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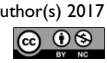

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A phased framework for long-term user acceptance of interactive technology in domestic environments

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Abstract
The temporal dimension of acceptance is under-researched in technology acceptance research. Yet, people's perceptions on technology use may change over time when gaining user experiences. Our 6-month home study deploying an interactive robot provides insight into the long-term use of use interactive technology in a domestic environment. We present a phased framework for the acceptance of interactive technology in domestic environments. Based on 97 interviews obtained from 21 participants living in different household types, the results provide an initial validation of our phased framework for long-term acceptance showing that acceptance phases are linked to certain user experiences which evolve over time when people gain experience with the technology. Involving end users in the early stages of development helps researchers understand the cultural and social contexts of acceptance and enables developers to apply this gained knowledge into their future designs.

Keywords
Domestication, interactive technology, long-term use, robots, technology acceptance

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Introduction

Today, only a few studies have investigated the long-term use of technological systems in home environments; thus, the traditional technology acceptance literature lacks a profound body of long-term research, even despite its extensive history in information systems research (Taylor and Todd, 1995). However, the development of user experiences with a technology or gaining user skills might change the user's attitudes toward (Hiltz and Johnson, 1989; Venkatesh and Davis, 2000), uses of (Majchrzak et al., 2000; Rice and Rogers, 1980) or even the user's conceptualizations (Rice and Contractor, 1990) of that technology. While earlier technology acceptance research has mainly focused on explaining why people initially adopt technologies, only a minority of these studies have paid attention to what happens in the post-adoption stage. This is where people decide between continuing and discontinuing the use of the technology. The consideration of different antecedents for pre-adoption and post-adoption beliefs has been argued for by earlier researchers (Davis et al., 1992; Rogers, 2003; Thompson et al., 1991). Attitudinal beliefs are formed based on three types of information: past behavior, affective information, and cognitive information (Zanna and Rempel, 1988). A reasonable assumption is that pre-adoption beliefs are mainly shaped by affect or cognition through indirect experiences with a technology (i.e. by watching others using the technology or via media), while post-adoption beliefs are mainly created based on past experience (Karahanna et al., 1999) as well as one's social network (Rice and Ayden, 1991; Rice et al., 1990). Consequently, beliefs after using a technology may differ from the beliefs that have led to the initial adoption of that technology. Only when people are willing to continue to use a technology after initial adoption, one could assume that the acceptance of that technology is a success. But even then, one should expect the possibility of discontinuance, replacement, or unintended negative consequences.

Studying long-term use within people's natural environments, such as domestic environments, can provide practical insights into the continuous use of and user experiences with these systems because these environments are stable and controllable for users. It is extremely fertile to explore changes in use behavior and user experience over time in these relatively stable and controllable environments. This article aims to provide insight into the long-term acceptance process by presenting a phased framework for long-term acceptance, validate this framework, and to see whether and how a longer, uninterrupted period of use of interactive technology in a domestic environment affects changes in long-term use itself, as well as the user's attitudes and behaviors associated with the long-term use of interactive technologies. Interactive technology refers to products and services on digital computer-based systems which respond to the user's actions through a multimodal interface, such as computers, smartphones, video games, and socially interactive robots.

A phased framework of long-term acceptance

An alternative approach to the commonly used adoption models (e.g. Davis, 1989; Venkatesh et al., 2003) in technology acceptance literature is offered by the domestication theory (Silverstone and Haddon, 1996) and the diffusion of innovations theory (Rogers,

2003). These theories incorporate a sociological perspective and take on a more ecological view on acceptance rather than focusing on the individual-level causal relationships between factors explaining technology acceptance. While the diffusion of innovations theory is useful as it explains how technologies are adopted through the concept of reinvention (i.e. how they are altered by the user along the way) and the organizational processes of structuring (i.e. how the technology and the social structures of the environment mutually change over time), the domestication theory is more valuable in the ways it provides insights into the intricate processes whereby the user assigns meaning and significance to the artifact, and how this is experienced by domestic users during the acquisition and consumption of the technology. However, these theories and other existing phasing of technology acceptance focus on either pre-adoption or post-adoption. Currently, no theory exists that offers an extensive phasing of the full acceptance process from anticipating the use of a technology and that goes beyond patterns of sustained used. Therefore, we will combine existing theories on phases of technology acceptance, together with findings from earlier long-term studies on technology use in the home (e.g. Demiris et al., 2008; Karapanos et al., 2009; Sung et al., 2009, 2010), to present a full process of six acceptance phases for interactive technologies: expectation, confrontation, adoption, adaptation, integration, and identification. Although some of these user experience terms or acceptance phases have been discussed in the literature, this is a first attempt to generate a sequence of phases that represent the full acceptance process. The described acceptance phases in our framework are linked to the user experiences and are not linked to the phases of technology diffusion as is the case in, for example, Roger's (2003) diffusion of innovations theory. In the following, we will describe our phased framework of long-term acceptance and enrich these descriptions with findings from earlier long-term technology acceptance research. These six phases are analytic concepts, not temporal distinctions with fixed steps in a particular order. Sometimes the proposed sequence holds, but in other occasions, the phases occur simultaneously or are reiterated in a feedback. It might even be that people dropout the sequence all together when they decide to reject the technology or discontinue its use (De Graaf et al., 2017). The six phases are user experiences regularly observed in the acceptance process of technology. The goal is to understand this process investigating people's user experiences when anticipating, adopting, and appropriating an interactive technology in their own homes.

Expectation phase

In the expectation phase, people learn about the technology, determine its value, and form expectations and attitudes toward it before they invite the technology into their homes (Sung et al., 2009, 2010). People seek information about the technology to reduce uncertainty, which is the most crucial aspect in attitudes and decisions toward adopting a technology (Rogers, 2003). They want to learn about the purpose of the technology, then try to understand the functionality of the technology, and finally pursue to provide explanations for its internal processes. After rationalization comes, affection and people will form their interpersonal attitude toward the technology (Rogers, 2003). This is where people become emotionally involved with the technology and actively try to gain knowledge about the technology and judges this knowledge. However, people who are

typically unsure are more likely to seek reinforcement in the opinions of others (Rogers, 2003). This may indicate that people who are hesitant to use an interactive technology are more susceptible to social influence. Another study exploring user experiences with mobile phones describes an expectation phase, although the researchers call it pre-adoption, in which people anticipate future experiences by establishing expectations (Karapanos et al., 2009). The expectation phase is all about the anticipation and preparation of obtaining a technology.

Encounter phase

In the encounter phase, people are encountering the technology in real life for the first time. This can be in a store, but also when one observes other people who are using the technology. It is possible that people have their first trials of using the technology. Most people prefer having some first trials before starting their actual use of a technology (Rogers, 2003), that is, adopting it. Moreover, this is also the first opportunity for people to reevaluate their prior expectations of the technology and the benefits or user experiences it has to offer (Hiltz and Johnson, 1989; Venkatesh and Davis, 2000). It might be that the formed prior expectations do not match with what the technology actually seems to be about. This is where an expectation gap might occur (Lohse, 2011), and where some people start showing the first signs of not entering the next acceptance phases. All things considered, the encounter phase is all about the initial first-hand user experiences with the technology.

Adoption phase

The adoption phase contains the decision that leads to the adoption (or rejection) of a technology. We emphasize the necessity to make a distinction between the concepts of technology adoption and technology acceptance. Here, technology adoption is regarded as the initial decision to buy and start using a technology. In contrast, technology acceptance is a process that starts with an individual becoming aware of a technology and, ideally, ends with that individual embracing the technology and incorporating its use in his or her everyday life. In the adoption phase, people have their first use trials with the technology in their private environments (Sung et al., 2009, 2010). However, uncertainty still exists about the expected consequences of the use of the technology. Therefore, people want to learn more about the technology and are trying to familiarize themselves with it (Karapanos et al., 2009), if they are still positive about the potential outcomes of technology use. For disruptive technologies, which demand a notable change of behavior by the user, this understanding of the technology also represents a distinction between innovators and the early majority adopters since both groups of users have very different expectations about innovative technologies (Moore, 1999; Rogers, 2003). In sum, the adoption phase is all about the first exploration of the newly obtained technology and the decision to initially adopt the technology.

Adaptation phase

The adaptation phase begins directly after the initial adoption, so people are still obtaining their initial user experiences but have a broad idea of what the technology is all

about. People are still pervaded by feelings of excitement as well as frustration as they experience novel features and encounter learnability flaws (Karapanos et al., 2009). People familiarize themselves with the technology, identify any issues or concerns, and show the technology to others (Demiris et al., 2008; Hiltz and Johnson, 1989). People will experiment with the technology's complexities and compatibilities in their personal spaces and make necessary changes to adapt the technology to their personal needs (Rogers, 2003; Sung et al., 2009, 2010). As people keep being curious about and aware of the presence of the technology (Demiris et al., 2008) and trying to appropriate the technology (Majchrzak et al., 2000; Rice and Rogers, 1980; Silverstone and Haddon, 1996), they will finally come to determine reaffirmation of their initial adoption or rejection of further use (Silverstone and Haddon, 1996; Sung et al., 2009, 2010). All in all, the adaptation phase is all about exploring the purpose of the technology in their natural environment and trying to adapt its use to personal (use) preferences.

Integration phase

In the integration phase, people are feeling a functional dependency on the technology (Karapanos et al., 2009), have created routines of use (Silverstone and Haddon, 1996; Sung et al., 2009, 2010), and have fully integrated the technology in their everyday lives (Demiris et al., 2008). During the integration phase, the technology has been changed or modified by the user (Rice and Contractor, 1990; Rogers, 2003), and the technology has become meaningful in people's everyday lives (Karapanos et al., 2009). They no longer notice the presence of the technology in their homes as long as it does not have their primary attention (Demiris et al., 2008). When the technology allows its users to personalize this shaping, the probability of long-term acceptance increases (Backer, 2000). However, it could be that the technology in this phase is used differently from the way it was intended by designers (Rice and Contractor, 1990; Silverstone and Haddon, 1996). Briefly, the integration phase is all about incorporating the technology in daily use routines.

Identification phase

In the identification phase, the technology exceeds its functional purpose and becomes a personal object as people get emotionally attached to it. Users accept the technology in our everyday lives, it participates in their social interaction, communicates parts of our self-identity that serve to either differentiate us from others or connect us to others by creating a sense of community (Karapanos et al., 2009). In this phase, the domestic environment reconnects with the public values (Silverstone and Haddon, 1996). This means that the technology can become a tool for making status claims or for expressing a specific lifestyle to one's social network. Although these factors can also influence initial adoption, in this phase, the characteristics of these factors are put into practice by the user through personal and social identification. The personal side of identification, for example, personalizing it and creating daily routines of use, increases over time. The social side of identification, for example, enabling self-expression and creating a sense of community, initially not only decreases but also shows a gradual and sustained

increase (Karapanos et al., 2009). People, again, seek reinforcement for the initial adoption and may even reverse this decision if exposed to conflicting messages about the technology (Rogers, 2003). However, as people try to avoid or at least reduce a stage of dissonance. Dissonance is the uncomfortable feeling a person experiences when incongruence occurs between attitude and behavior (Festinger, 1957). This uncomfortable feeling can be resolved by either altering personal beliefs (e.g. attitude toward the technology) or performed behavior (e.g. use of the technology). This means that when users obtain information that argues not to adopt an interactive technology, they will either advocate reasons why they would continue to use that technology or they will stop using that technology. Moreover, when people become familiar with a technology, they become more willing to ignore the shortcomings of that technology (Peters and Ben Allouch, 2005; Silverstone and Haddon, 1996). During the conformation stage, users want supportive information that prevents the occurrence of dissonance, and users are now willing to influence others about this innovation. In short, the identification phase is all about finding supportive information that approves continuance of use and the possibility for identify representations.

Design of the long-term home study

The aim of our study was to validate the proposed phased framework for long-term technology acceptance as described in section "A phased framework of long-term acceptance" and to see whether and how a longer, uninterrupted period of use of an interactive technology in a domestic environment affects changes in long-term use itself, as well as the user's attitudes and behaviors associated with the long-term use of interactive technologies. Our goal was to explore people's ordinary routines of technology use and natural acceptance processes. In addressing this goal, we employed a commercially available interactive robot. Studying long-term acceptance of an interactive technology with an existing commercially available domestic robot has both advantages and disadvantages, which we will address as a limitation in the discussion of our results. However, we preferred this type of interactive technology over others because we wanted to capture people's initial, unprejudiced reactions and experiences without prevalent societal norms regarding its use. The following sections will provide the details of the method used in this study.

The interactive robot

The robot used in this study is Karotz (see Figure 1), which is a 30-cm high Internet-enabled activated smart rabbit-shaped ambient electronic device. Communication occurs via verbal communication (voice commands), the light-emitting diode (LED) light in its belly, the moveable ears, and by detecting the presence of other objects nearby. As the Karotz is permanently connected to the Internet, it is able to react to, transmit, and broadcast all types of content available on his network.

Each 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 more likely to be perceived as more autonomous and

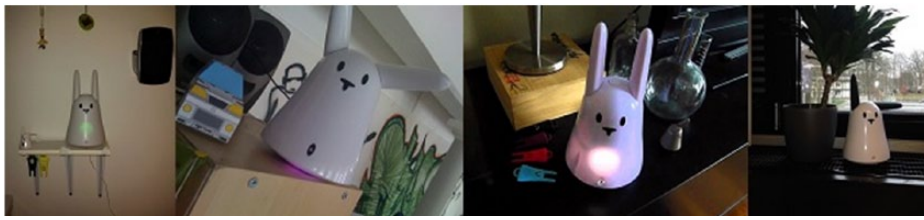

Figure 1. The Karotz robot deployed in the participants' homes.

animate. This basic set of applications ensured us that the user experience was somewhat similar among the participants or at least initially as some participants chose to adjust these applications to their own needs. Besides these basic applications, participants were free to install additional applications as they thought would be useful or fun for their households. This process of appropriation is one of the topics of this study and will be discussed. Except for one, all participants positioned the robot somewhere in their living room.

Data collection and procedure

The study ran from October 2012 to May 2013 and consisted of six moments of data collection at the theorized beginning of each of the six acceptance phases as described in section "A phased framework of long-term acceptance." The timing of the moments for data collection was adopted from earlier research studying the user acceptance of a robot in domestic environments (Fernaeus et al., 2010; Fink et al., 2013; Sung et al., 2010). In total, 21 participants started the study who consented to be part of the interview sessions. Our research was guided by people's natural interactions with the robot guided by voluntary use, and some of the participants stopped using the robot before the end of the project. These results on non-use from our long-term study, including reasons for not moving into the next acceptance phases, are published in a separate paper (de Graaf et al., 2017). Table 1 shows the distribution of the sample sizes among the acceptance phases.

For the interviews, a representative of the household reported on their own individual user experiences with some additional questions about the opinion of other household members. Semi-structured interviews, conducted at the participants' own homes, were used to obtain detailed user experiences with the robot. Questions were asked about the following topics: evaluation of the robot (e.g. Can you describe some advantages/disadvantages of the robot?), evaluation of the use behavior and acceptance (e.g. How often have you used the robot in the last period? Do you consider continuing the use of the robot, why/why not?), user experiences related to and depending on the current acceptance phase (e.g. What does a regular day of using the robot look like? Are you still excited about the robot/Have you become familiar with all aspects of the robot? How would you compare the robot with other devices in your home? Have you adjusted the robot to your personal preferences? Do you usually use the robot on similar moments?), and the sociability and relationship development with the robot (e.g. Can you describe how you perceive the robot? How are the interactions with the robot similar to/different

Table 1. Distribution of sample sizes among the acceptance phases.

Acceptance phase	Time points[a]	Interviews
Expectation	2 weeks before	21
Encounter	Day of the introduction	21
Adoption	2 weeks after	18
Adaptation	1 month after	17
Integration	2 months after	13
Identification	6 months after	7

[a]Time points with regard to introduction of the robot.

from interactions with other persons? Does the robot seem to have its own will/personality? Does the robot offer some kind of companionship?).

Data analysis

A total of 97 interviews with the 21 participants were conducted, recorded, and transcribed verbatim with the participants' approval. Each interview was divided into several sections containing parts of the participants' answers related to one topic. Based on the detailed descriptions of the acceptance phases presented in section "A phased framework of long-term acceptance" together with the transcriptions of the interviews, key concepts regarding user experiences were identified and translated into a coding scheme by the primary coder. The final coding scheme is presented in an appendix. Next, for each interview section, at least one code from the coding scheme was assigned to each interview section by the primary coder. Of the 97 interviews, 32 were randomly selected and the same procedure of applying codes was performed by a second coder. Intercoder reliability was substantial with a Cohen's kappa of .73 (Landis and Koch, 1977). In the results, from every interview transcript, "striking" or "typical" quotes (Hansen et al., 1998) were selected which illustrated, confirmed, or enhanced our understanding of the acceptance phases as explained through the emerged user experiences from the coding scheme.

Participants

Participants were recruited with various methods, such as word of mouth, advertising in public locations, and snowball sampling by asking assigned participants for referrals to other people who might participate. During recruitment, we tried to balance out the households' demographic profiles to seek diversity. Therefore, the participants were divided into four distinct types of homes (see Table 2): younger singles, older singles, younger couples, older couples, young families (children younger than 12 years old), mature families (children older than 12 years old), and student dorms. Furthermore, to facilitate the interactions with the robot, participants were required to have at least a limited working proficiency in either English or German because the Karotz robot did not provide interactions in Dutch. We compensated our participants who participated with both the questionnaires and the interviews by allowing them to keep their robot after study completion.

Table 2. Distribution of household types within the sample.

Household	*N*
Younger single	5
Older single	3
Younger couple	3
Older couple	2
Young family	3
Mature family	2
Student dorm	3
Total	21

Results

This section presents the main occurring user experiences in each acceptance phase that emerged from the interview data. Table 3 presents these user experiences from phase to phase. The upcoming sections will describe the user experiences for each acceptance phase in more detail ordered by the frequency in which participants discussed these user experiences.

Expectation phase

In the expectation phase, people want to know more about the technology and its purposes and therefore seek information about the technology. The participants talked most about their expectations about using the robot (e.g. *anticipation*). The participants, not knowing all the details of the robot yet, tried to image what it would be like to have the robot in their homes and whether things would change. "It depends on what [the robot] can do, … but I don't think it would make any difference [when the robot comes]"—female, 22, living in student dorm.

Moreover, the participants were preparing for the arrival of the robot (e.g. *preparation*). Although this also comes down to thinking about what it would be like to have the robot, preparation contains more details about specific use scenarios. The participants tried to prepare themselves for the kind of functionalities the robot had to offer and which effects that could have on their attitudes toward the robot or their technology use behavior in general. "If [the robot] can provide me with information that I normally look up on my computer or tablet, then I can keep sitting down. … I am all about the practical and convenience"—male, 31, living alone.

Additionally, the participants discussed looking up information about the robot and its usages (e.g. *information seeking*). Before the interviews, most participants explained that they already tried to find information online or that they would prefer more information about the robot:

> I had seen the [recruitment] leaflet in the supermarket. Later I went back to take it with me, because I wanted to read it all over. But it was gone thus I tried to Google it, but most of what I found was in English and I did not feel like reading all that. (Female, 57, living alone)

Table 3. Percentage of acceptance experiences ($n = 1663$) as coded in the interviews for each acceptance phase.

% of all reported experiences User experience	T1 ($n = 104$)	T2 ($n = 262$)	T3 ($n = 374$)	T4 ($n = 399$)	T5 ($n = 330$)	T6 ($n = 194$)	All ($n = 1663$)
Expectation experiences							
Anticipation	36	15	0	0	0	0	5
Association	12	11	8	9	7	7	9
Attitude formation	3	6	1	1	0	1	2
Discuss with others	1	2	13	9	6	10	8
Information seeking	13	8	10	2	1	0	5
Preparation	14	1	0	0	0	0	1
Adoption experiences							
Adjustment	0	1	8	3	1	0	3
Curiosity	9	5	4	3	0	1	3
Excitement	3	1	2	1	0	0	1
Adoption/adaptation experiences							
Exploration	0	13	21	15	7	1	12
Novelty	3	4	4	1	0	0	2
Trial and error	0	9	9	3	3	0	5
Adaptation experiences							
Personalization	0	1	3	11	11	8	7
Adaptation/integration experiences							
Familiarization	0	1	2	13	21	22	10
Integration experiences							
Incorporation	0	0	0	9	13	10	6
Reinvention	0	1	4	2	7	6	4
Use routines	0	0	0	2	10	9	4
Identification experiences							
Promotion to others	0	1	0	0	1	1	0
Confirmation	0	0	0	0	0	0	0
Emotional attachment	0	0	1	2	2	8	0
Identification	0	0	0	1	1	3	1
Maintenance	0	0	0	1	0	0	0
Personality attribution	0	1	1	3	1	3	2
Recognize benefits	6	19	9	8	8	11	10
Total	100	100	100	100	100	100	100

T1 = expectation phase; T2 = encounter phase; T3 = adoption phase; T4 = adaptation phase; T5 = integration phase; T6 = identification phase.

And, finally, the participants were associating the robot's purposes with other technologies (e.g. *association*). Because the participants had never used robot technologies before, they tried to make sense of it by comparing it to other objects they are familiar with such as personal computers and smartphones. "I think of it as some type of tool, media-player like, something from which you can obtain the news or that it could serve as an alarm clock"—female, 27, living with spouse.

Encounter phase

In the encounter phase, people encounter the technology for the first time. The participants talked most about the possible benefits of the robot (e.g. *recognize benefits*). Most participants perceived the applications of the robot as beneficial, such as the reminders or the weather forecast. Other participants looked at the bigger picture and explicitly said that the robot could save them time or that they would not use their computer anymore. "You don't have to turn on the computer anymore. Because you can push the button and ask for example for the weather forecast or the news"—male, 24, living alone. A few participants explained that they perceived some interaction modes as beneficial and appreciated the lifelike features of the robot.

Moreover, the participants were still anticipating their possible uses of the robot (e.g. *anticipation*). They were trying to picture how living with the robot would look like and explained that only time could tell how it all would work out in the upcoming weeks. Some participants expected that the robot could become an important part of their lives. Others discussed how the robot could be of use for their household. "To see what fits me and how I can incorporate a learning moment together with the children. That kind of things. It is just a totally different pastime. Just something extra"—female, 32, living with young family.

Additionally, the participants started to discover how to use the robot (e.g. *exploration*). Most participants said that, in the upcoming weeks, they would explore the different purposes of the robot and would discover how it all works. The participants explained that they just had to try some features and experience it themselves. Some participants expected that this would be fun and that the robot could surprise them with what it can do. "That we discover new stuff over and over again … and that I am surprised by what [the robots] is going to do"—female, 38, living with mature family.

While exploring what the robot has to offer, the participants explained that this goes along with a lot of trying to see what works for them (e.g. *trial and error*). They were testing the different available applications, uninstalling those that did not fit, and explained that some of the applications did not seem to work at all. For some participants, trying different applications was discussed among family members before going forward with it. "I still find it a bit difficult how you can install new apps in a proper manner. For example, I haven't managed to actually hear the weather forecast yet"—female, 55, living with spouse.

Also, the participants were still associating the robot with other technologies (e.g. *association*). Most participants saw the similarities between the applications of the robot and those of a smartphone or tablet. Other participants took the animated appearance of the robot into account by comparing the robot with a rabbit or just by acknowledging it social abilities. "In principle, it is somewhat the same as an iPad or iPhone, but more humanlike and a little less like an appliance"—female, 27, living with spouse.

Additionally, the participants discussed looking up additional information about the robot (e.g. *information seeking*). Most participants tried to Google information about the robot. Some other participants watched movies on YouTube or talked with others about the robot to learn what they could do with the robot. Even during the interview, the participants were asking me questions about how to use the robot and what kind of things they could or could not do with it:

> I have discussed [the robot] with some colleagues of mine who also have this robot. That was before I had installed it. And I asked them what I could do with it, what kind of object is it. And gathered some information from that. (Male, 38, living with young family)

Adoption phase

The adoption phase is where people actually start using the technology in their personal environment and gain their first serious user experiences with the technology. The participants mostly discussed discovering the purposes of the robot and how it works (e.g. *exploration*). Where exploration in the encounter phase dealt with intentions to explore the functionalities of the robot, this time, the participants had some stories about their first discoveries of the robot. "The next day [after the installation] we have sat down on the couch with the iPad and looked up what kind of apps there are. Tried it out a bit"—female, 27, living with spouse.

Moreover, the participants said that they had discussed having the robot with friends and co-workers (e.g. *discuss with others*). Especially when visitors came to their house, the participants liked to show the robot to them and to talk about it. Other participants also discussed the robot when meeting people outside their homes or some even shared pictures of the robot on social media. "I have talked a lot about [the robot]. A friend of mine has a similar robot. It is a nice conversation topic at parties … Other people are curious about it, they like it"—male, 32, living alone.

The participants still felt a need to seek more information about (using) the robot (e.g. *information seeking*). The information seeking behavior was quite similar to that in the previous period with the participants rereading the manual or searching the Internet for ideas of useful applications of the robot. A few participants even asked the researcher for more information. "I don't think I have seen it all. I think I will look on the internet. I have seen some homepages from which you could download some apps. I think I will snoop around to fulfill my needs"—female, 19, living in student dorm.

Additionally, the participants explained that they were trying out several tasks with the robot and sometimes failed at it (e.g. *trial and error*). This differed from the trial and error experiences in the encounter phase as this time the errors were not because of a lack of user experience but mostly because the robot did not work that well. "That wouldn't work in the beginning. I was like, haven't I done that right? Then I tried it in the same menu as the garbage reminder and it worked"—female, 24, living with mature family.

Nonetheless, the participants still acknowledged possible benefits of having the robot (e.g. *recognize benefits*). This time, the participants particularly welcomed the information provided by the robot and the remembrance function. Using the robot seemed to save time for some participants, while others appreciated the robot's reminding them to take out the trash or catch the bus on time. "It is just easier to use [the robot] as an alarm clock and for listening to music … And asking for today's weather forecast to the robot. I used to do that on my mobile phone, but that takes longer"—female, 22, living in student dorm.

Finally, the participants were trying to adjust how the robot should be handled with success (e.g. *adjustment*). The participants experimented with some personal settings on the robot and tried to adjust their behavior to better interact with the robot. Some participants

said they were learning to better understand what the robot says. Other participants felt they must adjust, make everything work better such as moving the robot to a different spot, switching it off when leaving the house, or silence it when it is time for bed. "[The robot] was annoying at night, because it made noise. But I have learned that I can make him be quiet"—male, 31, living alone.

Adaptation phase

In the adaptation phase, users have a broad idea of what the technology is all about. Yet, the participants were still mainly exploring how to use the robot (e.g. *exploration*). This time, for the participants, exploration is more in terms of being sure that they have discovered all the possibilities the robot offers. "I still have the feeling that I haven't, that I can install more functions on [the robot]. I haven't tried it all yet"—female, 57, living alone.

Additionally, most participants explained that the novelty effect had begun to fade away (e.g. *familiarization*). The participants were becoming familiar with what the robot does. They learned how to set the robot and the robot had no more surprises for them. "A little bit of astonishment … when it first arrived here … But that is getting used to, that is just a habituation process"—female, 57, living alone.

Also, the participants have appropriated the robot to fit their needs (e.g. *personalization*). They have adjusted the setting according to their needs. Some participants installed some additional spoken words into the robot, for example, to make it greet them at certain times. Other participants reduced the social features of the robot to a minimum. A few participants programmed the robot in such a way that it would turn on the radio, the news, or the weather forecast at set times. "I have programmed [the robot] to automatically provide the weather forecast in the morning and evening"—male, 32, living alone.

Yet, the participants were still associating the purposes of the robot with those of other technologies they use (e.g. *association*). However, this time, they focus more on the differences between the robot and other technologies instead on the similarities, which was more the case during the adoption phase. "The robot is a bit like a connection … more interactive than a radio or smartphone"—female, 22, living in student dorm.

Moreover, some participants were adapting the robot to make it part of their everyday lives (e.g. *incorporation*). They used the robot for purposes for which they used other technologies before, such as listening to music on the robot instead of on the radio. Other participants integrated the (uses of) the robot into daily routines, such as listening to weather forecast every morning or making the use of robot part of their daily activities. "I used to turn on the juke box or the radio on my laptop or on the television, but I use the robot for that now"—male, 24, living alone.

Furthermore, the participants were still taking to others about the robot and its purposes (e.g. *discuss with others*). The robot still causes some family discussions or when visitors come to the house and want to know more about the robot after they noticed it. And a few participants want to share their experiences on social media. Finally, the participants still realized that the robot has potentials (e.g. *recognize benefits*). Especially the diversity of use, the reminders and the social aspects were evaluated as a benefit. However, some participants indicate that the true benefits of the robot will only become

visible after further improvement or they point to other types of use for which the robot could be beneficial. “I think [the robot] is a supplement to our household… I like it that he reminds us of things … And that he says funny things”—female, 24, living with mature family.

Integration phase

In the integration phase, a used technology has become meaningful in a person’s life. The robot had no more surprises (e.g. *familiarization*) for the participants in the integration phase. The participants explained that they have explored all the options of the robot and picked their favorites. Also, the participants were no longer continuously aware of the fact that the robot was there and the novelty was completely gone by now. “In the beginning [the robot] attracts a lot of attention and that is lovely too. And now … you are not fully conscious of him anymore. It becomes normal”—female, 32, living with young family.

Moreover, the robot had become part of the participants’ everyday lives (e.g. *incorporation*). The usage of the robot has become a fixed set of activities. The participants were using the same applications on a regular basis or replaced other home technologies with one of the robot’s functionalities:

> For the radio, I already had [the robot] switched on. And that hasn’t changed. And I use the alarm clock once and a while when I must get out of bed. I actually use it for the same things again and again. (Male, 24, living alone)

Yet, the participants were still adapting the robot to their personal preferences (e.g. *personalization*). The participants explained that they kept changing the settings for some of the applications or installed additional applications to make better use of the robot. It was really about selecting the right set of applications that best suit their needs. “I have programmed [the robot] to automatically provide the weather forecast in the morning and evening”—male, 32, living alone. But, adapting the robot also entails changing its appearance with the supplementary set of ears or the stickers the participants received at times of the installation. “I have used those [the extra set of ears]. Because I liked the black ones more than the white ones”—female, 19, living in student dorm.

Nevertheless, the participants were already creating their daily use routines with the robot (e.g. *use routine*), despite the ongoing alteration of the settings. For some participants, the robot has become a part of their morning rituals or the use of the robot has become a special moment during the day. “There is a pattern in it. It might be that the exact time differs, but that won’t be much. I basically do the same things at a certain time”—male, 55, living alone.

Moreover, the participants still discussed the possible benefits of the robot (e.g. *recognize benefits*). This time, with the rejecters of the robot having left the study, the remaining participants were more positive about the benefits of the robot. They appreciated several functionalities of the robot, such as the radio and the reminders, which had made changes in the everyday lives of the participants. “Listening to the radio, installing some stuff to be a reminder that he says out loud. It is a very useful object once and a while”—female, 32, living with young family.

And the participants had begun to think about possible new applications of the robots (e.g. reinvention). The participants seem to agree that especially the reminder function if the robot is most beneficial. And some participants put the effort into thinking about or even making some first attempts in creating new applications for the robot. "I have downloaded the software [to create new apps]. I want to try to create a third group for the audio … for people who has difficulties to read. Audiobooks, that could be useful"—male, 55, living alone.

Identification phase

In the identification phase, a technology exceeds its functional purpose and becomes a personal object. The participants were fully accustomed to the robot (e.g. *familiarization*). They knew what the robot had to offer and how they could make use of that. However, familiarization was not always something positive at this point. For some participants, it resulted in boredom and they expected that the robot would offer some new applications. "I have seen and used most programs already … For me it is more like a toy and at a certain point it becomes boring"—female, 22, living in student dorm.

Moreover, some of the participants continued to talk about the possible benefits the robot provides them (e.g. *recognize benefits*). These participants who discussed the potentials of the robot were positive about the advantages the robot had offered. Surprisingly, most participants explained that it was not the robot's utility that they indicated as most beneficial, but it was the robot's sociability that they appreciated the most. "I would regret it if I did not have him anymore. So, in that sense it has a benefit in some way"—female, 27, living with spouse.

Although sharing experiences of the robot with other people (e.g. *discuss with others*) was still a topic of interest during the interviews, the participants explained that they had talked less about the robot. Being familiarized with the robot resulted in less triggers from the participants to share their experiences with others. A few participants explained to me that they would like to have an online community with other Karotz users to share their experiences with. "I used to do that in the beginning [showing the robot to visitors]. But at a certain time, everyone knew the robot already. So, I stopped doing that"—female, 22, living in student dorm.

The remaining participants integrated the use of the robot into their everyday lives (e.g. *incorporation*). They felt that the robot just belonged in their home as if it would be incomplete without the robot standing in its place doing what it does. "[The robot] belongs with us now"—female, 24, living with mature family.

Daily routines of using the robot (e.g. *use routine*) were created by the remaining participants. There were standard times at which the participants used the robot, and most of the time they used the robot for the same purposes. "I used the camera when I am at work, to look if everything was going okay back home. And the dairy function on Sunday evening. That were all things on the same moment"—male, 31, living alone.

The participants had the robot fully adapted to their personal needs (e.g. *personalization*). They were done exploring the programs and settings and they had spent quite some time doing that before they were completely satisfied with how the robot works best for

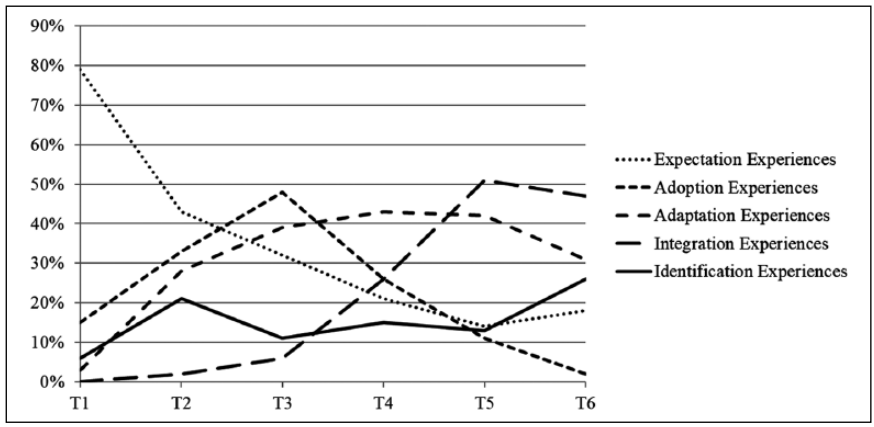

Figure 2. Visualization of the user experiences ($n = 1663$) as coded in the interviews. T1 = expectation phase, T2 = encounter phase, T3 = adoption phase, T4 = adaptation phase, T5 = integration phase, T6 = identification phase.

them. "I constantly searched for better programs … He is completely adjusted to me. That is useful"—female, 22, living in student dorm.

For most of the remaining participants, the robot has become something special that is just there. Most participants even expressed that they still liked to keep the robot and that they would miss the robot if someone had to take it away from them (e.g. *emotional attachment*). Most participants expected that they would miss the robot if I had to take it away. Some participants compared the robot with having pets. Other participants just felt that they owned the robot now that is has been in their homes for so long. "You get used to having it … It is just like having a pet, when you talk about it like that … He has become a part of our family … I still like him. I would not want to miss him"—female, 24, living with mature family.

Finally, most of the remaining participants came up with ideas to further develop the usability of the robot (e.g. *reinvention*). Some participants tried to program their own application or led others them with that. Other participants just shared their ideas for further development of the robot with me during the interviews. "I have tried to look up how you could make an English-speaking robot say stuff in Dutch. I Googled that, but that is quite difficult to do"—male, 32, living alone.

General discussion

This study provides insights into the long-term acceptance process by presenting a phased framework for long-term acceptance, validate this framework, and to see whether and how a longer, uninterrupted period of use of interactive technology in a domestic environment affects changes in long-term use itself, as well as the user's attitudes and behaviors associated with the long-term use of interactive technologies. We proposed six acceptance phases: expectation, encounter, adoption, adaptation, integration, and identification. Our results demonstrate that most user experiences, which were theoretically

linked to a certain acceptance phase, correspond to a substantial extent to the theorized timeline determined for the interviews. Figure 2 shows that user experiences linked to each acceptance phase was indeed discussed most by the participants in the interviews scheduled for that particular phase. Therefore, we conclude that our phased framework for long-term acceptance of interactive technologies holds when applied to people's experiences anticipating and appropriating the use of an interactive technology in their own homes.

One deviation from the adopted timeline for our phased framework is observed for the identification phase. After 6 months of the introduction of the robot, the participants still talked mostly about adapting the robot to their personal needs and trying to incorporate the use of the robot into their everyday lives. This suggests that the participants had not yet fully reached the identification phase at that point. Although the user experiences within the acceptance phases are believed to be fundamental and generalizable to other interactive technologies for domestic use, this result confirms that the timeline of the acceptance process might be different for each technology. For example, another study focusing on user experiences with a smartphone (Karapanos et al., 2009) has partially described similar user experiences and acceptance phases, but their participants already reached the end of the novelty effect and sustained use after 4 weeks of use. Even though the novelty effect ended after approximately 2 months in our long-term home study, the establishment of sustained use did not occur at that time for most of the participants. Thus, the end of the novelty effect and the establishment of habits seem to be two separate processes and should be regarded as such. Ronis et al. (1989) have argued that habitual behavior has been established once it has been performed frequently (i.e. at least twice a month) and extensively (i.e. at least 10 times). However, research on the establishment of new behaviors (Lally et al., 2009) indicates that it takes much longer for a repeated behavior to reach its maximum level of habituation. In their study, which investigated a wide range of behaviors, people needed approximately 2 months (i.e. 66 days on average) to establish a new behavior. However, given that the researchers examined a wide range of behaviors, there was a marked variation ranging from 18 (drinking a daily glass of water) to 254 (doing 50 pushups after morning coffee) days before behaviors had become habits. Because the satisfactory repetition of behavior in the past may result in habit formation (Ajzen, 2002; Ronis et al., 1989; Triandis, 1979; Verplanken et al., 1997), the duration of each acceptance phase may depend on the type of technology and is most likely related to the frequency and intensity of technology use. Therefore, caution is necessary when linking the acceptance phases to fixed time frames.

Some additional remarks on a few user experiences that deviated from the theorized timeline are necessary. First, instead of mainly discussing the robot with others in the expectation phase, the participants mostly discussed the robot with others around 2 weeks after the introduction, which we theoretically framed as part of the adoption phase. Indeed, innovative technologies are seldom solely adopted for their practical functions (Rogers, 2003). We observed in the expectation phase that participants were forming attitudes about the compatibility and relative advantage of the robot in terms of their own way or patterns of living. When people adopt technologies mainly because of the perceived social awards, lifestyle becomes a key factor of adoption (Li, 2015). It may thus be that, around the adoption decision, the participants had an increased motivation to talk

about the robot with other people, which has—in addition to its practical functions—also an interactive component.

Second, the participants continued to seek information about the robot until 2 weeks after the introduction, which suggests that people seek information beyond the expectation phase. Although the exact decision moment of whether one decides to use a technology or not is often referred to as adoption, the decision itself is a process as well. Once, and in many ways not possible until, a person has adopted a technology, often people do (and must) seek more information. Thus, adoption doesn't mean complete saturation of knowledge and use of the technology. Together, the user experiences of "discuss with others" and "information seeking" could be regarded as instruments to make sense of the robot or a way to reduce uncertainty. This not only demonstrates an activity related to Silverstone and Haddon's (1996) conversion, but it also goes beyond it in that it implies a mental construction of the used technology (Ling et al., 1999). The participants reported on their trialability and complexity aspects of the robot in the encounter phase, in that they were experimenting with the robot and sometimes experience its use as difficult. Because the robot was a rather complex piece of technology, the participants may have used the additionally sought information and discussion of their experiences with others as a venue for improving their understanding of the robot.

Third, even after 2 months of use, the participants still talked a lot about appropriating the technology to their own needs, which in our theoretical framework should have been finalized around 2 months of use where the integration phase begins. As stated above, we believe that these "delayed" shifts from one phase to the other could be linked to the specific technology that is under study.

Finally, the user experience of "recognize benefits" was part of all the interviews but was of especial interest to the participants at the day of the introduction to the robot during the encounter phase. Moreover, this topic reoccurred during the interviews after 6 months of use during the identification phase as theorized. The rise of this user experience in both phases is not surprising because these are the moments linked to initial adoption and continued use (Davis et al., 1992; Rogers, 2003). Utility is a prerequisite for adopting an interactive robot at this stage of the diffusion in our society (De Graaf et al., 2016), even though interactive technologies offer sociability purposes in addition to their utilitarian advantages.

These deviations from our adopted timeline associated with the sequence of acceptance phases call for further explorations of long-term use of interactive technologies. To further establish our proposed phased framework of long-term acceptance, future research should investigate user experiences with all kinds of interactive technologies. These studies should further explore whether similar acceptance phases and user experiences are observed including their associated timelines.

Limitations

Although our exploratory study has observed interesting trends for the process of long-term acceptance of interactive technologies in domestic environments, some potential limitations should be addressed. First, the interaction capabilities of the Karotz robot used in our study were somewhat limited. The choice of this robot is a consequence of the goal

of our study to investigate long-term social robot acceptance in multiple households ($n = 70$). We had to depend on commercially available robots because research robots are still not robust enough for extended deployment outside the lab without supervision of an expert. The limited capacities of commercially available robots might cause a gap between initial expectations and actual experiences after initial interactions (Lohse, 2011). The expectation gap encountered by our participants resulted in dropout before the end of the study. Robots could be labeled as a "disruptive technology" since they are more than just updated replacements of existing technologies (Ezer et al., 2009), and people are not easily prompted to embrace disruptive technologies (Dewar and Dutton, 1986; Green et al., 1995). Although robot technology is rapidly enhancing, the added value of most robot systems is still inferior compared to other domestic devices already present in the home. Based on people's motivations to reject or discontinue the use of the robot, De Graaf et al. (2017) conclude that the challenge for robot designers is to create robots that are enjoyable and easy to use or (socially) predictable to capture users in the short term and functionally relevant and possess enhanced social behaviors to keep those users in the longer term. Therefore, replication of our study with other types of interactive technologies and more sophisticated robots is necessary to ascertain whether comparable results occur on the acceptance of these systems. Second, although the participants in our study consisted of a well-selected group, some remarks about this group of participants and its relationship to the reported findings must be made. All participants voluntarily joined the study and could use the robot for free. This means that the risk and cost factors in the acceptance process were much lower for our participants, and therefore, the motivations of the users in our study will be somewhat different from the motivations and user experiences of "real" future users who will buy and employ social robots. Therefore, further research is necessary to investigate these user experiences when the technology of social robotics matures and the diffusion of social robots within society increases.

Conclusion

The research presented in this article has provided an initial validation of our phased framework for long-term acceptance of interactive technologies and show that acceptance phases are linked to certain user experiences which evolve over time when people gain experience with the technology. We have analytically mapped the full process of user acceptance of interactive technology in the home, which includes six phases from anticipating the use to beyond patterns of sustained used. All six acceptance phases are regularly observed when users go through the entire process. However, in other occasions, users may experience overlap between phases or phases are iterated in a feedback. It might even be that people dropout the sequence all together when they decide to reject the technology or discontinue its use (De Graaf et al., 2017). The presented research has made the full acceptance process observable by identifying the user experiences linked to each acceptance phase. Since our phased framework of long-term acceptance is based on two prominent theories in the information systems and technology adoption literature, namely, the domestication theory (Silverstone and Haddon, 1996) and diffusion of innovations theory (Rogers, 2003), complemented by the results of studies involving robots and other types of interactive technologies, we believe that our framework could be applied to a

broad range of interactive technologies. Involving end users in the early stages of development helps researchers understand the cultural and social contexts of acceptance and enables developers to apply this gained knowledge into their designs, a paradigm that has been recognized that users shape technology (Lie and Sørenson, 1996; Silverstone and Hirsch, 1992). Discovering people's perceptions, expectations, and impressions of interactive technologies in their private domestic environments over a longer period is vital for informing the design and acceptance of these technologies. Further research that investigates the long-term acceptance of interactive technology in domestic environments is necessary for a successful diffusion of these types of technology within society.

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Supplementary material

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References

Ajzen I (2002) Residual effects of past on later behavior: Habituation and reasoned action perspectives. *Personality and social psychology review* 6(2): 107–122.

Backer TE (2000) The failure of success: challenges of disseminating effective substance abuse prevention programs. *Journal of Community Psychology* 28(3): 363–373.

Davis FD (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly* 13(3): 319–340.

Davis FD, Bagozzi RP and Warshaw PR (1992) Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology* 22(11): 1111–1132.

De Graaf MMA, Ben Allouch S and van Dijk JAGM (2016) Long-term evaluation of a social robot in real homes. *Interaction Studies* 17(3): 462–491.

De Graaf MMA, Ben Allouch S and van Dijk JAGM (2017) Why do they refuse to use my robot? Reasons for non-use derived from a long-term home study. In: *International conference on human-robot interaction*, Vienna, 6–9 March.

Demiris G, Parker Oliver D, Dickey G, et al. (2008) Findings from a participatory evaluation of a smart home application for older adults. *Technology and Health Care* 16(2): 111–118.

Dewar RD and Dutton JE (1986) The adoption of radical and incremental innovations: an empirical analysis. *Management Science* 32: 1422–1433.

Ezer N, Fisk AD and Rogers WA (2009) Attitudinal and intentional acceptance of domestic robots by younger and older adults. In: *International conference on universal access in human-computer interaction*, San Diego, CA, 19–24 July.

Fernaeus Y, Håkansson M, Jacobsson M, et al. (2010) How do you play with a robotic toy animal? A long-term study of Pleo. In: *International conference on interaction design and children (IDC 2010)*, Barcelona, 9–11 June.

Festinger L (1957) *A Theory of Cognitive Dissonance*. Stanford, CA: Stanford University Press.

Fink J, Bauwens V, Kaplan F, et al. (2013) Living with a vacuum cleaning robot: a 6-month ethnographic study. *International Journal of Social Robotics* 5(3): 389–408.

Green SG, Gavin MB and Aiman-Smith L (1995) Assessing a multidimensional measure of radical technological innovation. *IEEE Transaction on Engineering Management* 42: 203–214.

Hansen A, Cottle S, Negrine R and Newbold C (1998) Media audiences: Focus group interviewing. In: Cottle S, Negrine R, Newbold C and Halloran JD (eds) *Mass Communication Research Methods*. London, UK: Macmillan, pp. 257–287.

Hiltz SR and Johnson K (1989) Measuring acceptance of computer-mediated communication systems. *Journal of the American Society for Information Science* 40(6): 386–397.

Karahanna E, Straub DW and Chervany NL (1999) Information technology adoption across time: a cross-sectional comparison of pre-adoption and post-adoption beliefs. *MIS Quarterly* 23(2): 183–213.

Karapanos E, Zimmermann J, Forlizzi J, et al. (2009) User experience over time: an initial framework. In: *Proceedings of the SIGCHI conference on human factors in computing systems, Boston,* MA, 4–9 April.

Lally P, van Jaarsveld CHM, Potts HWW, et al. (2009) How are habits formed: modelling habit formation in the real world. *European Journal of Social Psychology* 40(6): 998–1009.

Landis JR and Koch GG (1977) The measurement of observer agreement for categorical data. *Biometrics* 33(1): 159–174.

Li SCS (2015) Lifestyle and the adoption of information versus entertainment technologies: an examination on the adoption of six new technologies in Taiwan. *New Media & Society* 17(10): 1696–1714.

Lie M and Sorensen KH (1996) *Making Technologies Our Own: Domesticating Technology into Everyday Life*. Oslo: Scandinavian University Press.

Ling R, Nilsen S and Granhaug S (1999) The domestication of video-on-demand: folk understanding of a new technology. *New Media & Society* 1(1): 83–100.

Lohse M (2011) Bridging the gap between users' expectations and system evaluations. In: *International symposium on robot and human interactive communication (RO-MAN 2011)*, Atlanta, GA, 31 July–3 August.

Majchrzak A, Rice RE, Malhotra A, et al. (2000) Technology adaptation: the case of computer-supported inter-organizational virtual teams. *MIS Quarterly* 24(4): 569–600.

Moore GA (1999) *Crossing the Chasm: Marketing and Selling High Tech Products to Mainstream Customers*. New York: HarperCollins.

Peters O and Ben Allouch S (2005) Always connected: a longitudinal field study of mobile communication. *Telematics and Informatics* 22: 239–256.

Rice RE and Aydin C (1991) Attitudes towards new organizational technology: network proximity as a mechanism for social information processing. *Administrative Science Quarterly* 36: 219–244.

Rice RE and Contractor N (1990) Conceptual effects of office information systems: a methodology and application for the study of alpha, beta, and gamma change. *Decision Sciences* 21(2): 301–317.

Rice RE and Rogers EM (1980) Re-invention in the innovation process. *Knowledge: Creation, Diffusion, Utilization* 1(4): 499–514.

Rice RE, Grant A, Schmitz J, et al. (1990) Individual and network influences on the adoption and perceived outcomes of electronic messaging. *Social Networks* 12(1): 27–55.

Rogers EM (2003) *Diffusion of Innovations*. 5th ed. New York: The Free Press.

Ronis DL, Yates JF and Kirscht JP (1989) Attitudes, decisions, and habits as determinants of repeated behavior. In: Pratkanis AR, Breckler SJ and Greenwald AG (eds) *Attitude, Structure and Function*. Hilldale, NJ: Lawrence Erlbaum Associates, pp. 213–240.

Silverstone R, Hirsch E and Morley D (1992) Information and communication technologies and moral economy of the household. In: Silverstone R and Hirsch E (eds) *Consuming technologies: Media and information is domestic spaces*. London, UK: Routledge and Kegan Paul, pp. 15–31.

Silverstone R and Haddon L (1996) Design and the domestication of ICTs: technical change and everyday life. In: Silverstone R and Mansell R (eds) *Communication by Design: The Politics of Information and Communication Technologies*. Oxford: Oxford University Press, pp. 44–74.

Sung JY, Christensen HI and Grinter RE (2009) Robots in the wild: understanding long-term use. In: *International conference on human robot interaction (HRI)*, La Jolla, CA, 11–13 March.

Sung JY, Grinter RE and Christensen HI (2010) Domestic robot ecology: an initial framework to unpack long-term acceptance of robots at home. *International Journal of Social Robotics* 2(4): 417–429.

Taylor S and Todd PA (1995) Understanding information technology usage: a test of competing models. *Information Systems Research* 6(2): 144–176.

Thompson RL, Higgins CA and Howell JM (1991) Personal computing: toward a conceptual model of utilization. *MIS Quarterly* 15(1): 125–143.

Triandis HC (1979) Values, attitudes, and interpersonal behavior. In: *The Nebraska Symposium on Motivation.* Lincoln, Nebraska: University of Nebraska Press.

Venkatesh V and Davis FD (2000) A theoretical extension of the technology acceptance model: four longitudinal field studies. *Management Science* 46(2): 186–204.

Venkatesh V, Morris MG, Davis GB, et al. (2003) User acceptance of information technology: toward a unified view. *MIS Quarterly* 27(3): 425–478.

Verplanken B, Aarts H and van Knippenberg A (1997) Habit, information acquisition, and the process of making travel mode choices. *European Journal of Social Psychology* 27(5): 539–560.

Zanna MP and Rempel JK (1988) Attitudes: a new look at an old concept. In: Bar-Tal D and Kruglanski AW (eds) *The Social Psychology of Knowledge*. New York: Cambridge University Press, pp. 315–334.

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