice personal bit, a personal touch." – P5: phase 1.
"It [the robot] asked me questions that just were not relevant or important, you know, not time like" – P4: phase 2.
"[The robot] asks you questions about your lifestyle, but that is only because it knows what your lifestyle is."– P1: phase 3.

4.1.4. Intelligence

After the first phase the participants did not agree whether or not the robot was an intelligent piece of technology. But towards the third phase their opinions changed into thinking that it probably has some form of intelligence.

"So I would tell him [the robot] sometimes where I was going and what I was doing, but I don't think it understood." – P1: phase 1.
"It[the robot] was giving me the suggestion that it might be more sophisticated this time than it was last time" – P5: phase 2.

"When it [the robot] noticed movement around the house, [...] it tended to greet me." – P3: phase 3.

4.2. Hedonic factors

Hedonic factors include those factors concerning the user experiences while interacting with a technical device. Based on the analysis of the interviews combined with the existing literature on human-robot interaction and technology acceptance, we found five related hedonic factors: enjoyment, attractiveness, anthropomorphism, sociability, and companionship.

4.2.1. Enjoyment

Gaining joy from using the robot was an often recurring theme during the interviews. However, not all participants actually did enjoy interacting with the robot and those who did were less enjoyed by it during the third phase as compared to their experience from the first phase.

"It was just good fun having the robot here" – P1: phase 1.
"The thing was that I was enthusiastic about it [the robot] and amused by it."– P6: phase 1.
"It [the robot] has a function of talking to you, probably nagging you."– P3: phase 3.

4.2.2. Attractiveness

The appearance of the robot was also discussed during the interviews, especially in terms of whether participants liked it or not. Some participants thought the robot looked cute, while for others the appearance did not really matter and were more focused on its functionality.

"It [the robot] was just a small, kind, friendly looking thing" – P1: phase 1.
"I don't care if it [the robot] has a little cutely face" – P4: phase 1.
"Actually, it [the robot] was very beautiful from the top of our stairs."– P6: phase 1.

Furthermore, the participants tend to get pickier towards the later phases expressing their personal preferences for the robot's exterior.

"It [the robot] was quite quirky, wasn't it?" – P4: phase 2.
"It [the robot] was not the most beautiful thing." – P2: phase 3.

4.2.3. Anthropomorphism

Throughout all the usage phases the most mentioned theme was anthropomorphism in which the participants ascribe human-like attributes to the robot. However, some participants did have internal debates whether they would allow themselves to anthropomorphize an unanimated object.

"Very interesting the way that you are half recognizing it [the robot] as a person [...]. Odd thought to have, if you are not having them." – P6: phase 1.

Participants all talked about having a rabbit in their homes and described the robot as having at least some life-like essences, such as body parts and biological processes (e.g. sitting or sleeping).

"When I went near it [the robot], it would sort of start to wake up and have its ears up and down." – P3: phase 2.
"It [the robot] is just sitting there. It gives you a few funny looks." – P1: phase 3.
"It [the robot] went into a coma with its lights still on." – P2: phase 3.

Most participants described the robot as having mental states, such as intentions, feelings and personality characteristics.

"It [the robot] apologized rather a lot. [...] Because the apologetic bit pushed you rather further into thinking of it as a person." – P6: phase 1.
"It [the robot] was a bit friendly and a bit bossy." – P2: phase 2.
"The rabbit certainly initiated [a conversation] in the morning." – P5: phase 2.
"I don't know whether he [the robot] meant it [being entertaining] or not." P1: phase 3.

And a few participants even assigned moral standing to the robot.

"But that is not the rabbit's fault" – P1: phase 1.
"You try not to react to it personally, because it is just a little rabbit in the corner." – P4: phase 2.
"So whether it is a machine that talks to you or somebody who's is going to stay, you have got to have some communication with them just out of share politeness, and friendliness and just general humanity." P1: phase 3.

The topic of anthropomorphism appeared a lot more after the second usage phase, where the participants seemed to be in doubt whether the robot is 'lifelike' or not and they became more aware of its computational surface.

"It was questions. It [the robot] was programmed to ask." – P1: phase 2.
"The rabbit itself was kind of sweet. If it was furry, I would stroke it." – P2: phase 2.

However, after the third usage phase, whilst the topic of anthropomorphism was less mentioned as compared to after the second usage phase, most participants tend to agree that the robot had some humanlike features.

"I had a talking rabbit in the kitchen" – P1: phase 3.
"So I have squirrels outside, the rabbit inside [...]."– P1: phase 3.
"Because Harvey [the robot's given name] was Harvey. I talked to him as a male, and males do tend to get on your nerves from time to time because they don't like us [females]." – P1: phase 3.
"I was conscious it [the robot] was likely to be starting to wake up."– P3: phase 3.

4.2.4. Sociability

Participants also talked about the robot's ability to perform social behavior. In the interviews after the first and second usage phase most participants were somewhat negative about the robot's social skills. They expected that the robot would interact socially with its users and behave more realistic and more social.

"I never thought of the rabbit as being alive and human." – P1: phase 1.
"I expected to be able to interact with it [the robot], but that was a bit of a disappointment really." – P2: phase 1.
"It was a bit limited in what it [the robot] says to you." – P3: phase 1.
"I would have liked to have more depth [in the conversations] and more that the creature [the robot] could do." – P6: phase 1.
"We were charmed by its [the robot's] ears and try to work out what anything with the ears meant or what it meant by its ears." – P6: phase 1.
"It [the conversations] was quite limited really compared with a normal conversation." – P5: phase 2.

Only after the third usage phase, participants began to be more positive about the sociability of robot. However, their overall opinions were still neutral with equal positive as negative statements.

"So like anybody else, I am human and the rabbit is not." – P1: phase 3.
"I did stop myself from asking it [the robot] if it wanted a drink or something to eat." – P1: phase 3.
"Subsequently, when I went past, which was useful, she [the robot] asked how I was" – P2: phase 3.
"I am not too sure that it [the robot] knows what it was talking about." P3: phase 3.

One participant actually did not want the social part at all, neither the bunny shape of the robot. She saw the conversations with the robot just as a tool to log her exercises and would have preferred the robot to look like a big white box with big square buttons on it.

"I don't need to be asked how I am. I don't need that." – P4: phase 1.
"It feels like a bit more of a feminist way to do that [make robots more sociable]." – P4: phase 1.

4.2.5. Conversation

All participants have verbally spoken to the robot within all the usage phases. How much the participants talked to the robot varied, but all participants talked more to the robot each time it returned to stay within their homes. Also, the topic of conversation with the robot became more important after each usage phase. The video data showed that some participants used verbal communication to correct the robot when it was telling the wrong activities and started to mimic what the robot said using non-verbal behavior. One participant even forgot to use the buttons and cards to interact with the robot. She kept answering the robot verbally and tried to explain to it what she was going to do. All participants had their own specific reasons for why they interacted with the robot.

"There was not a lot of interaction, No." – P2: phase 1.
"If it [the robot] had communicated with me a lot recently, I would go about my own business. If we had not communicated a lot, then I would make an opportunity to communicate with it." P6: phase 1.
"I might have looked at it [the robot] one day and said, 'I'm not at my best. Don't ask me anything. Don't expect me to answer. It's not a good day.' You felt you could actually say that to the rabbit." – P1: phase 2.
"You know, sometimes I'd come down and talk to it [the robot], and sometimes I would not." – P2: phase 2.
"I think I even told him [the robot] that I was going upstairs to do some packing [for a vacation trip]." – P1: phase 3.
"So when I got back I thought, 'Oh good, I can tell [the robot] what I have done.'" – P3: phase 3.

Some participants would have wanted that the robot talked more to them, that it would recognized verbal language and had a wider range of conversational topics.

"It would be nice to ask the rabbit a few questions occasionally and see what happened." – P2: phase 1.
"Perhaps for it [the robot] to speak to me a little bit more often." – P3: phase 1.
"If it could pick up some verbal's, it would be good." – P6: phase 1.
"I would like a wider range of information. Time of the next bus. Things like that, information that I need." P5: phase 2.
"The rabbit interacted fairly short." – P2: phase 3.

4.2.6. Companionship

All but one participant saw the robot as a companion or at least saw its potential for companionship. The interview data indicates that most participants did discuss and tended to show (pictures of) the robot to family and friends. The video data also confirmed that a few participants showed the robot to others, such as friends, family and visitors.

"I did show one or two a photograph [of the robot] so that they [other people] would know what I was talking about." – P1: phase 1.
"I talked with a few people about it [the robot], not many." – P2: phase 1.

Some participants affirmed that they developed some sort of relationship with the robot.

"Very interesting the way that you are half recognizing it [the robot] as a person." – P6: phase 1.
"The minute you come in it [the robot] senses you. I mean, I might have said some funny things to the rabbit." – P1: phase 2.
"I know I have said to him [the robot] one Saturday: 'I have not much time to speak with you for the simple reason that [her son] is coming and I have got to give him my priority." – P1: phase 3.
"I suppose as I relate to any other machine. [...] I have got a computer and I am quite connected to that too." – P2: phase 3.

Others stated that they would have wanted to connect more to the robot. One participant said that she was not able to fully develop some kind of relationship with the robot because it did not completely fulfill her needs. Another participant needed to spend more time with the robot, knowing it was going to stay, before she could open up her heart for a relationship with the robot.

"I did find myself wanting to develop more of a relationship with it [the robot]." – P4: phase 1.
"The rabbit was only here for a few days, so I did not have the time to create an emotional bond with it." – P3: phase 3.

Some participants immediately gave the robot a name, whilst others did not feel the need to name the robot for different reasons.

"I didn't really have any emotions toward it worth giving it [the robot] a name" – P3: phase 1.
"I tended to settle it Bunny and perhaps Bunny came."– P6: phase 1.
"It was Harvey the rabbit, obviously." – P1: phase 3.
"If she [the robot] came to live with me, she would get a name. Not just for visits."– P2: phase 3.

Some participants even said that they had missed the robot for a few days after it was taken away.

"I did sort of miss it [the robot] when it was taken away." – P5: phase 1.
"We missed her [the robot]. Oh yes. [...] She had been given personality." – P6: phase 1.
"I missed him [the robot] for the first couple of days." P1: phase 2.
"Well you miss it [the robot] for what it does."– P3: phase 2.

Some participants tried to analyze their relationship with the robot and compared it with a guest staying for the night. Some participants even described their relationship with the robot as having children or felt the need to take care of it.

"Yes, that's dependence and that's nurturing [the way he interacted with the robot and how he felt about it]." – P5: phase 1.
"Because that [having the robot permanently] would be just like having children around." – P1: phase 3.
"Probably on average two to three times a day [taking initiative to talk to the robot], because that sounds quite reasonable to me if you would have somebody in the house, [...] even a lodger." – P1: phase 3.

4.3. Usage context

The usage context also influences people perceptions of a technology. Besides the social and psychological context of use, we also found some situational factors that could influence the user acceptance of social robots in people's own homes.

4.3.1. Social influence

All but one participant talked about other people's opinions about the robot. However this was not much and only a few participants actually cared for what other people thought about their use of the robot.

"They didn't say anything that would have affected me."– P3: phase 1.
"I can see you know that other people would [have given the robot a name]."– P4: phase 1.
"Some friends expected us to giving it [the robot] a name. I tended to settle it Bunny and perhaps Bunny came." – P6: phase 1.

All participants talked more about other people opinions towards the end of the third usage phase. But still, other people's opinions did not seem to have a major effect on changing the participant's own attitude towards using the robot.

4.3.2. Privacy

Most participants brought up experiences involving privacy while the robot was in their homes. Mainly this was caused by the option to video parts of the interactions with the robot and some participants explicitly said that it was essential that the robot asked for permission before recording anything. The videos showed that one participant even closed all the doors to all others rooms and warned his partner when he started to interact with the social robot. Also, participants would like to have control over the footage, being able to see and may be even delete parts of the data.

"In terms of invasion of privacy, the invitation is to press the button for video not videoed automatically. I think that's important." – P4: phase 1.
"I was in control of to press the button or not, but I could not check what it [the robot] had recorded and I could not go and say I am going to delete that." – P3: phase 3.

Also, one participant indicated that, although she herself chose where it was placed, the location of the robot in her home influenced how she perceived the invasion of their privacy.

"There is my bathroom and there is my bedroom, and sometimes I am thinking, 'it's taking video's in that area."– P3: phase 2.

Other participants were uncertain whether it was still recording or not after a longer time had passed after pressing the video-button.

"You press record and then you don't know [. . .] whether it [the robot] was still recording when you came back."– P1: phase 1.
"I was never quite sure when it was on or off [the video recording]."– P4: phase 1.
"When do I know it [the robot] is taking it [the videos] and when do I know it's not? I can't remember when I pressed the button."– P3: phase 2.

One participant was concerned about the privacy of others and did not use the video option when visitors were in her home.

"You make sure that you do not press the video if you've got guests."– P1: phase 2.

One participant did not take any videos. She was extremely aware of the robots presence and its capability to take videos, which made her feel uncomfortable just to walk past the robot. In the end, she was relieved when the robot was gone.

"It was like, oh good I don't need to worry now whether I'm going pass that doorway [where the robot was placed]." – P3: phase 2.

Two other participants did not think the robot was infringing their privacy and did not mind being videoed at all.

"I don't think that [my wife] and I are paranoid about being watched." – P6: phase 1.
"If it [the robot] wants to watch me, I'm fine." – P2: phase 2.

4.3.3. Trust

The trustworthiness of the robot was a serious issue for most participants, it seemed more important that privacy. Yet, most participants did trust the robot and its messages or they did not even think about questioning the integrity of the robot.

"[The robot] worked as I had understood that it should work" – P4: phase 1.
"It was very clear that a lot of thought came into the recommendation [the robot provides]."– P6: phase 1.

However, when the robot showed some inconsistency in its behavior or when it provided incorrect information, participants did experience some distrust towards the robot.

"I only trusted it [the robot] when it believed me." – P4: phase 1.
"My husband was suspicious of it [the robot]." – P2: phase 3.
"But I can be told all sorts of things and that may or may not be true." – P3: phase 3.

4.3.4. Perceived behavioral control

The participants talked about their capability of interacting with the robot and whether or not they were using it correctly. This was mostly discussed after the second usage phase. One participant stated that the feedback from the robot was not always clear to her, which made her feel uncertain about their interactions. Overall, only half the participants were completely confident about their technological skills.

"You also know you are in charge. You only have to press a button if you want to record." – P1: phase 2.
"Sometimes I wasn't quite sure how to prolong the conversation." – P2: phase 2.

4.3.5. Previous experiences

Besides perceived behavioral control as a factor in the psychological context, participants also talked about their familiarity with technology in general and in later usage phases also about their earlier experiences with this robot specifically. In the interviews after the first usage phase, half of participants talked about similarities between experiences with the robot and experiences with other technological devices as a way to familiarize themselves with the robot.

"I was thinking of the gaming generation, [. . .] you know, the little Tamagotchi's." – P5: phase 1.
"Normally I'd just listen to the radio weather forecast." – P5: phase 1.
"You remember the craze for these Japanese pets. [. . .] Looking after a computer doll." – P6: phase 1.

However, after the second and third usage phase, participants narrated more about their earlier experiences with the robot from the last times it came.

"The first time it [the experience with the robot] was really exciting."– P3: phase 2.
"It was giving me the suggestion that it [the robot] might be more sophisticated this time than it was last time."– P5: phase 2.

"I don't think it [my interactions] changed very much really. Because I had used it [the robot] before."– P4: phase 2.
"Like somebody or something that comes to you for the third time you are so familiar with them."– P1: phase 3.
"It was nice to see it [her relationship with the robot] improving with each visit."– P2: phase 3.

4.3.6. Prior expectations

Another factor in the psychological context was found in prior expectation. Most participants had at least some expectations, either consciously or subconsciously, about the robot before it was introduced into their homes. The participants did not have explicit expectations about the robot before it came to their houses and this was even less in the interviews after the second and third usage phase when they already knew what to expect from the robot. So, having any prior expectations was not an important topic for the participants. However, some expectations were shared.

"I was as interested as I was expecting to be, probably a bit more."– P6: phase 1.
"I had expected that if I held the card up where it [the robot] was reading it. [...] But whatever was on the card, I would have expected that to come out."– P1: phase 2.
"It [the usefulness] was not as much as I was expecting."– P2: phase 3.

4.3.7. Situational factors

The circumstances under which the interactions with the robot took place where influencing the experiences participants had with the robot. Moreover, the importance of the topic of usage context increased after each usage phase. Half of the participants told us that the particular moment of the day itself influenced how and when they interacted with the robot.

"I'd trigger that [the conversations] in the morning and last thing at night I would, or if I had more time."– P5: phase 1.
"I must have said some funny things to the rabbit [...], especially if I wasn't sleeping very well and I'd come down in the middle of the night."– P1: phase 2.
"It [the robot] would say hello to me usually at an inconvenient time. And if I talked to it, it would often try and engage in a conversation five minutes later if I walked pasted."– P2: phase 2.
"Sometimes it [the robot] was sort of trying to greet me when I was busy doing something else."– P3: phase 3.

Almost all participants said that also the location where the robot was positioned had an impact on their interactions with the robot.

"Generally, the way it [the robot] was positioned [...] and we did go through there [the hallway] in the morning. That movement initiated it [the conversations]."– P4: phase 2.
"If I had one permanently I would probably have put it in a different place where movement did not trigger it [the robot] so often."– P5: phase 2.
"If I had a bigger house, I would not have it [the robot] in the kitchen. [...] It would always activate more than anywhere else in the house"– P1: phase 3.
"Where it [the robot] was positioned, which was the hallway, [...] you are always on your way somewhere."– P2: phase 3.

Half of the participants also indicated that their way of living or the presence of others in the house impacted their use of the robot.

"I work a lot from home and at that time I was doing a lot more [exercise]."– P4: phase 1.
"Particularly when I had friends or children nearby, it was nice to start off with the rabbit."– P6: phase 1.
"We had some visitors while it [the robot] was here, [...] so they'd engage with it."– P2: phase 2.
"The weather obviously [was an advantage], because I don't drive."– P5: phase 2.
"I had my grandsons here, [...] then it was not always convenient when it [the robot] talked to you."– P5: phase 2.

One participant said that even her mood at the time of the interaction seemed to influence how she felt about the robot and her experiences with it.

"Things [like the robot] do tend to entertain you from time to time, depending on what sort of day I have had."– P1: phase 3.

4.4. User characteristics

The users' individual characteristics also play a role in the process of accepting new technologies. Holding the interview transcriptions against the theoretical background, we found the user characteristics of age, gender, personal innovativeness and type of household.

4.4.1. Age

Half of the participants stated age as an influential factor for using a robotic device. However, age was not mentioned al lot and most participants did not talk about it anymore in the second and third interviews.

"The whole purpose of these rabbits is to see how active elderly people are."– P1: phase1.
"The very elderly, the eighty and ninety years old, [...] they don't engage [with these kinds of technologies]."– P4: phase 1.
"But someone who could be ten years older than me, who hasn't seen a computer, they might find it [the robot] really weird and strange."– P1: phase 2.
"Lots of people would benefit [from having the robot], because some old people just don't do anything."– P1: phase 3.

4.4.2. Personal innovativeness

Most participants stated that they had some general interest in technology anyway, which made them more receptive to the robot in the first place.

"I am not a highly technical minded person, as my son would. [...] But my laptop I keep upstairs in my spare room and it is connected to the internet. I use my computer quite a lot."– P1: phase 1.
"I always tried new technologies when they came out."– P2: phase 1.
"I don't get the latest gadgets as they appear, [...] but I have iPods, I got five."– P3: phase 1.
"I have got a talking computer, which [...] I use for getting my information basically."– P5: phase 1.
"I like to read about it [science and technology]."– P6: phase 1.

4.4.3. Type of household

The participants talked about what other people with different backgrounds or different living situations would do with a robotic health device and sometimes why this might be the case. For example, the participants referred to other older people who might not be as active as they were or those people who would instantly try to build a relationship with the robot.

"I found that I didn't need to do that [giving an inanimate object a personality], but I can see that other people might."– P4: phase 1.

"[The robot could be useful to] someone who perhaps didn't have access to the internet, or couldn't watch TV. Or may be a person who couldn't see, who have to hear."– P2: phase 2.

However, some participants also stated that some people might not want to use robots, because these people are not very familiar with technological devices in general.

"There might be a lot of people who would not be able to manage that [interacting with the robot properly]. So that could be a non-starter before it even gets off the ground."– P1: phase 1.

"I know that we have got a lot of people, older adults, who don't use health services assertively. They are really quite stoic, you know, the old working class."– P4: phase 1.

"Some people just could not see the point or fun of it and the interest of it [the robot]."– P6: phase 1.

4.5. Domestication

The domestication theory was used to analyze the long-term user acceptance of the robot. Results on the process of technology acceptance into people daily lives are presented along the included phases of appropriation, incorporation and conversion. This section will conclude with the results on the explicit question whether the participants would continue to use the robot after the experiment if they could.

4.5.1. Appropriation

During the first phase participants were trying to get to know the robot and its functions by experimentation and getting familiar with the robot's interaction behavior. These are all characteristics of the appropriation phase. The video data revealed that some participants found their selves a way to fool the robot. One participant used spare keys when going outside for little household chores so the robot would not know she went out of the house. She also tried to figure out how long the robot would continue to video her. Another participant pressed the no-button when the robot asked her if she had a good time doing the activity just to see how it would react. The interview data confirmed this finding.

"I could fool it [the robot] when just leaving the keys on [the hook] and not letting it know."– P1: phase 1.

"I didn't know what to expect. Later I knew exactly what to say [to the robot]."– P3: phase 1.

"It [the robot] is more of a novelty I think."– P5: phase 1.

"You spend a lot of time thinking about what the rabbit is programmed to do and whether you are understanding it."– P6: phase 1.

"The first time it [having the robot] was really exciting, and I had all these colored lights."– P3: phase 2, referring back to her experience in phase 1.

4.5.2. Incorporation

Already during the second usage phase, we could see that some participants were entering the incorporation phase. However, it was only after the third usage phase that all participants showed by their behavior that they were fully moved into the incorporation phase. Also, the topic of domestication became of greater importance for the participants after the last usage phase. Some participants indicated that the robot had somewhat caused a change in their behavior by saying that they exercised more because of the social robot or that they altered their sports activities on advice of the robot.

"I got familiar with it [the robot], [...] perhaps interacted with it more."– P2: phase 2.

"It [the robot] stopped me from doing too much in that short space of time."– P1: phase 3.

Some participants said already during the second interview that the newness of the robot was gone and that they were fully used to having the robot in their homes. However, for most participants, this was only the case after the third usage phase.

"Off course, it's a bit like lots of things, isn't it? Familiarity breeze contempt, so you get used to the same things do you."– P1: phase 2.

"I just got used to having him [the robot] around" – P1: phase 3.

"I guess you are getting used to what she [the robot] is going to say."– P2: phase 3.

"I got used to the idea of it would greet me in the morning."– P3: phase 3.

The participants actually integrated the social robot into their daily lives by creating a routine of use and by interacting with the robot in the same way or on around the same time.

"I suppose, in the long term, I had accepted him [the robot] into my house."– P1: phase 3.

"You are getting into a routine, you just get used to her [the robot]."– P2: phase 3.

"I could predict what the routine [of using the robot] would be."– P3: phase 3.

4.5.3. Conversion

In the interviews after the third usage phase, one participant already showed a first sign of shifting into the conversion phase by justifying why she uses the robot.

"Probably on average two to three times a day [taking initiative to talk to the robot], because that sounds quite reasonable to me."– P1: phase 3.

4.5.4. Continued use

To the question if they would continue to use such a health device if it was available, only two participants said they really had enjoyed using the robot and could imagine having one in the future. Half of the participants stated that the social robot did not completely meet their needs and would like to see some improvements (especially technical ones) before they would continue to use it. Only one participant explicitly said that she would not want the robot permanently in her house, because she had higher expectations of it and had hoped to develop more of a relationship with it.

4.6. Ideas for improvement

During the interviews the participants came up with a several suggestions to improve future socially interactive agents, such as social robots.

"[There are] different things that you do where the robot was not programmed for."– P1: phase 1.

There were some suggestions made to improve the **application** of the robot. Half the participants would like it if the robot could play some music, either of their own or just the radio. According

to one participant it would be useful when the robot could provide the local bus schedule. Some others suggested that the robot could remind them of taking their medication.

"It [the robot] could sing Brian Adam to me all day long, [...] or a bit of Robbie Williams." – P1: phase 1.

"It [the robot] would be rather nice to say when the next bus is coming."– P5: phase 1.

"I had rather assumed that it [the robot] would be able to tell me about my medicines."– P6: phase 1.

Also, the participants came up with ideas to amend the **usability** of the robot. Especially the interaction mode was discussed by most participants. They all would have liked it if the robot was enabled with more comprehensive conversation, was more socially responsive, and if it allowed natural language for interaction. Some suggested that even little more tactile feedback would increase their user satisfaction. One participant argued that the speech reaction speed of the robot was too slow. A few participants would have liked it when it was possible to switch off the robot or that it would sleep at night.

"There was no satisfaction in pressing it [the buttons], because you did not know whether you had pressed it hard enough or correctly." – P2: phase 1.

"That you could actually tell it [the robot] that you were there."– P3: phase 1.

"If it [the robot] could pick up some verbal's, that would be good."– P6: phase 1.

The participants also provided us with some thoughts to alter the **appearance** of the robot. A few participants could imagine the robot having fur so they could pet it. However, instead, another participant would prefer robots to look more like a technical device.

"I would like the robot to have fur, so that I could touch it."– P3: phase 1.

"If it [the robot] was furry, I would stroke it."– P2: phase 2.

In summary, the hedonic factors gained most attention in the experiences of the participants. Especially, the participants tend to ascribe humanlike feature to the robot (e.g., anthropomorphism) and their perception of the robot's aliveness increased over time as well as their amounts of conversations with the robot. All but one participant at least acknowledged the robot's potential for companionship. However, the utilitarian factors, with special attention for usefulness, could be considered as a fundamental base before engaging in long-term interactions with robots. The purpose of the robot must be clear for a successful acceptance leading to continued use. Last, even in the case of a non-moving robot, the usage context plays an essential role in the user experience. Especially the situational factors, such as having visitor over or the time of the day, influenced how the participants used the robot.

5. General discussion

This long-term, exploratory field study has yielded interesting theoretical insights to move towards a better understanding of the user acceptance of social robots in peoples own homes. This study shows that social robot acceptance in the home somewhat follows the adoption process as described in the **domestication theory**. The older adults in this study who experimented with the social robot tended to do this less during the second usage phase and did not experiment at all during the third and final usage phase. These results are in line with earlier findings (Fink et al., 2013; Forlizzi & DiSalvo, 2004; Sung et al., 2009) suggesting that experimentation particularly happens when people first received their robots. This is in line with the domestication theory, where experimentation is part of the appropriation phase (Silverstone & Haddon, 1996). Older people seem to successfully incorporate a social robot into their daily lives by giving it a function in their daily routines. They used it, for example, to become aware of their own exercises, to listen to the weather forecast, and to show the robot to others. However, some older adults did see the social robot only as a technological device to record physical activities and could become somewhat frustrated with the additional conversations the social robot initiates autonomously. Our study reflects earlier findings (Young et al., 2009), allowing us to assume that the successful incorporation of social robots in everyday life depends on the user's perception of them. Furthermore, the older persons who participated in our study seem not to have yet reached the conversion phase (Silverstone & Haddon, 1996). None of the older adults stated in the interviews that they perceive the social robot as a status symbol nor do they use it to claim a certain lifestyle they want to express while using the social robot. However, one participant started to rationalize her own use of the robot, which can be seen as a first sign of the conversion phase. All together, we conclude that this phase will probably flourish further after an even longer period of use. The literature suggests that longitudinal studies need to last for at least two months if you aim for observing continued use after the initial acceptance and beyond the novelty effect (Sung et al., 2009). Currently, we are conducting a follow-up study to investigate the existence of different phases of technology acceptance and to see whether and how a longer, uninterrupted period of use of a social robot in a domestic environment affects the long-term use of social robots.

Second, we observed a **mere-exposure effect**, which the tendency to evaluate novel stimuli more positively after repeated exposure. Our results indicate that, over time, older people tend to appreciate several aspects of the social robot more. They evaluated the robot as more useful, more intelligent and more sociable after each usage phase when they became more familiar with the robot. Also, ease of use was no longer a barrier in the third usage phase. Earlier studies on long-term smartphone device use also report a shift in the user's concern from ease of use to usefulness (Karapanos, Zimmerman, Forlizzi, & Martens, 2009; Peters & Ben Allouch, 2005). When people use technologies for a longer period of time, people are more willing to ignore the shortcomings of that technology because of factors such as habitual use and familiarity (Silverstone & Haddon, 1996). This result can be explained by a novelty effect (Sung et al., 2009) in the beginning which fades away after some time, but enjoyment increases again when people see the robot as a familiar interactant. Moreover, familiarizing oneself with a robot causes people to experience more meaningful social interactions with that robot, as earlier findings suggest (Kim, Han, Jung, & Lee, 2013). Currently we are conducting a long-term follow-up study to investigate the changing user evaluation of social robots and to see when, how and why changes occur.

Third, the **hedonic social interactions** seem to be the most important for the acceptance of social robots in the home. Throughout all usage phases, the older adults talked the most about these factors and how they influenced their evaluation of the robot and their interactions with it. This finding is contrary to most former technology acceptance research stressing the central role of usefulness as determining user acceptance (Lee et al., 2003). One explanation could be that usefulness does not have the same function as in earlier technology acceptance research where the investigated technologies are of utilitarian nature. When the purpose of the robot is to be social, it could be that people tend to focus on other aspects of that robot. Another explanation could be that the participants talked more about the social capabilities of the robot, instead of its usefulness, simply just because the social interactions are a more interesting topic to talk about. Nonetheless, despite the greater attention on the hedonic factors, the utilitarian

factor of usefulness seems to be a fundamental base for engaging in long-term use with a social robot. This importance of practical utility is also stressed by Fink et al. (2013), who reported that people who did not perceive the robot to be useful stopped using it after some initial trials.

Fifth, the importance of the **usage context** increases over time, with a special focus on the increase of social influence and situational factors. Moreover, evaluations of contextual factors of privacy, trust, and perceived behavioral control seem to influence the continued use of social robots. The older adults in this study who evaluated these contextual factors negatively would not have continued the use of the social robot after our study if they could. It also seems that these variables could be related to each other. Participants who evaluated one of these aspects as negative were more likely to evaluate the other aspects as negative as well. Furthermore, privacy seems to be a very personal issue as almost each participant who felt an invasion of their privacy seem to have their own specific reason (location, control of data, ignorance) why this was the case. However, in this study all privacy issues are related to the option of allowing the interactions to be recorded on video. In our current longitudinal study, we are further deepening our understanding of the influence of these contextual aspects on the long-term acceptance of social robots.

Finally, our study also indicates the possibility of establishing **human-robot relationships**, however, even among the participants themselves, this seems to be a sensitive topic. The results of our study indicate a greater influence of hedonic factors over utilitarian factors on whether or not people build a relationship with social robots. Especially the amount of time participants anthropomorphized the robot and appreciated its sociability seemed to explain whether or not participants saw the robot as a companion. An earlier study also reported that a higher appreciation of the robot sociability resulted in more intense social responses towards it (Baddoura & Venture, 2013). Furthermore, the way the older people interact with the social robot, e.g. anthropomorphizing the robot or not, seems to influence the type of relationship they build with it. Our findings indicate this phenomenon to be a promising direction for future research. During their interactions with social robots people share stories and secrets recreating periods of their lives, which could result in psychological attachment to these robots. However, it seems that people need to discard any shame of interacting with these robots before they can allow themselves to build a relationship with them. Two of our participants who thought that others must find them crazy to think of the robot as a person or companion. Similar findings were reported by Turkle (2011). Furthermore, we experienced a similar effect with participants needing to trust that the researcher would understand their relationship with the social robot before openly discussing it during the interviews. Once the researcher had asked the questions about giving the robot a name and the possibility of having a relationship with the social robot, the older adults seem to refer to the robot as 'him' or 'her' more frequently and talked more freely about their relationship with it than before these type of questions were asked. During his study, also Kidd (2008) had to earn the trust of his participants in order for them to talk about their relationship with his social robot. People need to feel that other people understand their relationship with the social robot. This phenomenon stresses the need for a well thought-out research design that takes reticence into account before being able to make conclusions about human-robot relationships. Researchers exploring the relationships people build with social robots need to be aware of people's reticence when talking about their relationship with an artificial companion. Otherwise researchers will not be able to uncover all details about what is going on between users and their social robots, leading them to false and premature conclusions.

Next to these eight theoretical insights, this study also yields some interesting insights concerning the design social robots. First, although the older adults really liked it, they would like to **extend the social interactions** provided by the robot. Not surprisingly – given the robot's simple dialog system–, the older persons in this study do find the interactions with the social robot rather simple and repetitive. However, most of them liked the additional conversations such as the weather forecast and the recommendations for local events. During the interviews, older persons have expressed their desire for even more services being performed by the social robot. The suggestions ranged from listening to the radio to providing the local bus schedule.

Second, the **social capabilities** of a robot are (subconsciously) observed by its user and should be given enough attention in the design process. Because of its careful dialog design, the older adults experience the social robot as polite and friendly. For example, the social robot attributed interaction errors to itself and employed mitigating expressions when it made requests of its users. Nevertheless, the older adults did not like the question whether they were intending to weigh themselves that day, despite various conversational strategies to make this question more acceptable to its users. In the expectation that in the future, social robots will have to remind their owners of activities that are not always enjoyable, these findings suggest (1) a need for designers to take this into account and (2) a direction for further research on the relation between human-robot relationships and compliance with its advice and mentoring.

Last, designers of social robots should also **consider contextual factors** such as privacy, trust and perceived behavioral control in relation to the data being recorded and stored. Older people using a social robot state that they would have liked it to be able to access the video recordings and have the authorization to delete all or parts of such data.

5.1. Limitations

The main goal of the SERA project was to see how people react to a robot in their home with increasing interaction capabilities. Instead of designing a perfectly usable system, we implemented an incremental research design which included small changes of the robot interface (for example the voice), its behavior (for example the ear positions), and in dialog (for example the recommendations). However, this makes it challenging to separate habituation and long-term acclimatization effects from those effects elicited by the changes in interface and dialog. Additionally, we need to acknowledge the limited capabilities of the robot for social interactions with the participants. Using RFID-tags is not a natural humanlike way of interacting with one another and the interaction dialogs were rather simple, which both influence the results of our preliminary exploratory study. Yet, the older adults did seem to positively evaluate the hedonic social interactions of the robot, and, as stated by Krämer, Eimler, von der Pütten, and Payr (2011), in the end it is the user that defines communication, relationship and roles. Furthermore, because of the exploratory nature of this study, there were only a few participants and they may not be representative for the kind of elderly who might need a domestic robot in the near future. Nonetheless, this small sample size provides us with rich, in-depth, qualitative data inspiring us to future research directions about the long-term use of social robots, whether or not people build relationships with these robots and how this affects the user acceptance of these types of technologies. Although the findings from this study are necessary limited to the studýs participants, initial small and qualitative research is an essential step to providing in-depth insight into how people will use social robots in their domestic environments.

6. Conclusion

This long-term explorative study has uncovered several important findings for the acceptance of social robots in domestic environments by older adults. The results show some practical implication for the acceptance of social robots in people's own homes. Although the acceptance of robots somewhat follows a similar acceptance process as other technologies, full incorporation of the robot in the participants daily lives seem to depend on their perception of the robot. This finding is in line with statements from other researchers (Young et al., 2009). Moreover, we have observed a mere-exposure effect. The participants evaluated the robot more positively over time, which can be explained by the fact that people are willing to ignore the shortcomings of a technology because of factors such as habituation and familiarity (Silverstone & Haddon, 1996). To study continued use after initial adoption, researchers need to go beyond the novelty effect which ends around two months of use (Sung et al., 2009). Currently, we are undertaking this challenge in a follow-up study with the goal to investigate when, how and why changes in evaluation occur.

For the acceptance of domestic robots, hedonic social interactions are to be the most important according to our participants' narrations of their experiences, however, the systems usefulness seems to be a fundamental base for engaging in long-term use. This has also been stressed by Fink et al. (2013), who reported that some people that did not perceive the robot's usefulness stopped using it after some first trials. In addition, for the long-term acceptance of robots to be used in the home, the usage context needs to be taken into account as its influence on continued use increased over time in our study. Especially the negative evaluation of privacy, trust and perceived behavior control resulted in discontinuance of the robot.

Finally, our results also indicate that older people are willing to bond with robotic devices. Those participants who anthropomorphized the robot more and perceived the robot as more social were more likely to perceive the robot as a companion. This might be a promising direction for future research, but researcher exploring this topic should be aware of people's reticence when talking about their relationship with a robotic device. This reticence of freely talking about human-robot relationships has been observed before (Kidd, 2008; Turkle, 2011).

Conducting a long-term field study reveals that the permanent presence of a social robot in users' own homes raises challenges to research studies that are unlikely to be revealed in one-day laboratory human-robot interaction studies or even in multiple observations of short interactions between humans and robots. Long-term research studies in natural settings, for example in people's own homes, are essential to determine the vital challenges social robots encounter in order to be successfully accepted by their users. These vital acceptance challenges are unlikely to be revealed in one-day laboratory human-robot interaction studies or even in multiple observations of short interactions between humans and robots. People have been shown to be willing to engage in social hedonic interactions with robots. Even when the perceptive and expressive capabilities of social robots are limited, people seem ready to 'play along' (Turkle, 2011). This study shows that long-term explorative studies can contribute to a more complete and in-depth understanding of the factors playing a role in the acceptance and continued use of social robots and the establishment of effective and meaningful relationships between people and social robots.

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