Long-Term Acceptance of Social Robots in Domestic Environments: Insights from a User's Perspective

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Abstract

The increasing mere presence of robots in everyday life does not automatically result in gradual acceptance of these systems by human users. Over the past years, we have conducted several studies with the goal to provide insight into the long-term process of social robots in domestic environments. This paper presents our overall conclusions from the combined findings of our multiple studies on social robot acceptance. We will provide insights from a user's perspective of what makes robots social, describe a phased framework of the long-term process of robot acceptance, present some key factors for social robot acceptance, offer guidelines to build better sociable robots, and provide some recommendations for conducting research in domestic environments. With sharing our experiences with conducting (long-term) user studies in domestic environments, we aim to serve to push this sub-field of HRI in real-world contexts forward and thereby the community at large.

Introduction

Over the most recent decades, the field of social robotics has advanced rapidly. There is a growing number of different types of robots, and their roles within society are expanding. Yet, research in robotics suggests that the mere presence of robots in everyday life does not automatically increase the acceptance of these robots and the willingness to interact with them (Bartneck et al., 2005). A challenge for the success of social robots is their acceptance by future users. Furthermore, the inclusion of future users at the early stages of design is important for developing socially robust, rather than merely acceptable, robotic technologies (Sabanovic, 2010).

Evaluating peoples' perceptions and behaviors in the process of the long-term user acceptance of social robots in real-world contexts is necessary for assessing and intertwining the various social, scientific and technological concerns that are relevant for designing acceptable social robots for domestic purposes. The ultimate test of robots consists of showing their capacities in an open social environment in which robots must work constantly and autonomously. Through understanding how people perceive and accept social robots in their own private social and physical environments, it will be possible to design socially inter-active robots (Fong, Nourbakhsh, & Dautenhahn, 2003) for which social interaction plays a key role in peer-to-peer human-robot interaction. Evaluations of people's perceptions and acceptance of social robots can be utilized to create new theoretical and practical models of relevant social robot behavior and design.

Over the past years, we have conducted several studies with the goal to provide insight into which factors most influence the user acceptance of social robots in domestic environments and to investigate how people's user experiences with a social robot develop over time. This paper presents our overall conclusions from the combined findings of our multiple studies on social robot acceptance. Offering insights from a user's perspective, our research may help researchers and practitioners to further develop an integrated model of social robot acceptance and may help developers of social robots to create systems that fit the special needs and demands of future users.

Defining Social Robots

Examining the different definitions provided in the literature, there seems to be consensus that social robots are those robots capable of socially communicating in a humanlike manner (e.g., Breazeal, 2005; Dautenhahn, 2002; Duffy, 2003; Kirby, Forlizzi, & Simmons, 2010; Leite, Martinho, & Paiva, 2013; Looije, Neerinckx, & de Lange, 2008). However, a description of what communicating in a 'humanlike manner' means often remains unspecified. Bartneck and Forlizzi (2004) have given a more encompassing definition and specify that social robots interact socially by following the rules of behaviors expected by those people with whom the robot is designed to interact with. However, social robots existing today are still far away from being capable to incorporate human social behavior. We believe that it actually are the human users who interpret the behavior of robots in social terms rather than the other way around. This notion is also acknowledged by others (Lee, Park, & Song, 2005), who state in their definition that social robots are designed to 'evoke' meaningful social interaction. Therefore, we define social robots as robots that elicit social responses from their human users because they follow the rules of behavior expected by their human users. However, given that the technology will inevitably change in the future, the definition of social robots may similarly change. Yet, the core of all the definitions in the literature share the characterizing aspect of interacting socially in a human-like way, which will most likely remain.

Multiple Studies for the Evaluation of Social Robot Acceptance

Over the past years, we have conducted several studies with the goal to evaluate social robot acceptance in domestic environments. Here, we will briefly introduce the methodology of each of the studies.

The SERA Project

The EU-funded Social Engagement with Robots and Agents (SERA) project was carried out between 2009 and 2011. Its aim was to advance science in the field of the social acceptability of verbally interactive robots and agents, with a view to their applications, especially in assistive technologies, such as robot companions and virtual assistants. To achieve this goal, the project undertook a field study with three ten-day iterations to collect data on real-life interactions with robotic devices within people's own homes. The three iterations tested the different conditions (functionalities) of the equipment, which consisted of a computer, sensors and a simple robotic device (the Nabaztag) as the front-end for conversational interaction. The participants were told that the goal of the study was to improve their health. At the beginning of each interaction the social robot asked participants to agree upon being videotaped letting them press a button. The participants (n= 6) were recruited via the Sheffield 50+ targeted mailing list and interviewed after each iteration about their use experiences with the robot. See (de Graaf, Ben Allouch, & Klamer, 2015) for more details on this study. In this paper, we will refer to this study as the SERA project.

The Karotz Home Study

To further build upon the results of the SERA project, we conducted the Karotz Home Study to investigate the long-term process of social robot 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. In addressing this goal, we employed Karotz, the successor of the Nabaztag used in the SERA project. The robot was installed with a basic set of applications, such as daily news broadcasts, daily local weather reports, favorite radio stations, personalized reminders, and randomly spoken phrases to make the robot being perceived as more autonomous and animate. Our goal was to explore people's ordinary routines of technology use and natural acceptance processes. Therefore, we allowed the participants to stop using the robot at any time during the study. The Karotz Home Study ran from October 2012 to May 2013 and consisted of six moments of both quantitative (i.e., questionnaires) and qualitative data (i.e., interviews) data collection. In total, we collected questionnaires from 102 participants, and 21 participants started the study who consented on being part of the interview sessions. For more details on the methodology of this study, see (de Graaf, Ben Allouch, & van Dijk, 2014; de Graaf, Ben Allouch, & van Dijk, in preparation A). In this paper, we will refer to this study as the Karotz Home Study.

The Online Acceptance Survey

The goal of the Online Acceptance Survey was to present a conceptual model of social robot acceptance using structural equation modeling. This conceptual model both expands and deepens the theory of planned behavior by providing a comprehensive overview of predictors for technology acceptance and behavioral intention from psychology, information systems, communication science, human-computer interaction and human-robot interaction which have been shown to play a role in the acceptance and use of technology in general and robots or virtual agents specifically. In December 2013, a demographically representative sample of the Dutch population (n= 1162, response rate= 26,3%), obtained from a Dutch panel sample administered by a profit research and consultancy company, completed the questionnaire. For more details on the methodology of this study, see (de Graaf, Ben Allouch, & van Dijk, in preparation B). In this paper, we will refer to this study as the Online Acceptance Survey.

What Makes a Robot Social?

According to Breazeal (2005), an ideal social robot is capable of communicating and interacting in a sociable way so that its users can understand the robot in the same social terms, to be able to relate to it and to empathize with it. To behave socially, robots must possess a set of essential social behaviors. Interestingly, based on the interviews held in the Karotz Home Study, we conclude that users remark similar essential social characteristics for future robots that social roboticists already pursue in their creations (Fong et al., 2003; Mutlu, 2011). The two most important social abilities indicated by our participants were two-way interaction and possessing thoughts, feelings and emotions. These social abilities are related to the social characteristics of dialog, learning and developing social competences, exhibiting a distinctive personality, and social learning that were presented by Fong et al. (2003) and Mutlu (2011). Dialog entails that robots should be capable of verbally communicating with us. Learning and developing social competences entail that robots should possess a considerable amount of social skills for interacting with their human counterparts. Exhibiting a distinctive personality entails that robots should have a compelling personality (Breazeal, 2005) that can be expressed through emotions, embodiment, motion, manner of communication, and the tasks that they perform (Fong et al., 2003; Severson-Eklund, Green, & Hüttenrauch, 2003; Yoon et al., 2000). Social learning and imitation partly entail the robot's ability to understand human mental models (Multu, 2011). However, roboticists need to acknowledge that social robots themselves are essentially not social. Social robots are machines programmed in such a way that their behavior is perceived by humans as social, which, in turn, evokes social responses from human users. In other words, the robot's sociability is shaped in the mind of the human user.

The Process of Long-Term Acceptance

The temporal dimension of acceptance is under-studied in human-robot interaction research. To date, only a few studies have investigated the long-term use of a robot in home environments (e.g., de Graaf & Ben Allouch, 2014; Ferneaus et al., 2010; Fink et al., 2013; Sung et al., 2009; Sung et al., 2010). However, when studying social robot acceptance, it is important to make a clear distinction be-tween the concepts of technology adoption and technology acceptance. We regard technology adoption as the initial decision to buy and start using a technology. By contrast, technology acceptance is a process that starts with an individual becoming aware of a technology and, ideally, ends with that individual incorporating the use of that technology in his or her everyday life to the extent that it exceeds its functional purpose and becomes a personal object as the individual becomes attached to it.

Based on theory –i.e., domestication theory (Silverstone & Haddon, 1996) and diffusion of innovations (Rogers, 2003)–, existing long-term home studies involving the use of technology (Demiris et al., 2008; Ferneaus et al., 2010; Karapanos et al., 2009; Sung et al., 2010) and findings from the Karotz Home Study, we have provided a frame-work for the process of technology acceptance that de-fines six acceptance phases. The transition from each phase to a next one exists of a decision made by the user to either continue or discontinue the use of the technology.

The Acceptance Phases

Technology acceptance starts with the expectation phase, which is all about the anticipation and preparation of obtaining a technology. People seek information because they want to know more about the technology. Based on this knowledge, they will form an attitude and expectations about that technology. Second is the confrontation phase, which contains the first time people are confronted with the technology. Some people will endeavor to use the technology themselves, whereas others will just observe other using the technology. Third comes the adoption phase, which begins when people actually start using the technology in their own private environment. This is where people gain their first use experiences along with some frustrations from learnability flaws. Fourth, the adaptation phase, which starts approximately four weeks after adoption. In this phase people obtain a broad idea of what the technology is about. People will experience some novelty effects and are trying to familiarize themselves with the technology. Fifth is the integration phase, which starts approximately two months after adoption. This phase is all about the incorporation of the technology in the user's daily life. This is where people have fully familiarized themselves with the technology, experience functional dependency and have established use routine. Sixth and final is the identification phase, which start around six months after adoption. In this phase people seek supportive information that approves their initial adoption decision. This is where the technology will exceed its functional purpose and becomes a personal object. People may use the technology to express a certain lifestyle or become emotionally attached to the technology. We have tested this theoretical phased framework for social robot acceptance in the Karotz Home Study. Based on the inter-views conducted in that study, we have provided in-depth descriptions of the users' experiences associated with each phase (de Graaf, Ben Allouch, & van Dijk, in preparation A).

Applying the Phased Framework of Acceptance

Examining the results from the Karotz Home Study, we have observed that the occurrences of most acceptance experiences, which were theoretically related to a certain acceptance phase, corresponded to the theorized timeline as suggested in several long-term studies on domestic technologies (Fink et al., 2013; Silverstone & Haddon, 1996; Sung et al., 2010). However, in general, it seems that the participants in the Karotz Home Study did not fully reach the identification phase. One very reasonable explanation for this finding is that only three of the remaining seven participants in the last round of interviews were still using the robot at that moment and intended to continue to use the robot after the study. However, some researchers argue that it is difficult for technology to penetrate people's traditional ways of living, especially with respect to everyday routines and chores in and around the house (Leppänen & Jokinen, 2003). People have a fixed lifestyle, and the arrival of a new technology cannot easily persuade them to change their everyday routines. Additionally, the participants indicated that the robot we employed in the Karotz Home Study did not offer many new features that were not already represented by the other technologies that they were already using, such as their smart phones. Thus the utilitarian shortcomings of the robot employed in the Karotz Home Study may provide another reason why not all participants fully accepted the robot and only a few reached the identification phase. Further research is necessary to confirm what types of user experiences are associated with the defined acceptance phases of our phased framework and how these acceptance phases can be linked to timelines. In addition, future research may investigate the user experiences of different technologies in a long-term home study and compare the timelines that the users needed to evolve from phase to phase.

Key Factors for Social Robot Acceptance

The findings of our research indicates that usefulness is a requisite for social robot acceptance and that certain additional important factors may further explain why people start or continue to use a social robot in their own homes. In the Online Acceptance Survey, we investigated people's anticipated acceptance of domestic social robots using structural equation modeling (de Graaf, Ben Allouch, & van Dijk, 2014; de Graaf, Ben Allouch, & van Dijk, under review). The results show that the evaluation of a social robot's usefulness is intertwined with the cognitive decision to accept that robot. Additional factors show that the acceptance of a social robot for domestic use increases when future users believe that they possess the necessary skills to use a social robot, when they perceive that having such a robot enhances their status, and when they expect that such a robot provides more enjoyable interactions, behaves less sociably, and causes fewer privacy concerns. However, when examining the data from the SERA project and the Karotz Home Study, it appears that the importance of the factors explaining social robot acceptance changes over time. The initial adoption of social robots are mostly influenced by factors such as self-efficacy and prior expectations, whereas continued use is mostly influenced by attitudinal beliefs about the robot such as enjoyment, perceived sociability and companionship. It is believed that the importance of the acceptance factors depends on the development stage in which the technology is located (Ben Allouch, 2008; Peters, 2011). When people gain experiences with a technology, other factors explain people's intention to continued use compared to the factors that explained their initial adoption decision.

In addition to a change of focus, we also observed in both the SERA project and the Karotz Home Study that the evaluation of the robot on most acceptance factors increased over time when the participants gained experience with the robot and became familiar with it. This is called a mere-exposure effect, which is the tendency for novel stimuli to be liked more or rated more positively after someone has been repeatedly exposed to them. The effect has been reported in other human-robot interaction studies as well (Fink et al., 2013; Kim et al., 2013). This result can be explained by a novelty effect in the beginning that fades away after some time. The emergence of novel-ty as well as mere-exposure effects emphasize the relevance of long-term studies because the evaluations of technologies evolve over time (Peters & Ben Allouch, 2005). Therefore, researchers should understand that collecting technology evaluation data at one time point consists of a snapshot of the measures incorporated in their study.

How To Develop Acceptable Social Robots

Based on the combined findings of our research, some practical implications can be drawn to guide the future development of social robots and to increase their acceptance within society.

Create a Clear Purpose of the Robot

A first recommendation for developers is to make sure that the purpose of their robot is clear for potential users. Concluded from different studies, one of the most important factors for social robot acceptance is most likely its utility, its usefulness (Davis, 1989) or its relative advantage (Rogers, 2003). The purpose of the robot must be clear for a successful acceptance that leads to the initial adoption of the robot. The importance of usefulness has also been stressed in an earlier long-term study with the Roomba vacuum cleaner robot (Fink et al., 2013), with the majority of the households in their study failing to perceive the robot as useful. Similarly, those participants in the Karotz Home Study who discontinued using the robot indicated that they had replaced (the functionalities of) the robot with another device. These other technological devices not only fulfilled similar goals, but also did so in a more satisfying way. Together, these results indicate that developers of social robots should aim for clear utility of their robots.

Increase the Robot's Sociability

A second recommendation is that developers should focus on increasing the sociability of the robot. Given that the results of the Online Acceptance Survey indicate that a more sociable robot increases the user's perception of the adaptability of that robot, social robots need to further develop their sociable behavior. Furthermore, findings from the SERA project and the Karotz Home Study show that some users would like to experience more sociable behaviors from social robots. Additionally, the perceived sociability of the robot was one of the most important factors explaining why the participants continued to use the robot in the long run. To increase the sociability of robots, developers should incorporate knowledge from the discipline of interpersonal communication into their designs. People interact with robots following the same rules as in human-human interactions (e.g., Banks, Willoughby, & Banks, 2008; Bickmore & Pickard, 2005; Kerepesi et al., 2006). Other researchers argue that it seems unnecessary to depart from these rules when evaluating human-robot interactions (Krämer, von der Pütten, & Eimler, 2012). Therefore, developers should investigate theories of human-human interpersonal communication to create more sociable robots.

Consider the Process of Long-Term Acceptance

As a third recommendation, developers should consider the process of long-term acceptance. Acceptance is a long-term decision-making process, and each phase has its own focus on certain acceptance factors that influence social robot acceptance. From the Online Survey we conclude that, for the anticipated acceptance of social robots, people seem to focus on factors such as previous experiences with similar technologies, self-efficacy, status and privacy concerns. Subsequently, based on the results from the SE-RA project and the Karotz Home Study, the focus of the decision to continue the use of social robots shifts to the evaluation of the attitudinal beliefs associated with the use of the robot after the initial adoption. The most important attitudinal beliefs were the robot's usefulness, the enjoyable interactions it has to offer, and the social presence experienced by the users were important factors during initial acceptance. However, the main reasons for continued use by the users was their perceived sociability of the robot. Thus, for the successful diffusion and acceptance of social robots within society, developers should provide potential users with the necessary information that would make them feel more familiar with robot technologies and enhance their self-assessment of their abilities to use social robots. After people have bought the robot, developers of social robots should ensure that the users perceive the robots as useful, enjoyable and sociable interactive technologies.

Consider the Use Context

A fourth recommendation for developers is to consider the use context. In addition to the factors related to the robot, our research has collectively found that the use context influences the long-term acceptance of social robots. Examples of use contexts include the user's living situation, the time of day, and the location where the robot is used. The participants in both the SERA project and the Karotz Home Study mostly indicated that the context of the interaction had an impact on their experiences with the robot. For example, periods around major events, such as vacation holidays, but also the room in which the robots was used, had an influence on their use experiences of the interacting with the robot. Developers of social robots should realize that the aspects of the use context are linked to the use experiences and thus the user evaluations of their robotic system.

Account for the Mere-Exposure Effect

A fifth and final recommendation for designers is to account for the mere-exposure effect. The diffusion of social robots within society will increase familiarization with these technologies. However, the end of the novelty effect, when people are familiar with robots or when robots have become ubiquitous in society, does not necessarily mean that people will embrace social robots. Actual user experiences with robots serve as inputs that reshape people's attitudes towards robots and may or may not have a positive effect. Thus, developers of social robots should recognize the value of both the positive and negative effects associated with the diffusion of social robots within society.

The Challenges of Research in Home Environment

Besides these guidelines for developing social robots, our experiences with long-term user studies indicates that invading the user's private space involves additional challenges above and beyond those associated with lab studies. Here we will address these challenges along with some recommendations for researchers interested in conducting long-term studies in domestic environments.

Investigating Traditions and Routines

Conducting a long-term home study reveals that the permanent presence of a robot in the user's own home raises challenges for research that are unlikely to be revealed in one-day laboratory human-robot interaction studies or even in multiple observations of short-term interactions between humans and robots. Researchers need to be aware of these challenges before and while they conduct their studies. When researchers conduct research within people's own homes, they need to comprehend the meaning of the home for the human users. Given that the home is a human constitution, a social arena for human action, the home evokes feelings (Leppänen and Jokinen, 2003). Households contain specific social norms and traditions that frame people's actions and their everyday lives. People are somewhat traditional in their lifestyle, at least in regard to everyday routines and household chores, which are not necessarily easily penetrated by technology (Leppänen and Jokinen, 2003). To obtain an in-depth understanding of the users, researchers need appropriate methods (O'Brien et al., 1999) and must explore new ideas with the users (Bernhaupt et al., 2008) and investigate the appropriation and incorporation of technologies in real-world contexts (Silverstone & Haddon, 1996).

Sampling for Long-Term User Studies

A second challenge in long-term home studies is the selection of participants. Given that the samples in long-term studies are typically small, researchers should think very carefully about the selection of their samples. The participants in the SERA project were recruited via a specific target group list, and the participants in the Karotz Home Study were recruited by various methods, such as word of mouth, advertising in public locations (e.g., libraries, leisure centers and supermarkets), and snowball sampling by asking assigned participants for referrals to other people who might participate. During recruitment, we attempted to balance the households' demographic profiles to seek diversity and to equalize participants from each household type. Tightly specifying the participant group provides more reliability given the small group size. We compensated our participants involved in both the questionnaires and the interviews by allowing them to keep their robots after completion of the study. Furthermore, to increase both homogeneity and convenience, most participants lived within 10 square kilometers of our university, the University of Twente in The Netherlands.

Although the participants in our long-term studies consisted of a well-selected group, some remarks about this group of participants and its relationship to the reported findings must be made. First, all participants voluntarily joined the study and were able to use the robot for free. Therefore, the motivations of the users in our long-term study could be somewhat different from the motivations of 'real' future users who will buy and employ social robots. Although our research was able to reveal the underlying factors that explain social robot acceptance, the strength of the effects may be different for 'real' users of social robots. Therefore, further research is necessary to investigate the interrelationships among the acceptance factors when the technology of social robotics matures and the diffusion of social robots within society increases.

Planning and Coordinating a Long-Term Study

A third challenge in long-term home studies entails the fact that the planning and coordination of all the different steps in the research process turned out to be somewhat time- and resource-consuming. Scheduling all the home visits at several times during the project caused certain problems. Participants were busy, cancelled at the last minute or were not home at the scheduled time. These in-stances resulted in delays in the project, and researchers should anticipate these issues when planning their research projects. Additionally, unexpected technological complications, device errors and other influencing external factors were additional barriers that we encountered when con-ducting research in a real-world context.

Robustness and Reliability of the Robotic System

A fourth challenge in long-term home studies in robotics can be found in the employment of the robot itself. In addition to incorporating a well-designed method for the study, investigating social robot acceptance in real home settings requires having a reliable robotic system. Human-robot interaction researchers must confirm that the robot is prepared to engage in the interaction (Kidd & Breazeal, 2005), especially because long-term use in real homes does not allow for Wizard-of-Oz scenarios. Given that robotics technology has only recently become adequately robust to allow for the executing of long-term evaluations in home settings (Ferneaus et al., 2010; Nguyen et al., 2013), this is one of the reasons why research in domestic environments as a context of use remains in its infancy. Nevertheless, with the arrival of commercial robotic products, such as robotic vacuum cleaners and robotic toys, the domestic use of robots is currently a reality.

Penetrating the User's Private Space

A fifth challenge in long-term home studies concerns the penetration of the private environment of the participants. When researchers conduct research within people's own homes, they need to comprehend the meaning of the home for the human users. Given that the home is a human constitution, a social arena for human action, the home evokes feelings (Leppänen and Jokinen, 2003). Households contain specific social norms and traditions that frame people's actions and their everyday lives. People are somewhat traditional in their lifestyle, at least in regard to everyday routines and household chores, which are not necessarily easily penetrated by technology (Leppänen and Jokinen, 2003). Researchers thus must be aware of these challenges when conducting research in people's private spaces.

People's Reticence towards Social Responses to Robots

A sixth and final challenge in long-term home studies is that people seem not to easily talk about their social responses towards robots. Therefore, we recommend re-searchers investigating the socially evoked responses by robots and human-robot relationships need to adequately introduce this topic in their data-collection methods. It seems that people need to discard any reticence that they may have with respect to interacting with these robots be-fore they can allow themselves to build a relationship with them. In both the SERA project and the Karotz Home Study, some participants expressed their concern that others would find them crazy for thinking of the robot as a person or companion. Similar findings were reported by Turkle (2011). It seems that participants need to trust the researcher and trust that he or she will understand their 'relationship' with the robot before openly discussing this relationship during interviews. Once we had asked questions about giving the robot a name and about the possibility of having a relationship with the social robot, the older adults seemed to refer to the robot as 'him' or 'her' more frequently and talked more freely about their relationships with it than before these types of questions were asked. Kidd (2008) reported having the same experience, that is, that he needed to earn the trust of his participants in order for them to talk about their relationship with the social robot employed in his research.

These findings stress the need for a well conceptualized research design that takes participants' reservations into account before being able to draw conclusions about human-robot relationships. Researchers exploring the relationships that people build with social robots need to be aware of people's reticence when talking about their relationships with an artificial companion. Otherwise, re-searchers will not be able to uncover all the details concerning what is transpiring between the users and their social robots, leading them to false and premature conclusions. Thus, researchers should not underestimate the necessity of good social skills (Ogonowski, Ley, & Stevens, 2013). Entering a person's personal space for research re-quires scientists to take a sensitive and empathic approach in order for the participants to open up.

Conclusion

Robotic systems should eventually be tested in ecologically valid settings to determine whether and how it actually meets real-world needs. Only recently, robotic systems have become reliable and robust enough to be deployed in real-world settings (Ferneaus et al., 2013), such as homes, schools, care facilities, museums and alike. And long-term acceptance research of social robots in such real-world setting is about to become sub-field in evaluating the inter-actions between robots and their human users. This stresses the need for more ecologically valid research and the inclusion of the actual potential end-users required to be able to gain insight into how people perceive, accept and interact with robots in real-world contexts as well as to test their feasibility and/or usability in such contexts. The aim of ecologically valid research is to use methods, materials and settings that approximate the real-world as much as possible. Studying HRIs in real-world contexts reveals more natural interactions and human reactions. Moreover, the robotic system can be tested within its intended use context which is unpredictable, dynamic and unstructured, something that is difficult if not impossible to simulate in the lab. Therefore, HRI research in real-world contexts offers a unique insight into the interactions between robots and their human users.

This paper presents our overall conclusions from the combined findings of our multiple studies on social robot acceptance in domestic environments during the last five years. Consecutively, we have provided insights from a user's perspective of what makes robots social, described a phased framework of the long-term process of technology acceptance, presented some key factors for social robot acceptance, offered guidelines to build better sociable robots, and shared some recommendations for conducting research in domestic environments. With sharing our experiences conducting long-term user studies in domestic environments, we aim to serve to push the sub-field of HRI in real-world contexts forward and thereby the community at large.

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