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Studying robots outside the lab: HRI as ethnography

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Abstract: As more and more robots enter our social world, there is a strong need for further field studies of human-robot interaction. Based on a two-year ethnographic study of the implementation of a South Korean socially assistive robot in Danish elderly care, this paper argues that empirical and ethnographic studies will enhance the understanding of the adaptation of robots in real-life settings. Furthermore, the paper emphasizes how users and the context of use matters to this adaptation, as it is shown that roboticists are unable to control how their designs are implemented and how the sociality of social robots is inscribed by its users in practice.

This paper can be seen as a contribution to long-term studies of HRI. It presents the challenges of robot adaptation in practice and discusses the limitations of the present conceptual understanding of human-robot relations. The ethnographic data presented herein encourage a move away from static and linear descriptions of the implementation process toward more contextual and relational accounts of HRI.

Keywords: human-robot interaction, social robots, long-term interaction, robots in the wild

1 Introduction

Elderly care is seen as a field of ‘special interest’ [1] within social robotics. As the population ages and a lack of caregivers are expected [2], social robots are increasingly viewed as technological fixes to demographic and age-related challenges, e.g. loneliness and cognitive impairments [3, 4]. Social robots have already entered elderly care facilities in various countries [5–10] and the adoption of various social robots is expected to continue [11, 12]. As these robots emerge in society, it becomes an even more urgent task to relate to effects of robots designed for social interaction, to critically consider citizens’ perception of robotics, and to be able to assess how robots meet the desires and expectations of their users.

Understanding how social robots are adapted into practice in various use contexts will yield crucial insights of robot applicability in general. It will raise important design and policy questions [13] and assist addressing ethical questions to lessen the unforeseen consequences of emerging robots [14]. The author agrees with de Graaf, Ben Allouch, and van Dijk [15] that the scope of investigation has to move outside of the design laboratory and beyond the short-term studies of HRI in order to study effects of the presence of social robots and account for more than novelty and exposure effects. This research agenda calls for long-term studies of HRI and ethnographical encounters with robots in the wild [16].

To contribute to the still scarce [17], yet much requested, long-term studies of HRI [15, 18–24], the author has conducted an ethnographic study of the socially assistive robot Silbot’s transfer from South Korea to Denmark and Finland in 2011 and the following adaptation there. An updated version of Silbot is still used in Danish elderly care, but this paper argues that the robot’s adaptation and usage in practice has only recently been normalized [25] as the robot’s use has become somewhat stabilized. The author considers this paper an occasion to elaborate present theories about human-robotic interactions, the models used to describe adaptation of robots in practice and to assess the value of ethnography to the understanding of HRI.

2 Defining a socially assistive robot

Roboticists Dautenhahn and Billard define a social robot as a robot able to ‘engage in social interactions’ [26]. Humans can interact with these robot as they would with any other ‘socially responsive creatures’ [27]. Such robots are designed ‘to produce effects of sociality and agency’ [28] and function as believable interaction partners [29]. They adhere to rules of expectable social behavior [15, 30], and

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are constructed to operate as humans and in some cases even as human surrogates [31]. Fong *et al.* call robots like these *socially interactive* [20] stressing the social interaction as a primary function, albeit applied to various purposes.

Socially assistive robots can be understood as a subcategory. Their specific function is to help their users [2, 12] through social interaction and they are produced to "create close and effective interaction with a human user for the purpose of giving assistance and achieving measurable progress in convalescence, rehabilitation, learning etc." [32].

2.1 Robots as social agents

To comprehend the sociality of social robots it seems necessary to point out that these technologies are "enveloped by human practices" [33] and the author questions whether these robots can be understood outside of social practices [5]. As Giddens [34], the author considers the "domain of the study of social sciences" to be "social practices ordered across time and space". Like other social scientists, the author regards technologies, such as social robots, as elements in social practices carried out by humans [35, 36]. In other words, social robots are 'nothing' unless integrated into social practices [37] and to have "effects" these machines must be used by humans [36]. As other technologies social robots display nonhuman agency [33], but their actions are only visible to the social scientist or ethnographer, once the robots are allowed to function as material elements in real-life practices.

According to Alač, it makes good sense to study robots ethnographically [28] and as part of social practices [28, 38–40]. Not to establish what a robot is, but to explore "how its status is done in practice." [28]. Alač has studied how human users interact with and make robots "become alive" [38]. She argues that even though a social robot is specifically engineered to generate impressions of life and responsiveness its sociality cannot be understood as an intrinsic value alone. Rather, it is dependent on human interactions in social practices where users "enact the social character of the machine." [39]. In a series of participant observations, Alač and her colleagues have observed how adults and toddlers engage with a social robot in a laboratory setting i.e. how the adults' enactments of the social robot as an intentional being further the toddler's interest in interacting with the robot. When these adults speak to and via the robot they "imbue the technology with its social character." [28]. Alač argues that the social robot needs such "interactional support" or *interactional maintenance* to function as a social agent, without it the toddlers lost their interest in engaging with the robot [40]. It is important to emphasize that Alač's ethnographic studies of HRI were done in more or less controlled laboratory settings. She speculates about what happens when the social robots move out of the laboratory to interact with users distant from their designers [39]. Hopefully, this article can enlighten this speculation and will be considered a contribution to the still few studies of HRI outside the laboratory and in everyday practices [16].

2.2 A robotic brain fitness instructor

The South Korean Robot Silbot, designed by the Korean Institute of Technology (KIST) in 2010, can be characterized as a socially assistive robot [12]. Silbot-2 was shaped like an egg resting on top of three wheels and had the height of a six-year-old child (approximately 41,4 inches). The 66 lb. robot had a friendly looking, cartoon-like robotic face capable of real-time facial expressions. During the interaction the robot would unfold its two arms, and flap its penguin-like flippers, and its voice would sound from the two inbuilt speakers above its waistline. The robot was reprogrammed from a tele-operated English teacher in South Korean elementary schools [7, 41] to a facilitator of cognitive exercises to elderly citizens with the purpose of preventing or halting age-related illnesses such as dementia. The latter use case was presented to Danish and Finnish health care representatives at separate occasions. Silbot was tested in the Finnish capital, Helsinki, and the Danish city of Aarhus between the fall of 2011 and early 2012. Apart from the socially assistive robots Silbot and Mero (a talking head with a moveable neck), the concept of "Brain Fitness with Elder Care Robots" included 16 digital cognitive games e.g. a calculation game, a tile-matching puzzle game, Bingo, a sing-along session, and a game where the participants had to memorize a route taken by Silbot on a checkered floor in order to walk it themselves. In a regular Brain Fitness session the participants would usually play two or three of cognitive games selected by the game instructor beforehand. One session would ordinarily last 90 minutes with a short break after the first 45 minutes.

The elderly citizens played the games and interacted with the robots using Samsung touchscreen tablets, while Silbot functioned as a quiz master, explaining the game rules, cheering up and hurrying the elderly participants. During the game sessions the citizens would be seated behind small tables in a semi-circle or straight line facing Silbot. The robot would move around on a checkered floor in the middle of the room, while Mero would be positioned on a podium behind it. At the far end of the room a flat screen would display either the game instructions or the animated games being played. The robot system operator would be seated behind a PC next to Mero and the flat screen, while the human game instructor (in the Danish case an occupational therapist) would walk around the room to elaborate the game instructions or help the elderly citizens with using their tablets.

The Danish and Finnish Pilot tests were concluded with different results. In Helsinki, the project team considered the robots unnecessary, underdeveloped and *too* expensive and the collaboration with KIST ended after the pilot project was concluded. This paper will not go into further details about the Finnish pilot project, as the author have written about it elsewhere [5, 42]. In Denmark the Municipality of Aarhus bought three exemplars of Silbot (Mero was taken out of operation due to technical problems) and promoted the Brain Fitness classes for elderly citizens. In 2012 Silbot-2 was replaced in Aarhus with a new version constructed as a response to various shortcomings and requirement specifications stated by its Danish operators. This version, Silbot-3, was distinctly different from the first version. With the height of 45,20 inches it was shaped like an hour-glass-like torso mounted on a mobile platform. A small flat screen revealed a pensive, friendly Caucasian female face above the flexible neck. The penguin-like flippers were replaced by two movable arms with flexible joints and its 46 lb. weight gave a slightly slimmer and taller impression as compared to its predecessor. Silbot-3 is still used; as elderly citizens of various ages and with various types of dementia participate Brain Fitness classes in Aarhus on a weekly basis.

3 Methods

I have conducted ethnographic fieldwork in both Denmark and Finland to explore user experiences with adapting Silbot into practice. In Helsinki, I visited the original test bed in late January 2016 and interviewed six relevant stakeholders of the original pilot project. In Aarhus, I have conducted 13 interviews in 2016-2017 with seven stakeholders from the original pilot project 2011-2012 and some of them are still involved in operation of Silbot. I have been a participant observer [43, 44] at various Brain Fitness sessions throughout the years 2015-2016. Besides from this I have collected and analyzed various documents in relation to Brain Fitness. As other authors have argued [43, 44], I find that none of the methods mentioned above can stand alone or make up for an ethnographic approach to e.g. human-robot interaction, as no singular method can "reveal all relevant features of empirical reality", whereas different methods will reveal various aspects of empirical reality [45]. I will describe my methods in the following sections.

3.1 Participant observation

I have observed the training of future game instructors and system operators on three separate occasions. When I entered the field, the game instructors also had to operate the robotic system themselves, besides from taking care of elderly citizens. In the pilot tests in Denmark and Finland 2011-2012 the system was operated by Korean engineers from KIST. The training sessions of future game instructors were organized by the Municipality of Aarhus and introduced the aspiring game instructors to Brain Fitness by allowing them to play the cognitive games and discuss the health benefits, pedagogy and game strategies with the former game instructors, responsible for Brain Fitness from 2011-2015. I followed and observed how these game instructors interacted and worked with Silbot in three regular game sessions, where elderly participants played the cognitive games. On other occasions I observed how Silbot was presented and demonstrated to stakeholders from other departments of the Municipality of Aarhus as well as external interested parties. These demonstration sessions would typically proceed as the regular game sessions with senior citizens, i.e. the interested parties would participate in Brain Fitness by playing two or three of the cognitive games followed by a discussion of the benefits of Brain Fitness with the game instructor.

As a participant observer [43] I was present at the Brain Fitness sessions mentioned above. Usually, I would be seated among the participants behind one of the tables at the far end of the room. From this position I observed the ongoing interaction with the robot, wrote down 'situated vocabularies' [44], took field notes, occasionally drew quick sketches of the robot, took photos, or recorded its movements. On one occasion, in one of the training sessions for future operators, I participated in the Brain Fitness session and played along with these soon-to-be game instructors. I discovered myself having difficulties and being frustrated with remembering the values in a calculation game while being far better at solving a 16-piece puzzle within the pre-set time frame. As Davies [43], I have found participant observations have enabled open discussions with people in the field and helped me identify key informants. They have provided a sound basis for qualitative interviews to follow up on the insights generated from during fieldwork.

3.2 Qualitative interviews

The qualitative interviews in Finland and Denmark were conducted as semi-structured interviews following an interview guide [46] with pre-formulated questions and with the flexibility to generate new questions during the interviews. All interviews were recorded and transcribed – apart from three unstructured interviews in Denmark in the beginning of 2015 with the project managers. These interviews provided background information before the fieldwork was conducted. The interviewees in Finland consisted of the former game instructor, the director of the elderly care center where the pilot test was conducted, the former head of elderly care services in the Municipality of Helsinki, the former project manager, a project team member, and the managing director of the Finnish company responsible for conducting the pilot test. In Denmark I interviewed the first Danish game instructor, three members of the initial project team, the current project leader, an external partner in the original pilot test, and the present Danish game instructor. Some of the Danish interviewees have been interviewed more than once in the study period. These interviews have allowed the interviewees to elaborate upon statements made in various documents and evaluation reports I have obtained as part of my research. The Finnish interviewees discussed whether they considered their pilot test a success or failure and the adaptability of Silbot to a Finnish elderly care context among other topics. The Danish interviewees have responded to various topics, incl. the original setup of the pilot test, the ongoing collaboration with the Korean stakeholders, the various versions of Silbot, and their pedagogical approach to and changes to Brain Fitness, etc. The interviews have allowed the interviewees to clarify what can be read 'between the lines' in evaluation reports and project plans, but also to position themselves in relation to the robot and accentuate their own role and responsibility in relation to Brain Fitness as a practice.

3.3 Document analysis

In addition to qualitative interviews and participant observation, I have read various documents about the pilot projects (including project contracts, evaluation reports, journal entries made by the first Danish game instructor, a requirement specification report and various press releases) many of these documents were formulated in collaboration with KIST. These written materials have provided valuable insights into the negotiations, personnel, and dynamics behind the Brain Fitness setup. I agree with social scientists Atkinson and Coffey that documents should be considered "data in their own right." [47]

3.4 Doing ethnography

According to Bruun, Hanghøj, and Hasse [16] providing "hard-and-fasts descriptions" of ethnographic methodology seems challenging as ethnographic data-gathering methods are flexible and adaptive to the real-life settings they are designed to investigate. The ethnographer knows that real-life settings under study, i.e. the object of ethnography is emergent [48] and that this requires methodological adaptability. At first sight, fieldwork might appear as just being about "chatting with people" and ethnography as something anyone can do without particular expertise [49]. However, doing ethnography requires substantial analytical skills as the ethnographer must be able to "*understand* and *analyze* what people say" [49] and mean [16]. This must be followed up by observations as the ethnographer realizes that in order to know what people do asking them is not enough. What people do in real-life settings might not be consistent with what people say they do [49]. People tend to overlook certain aspects of their real work, e.g. Forsythe [49] found that technical people display a tendency to 'delete' social and communicative work when asked to reflect upon their own work processes. Ethnography, and participant observation in particular, can make these invisible actions of people visible.

Participating in the real-life settings under study can be considered a "distinct (anthropological) avenue towards understanding" [48]. In other words, doing ethnography is about learning and enabling ethnographers to become a co-constructors of their own data [43] through their embodied participation in the empirical field. Ethnographers acknowledge their presence, their situatedness, their perspective, and that the facts they establish depend on their social relations [48]. Yet, with the willingness to learn from their informants they can "identify and problematize things that insiders take for granted" [49] and allow the ethnographer to document the "complex reality of social and material life" [16]. Analyzing what matters to people endows the ethnographer with a pronounced sensitivity towards humans and materiality [50].

4 Findings

When the Korean robots arrived in Aarhus in 2011 they were less developed than the Danish stakeholders expected. Interviews with the first Danish game instructor and other stakeholders in the pilot project give the impression of a fragile robotic system that needed a lot of onsite tuning to perform Brain Fitness. Only 8 of the 16 cognitive games functioned. Still, the games and the robots as presented by the Koreans were plagued by recurrent technical problems. Onsite debugging proved a time-consuming task as the system feedback were deemed insufficient by the Danes, who had to stay in constant contact with the developers in South Korea throughout the test period. The following sections will present some of the insights gained through my ethnographic study and hopefully will give the reader an idea about discoveries made possible by ethnographic data-gathering methods.

4.1 Hardware problems

The built-in sensors in Silbot (as well as the motion sensor used by the system to track player movements) proved highly sensitive to bright and direct sunlight. This caused Silbot to lose its directional input and made the robot drive off its checkered floor, meant to keep it in place, and crash into the nearby wall or furniture more than once. During my fieldwork at the Danish rehabilitation center I experienced Silbot-3 driving off the game floor and crashing into the table in front of me. The game instructor rushed to get hold of the robot to prevent it from crushing me. This happened despite the fact that the present version of Silbot is equipped with several built-in sensors to avoid collisions. During power-up Silbot has to calibrate in order to locate its position on the checkered floor. However, this phase sometimes goes critically wrong and leaves the robot unresponsive and unable to move inside the squares. Once, I had to help the game instructor move the entire checkered floor as she estimated that this would be easier than re-calibrating the robot.

In one of the games where the players can catch animated moneybags displayed on the flat screen, the motion sensor could not detect all of their movements. The game was constructed based on the average height of Korean citizens and Danes are considerably taller. Likewise, I observed how the tablets were prone to run out of battery during the game sessions. They crashed or "froze" and, as a result, the elderly citizens unable to finish the games. In addition to these technical problems, the game instructors have had to restart the games several times during a training session as the players could not interact with the system.

The present game instructor emphasizes that the technical problems occur only once in a while. Furthermore, the project manager underlines how the operational reliability of the robot has been considerably improved after years of testing and modifications. She finds that cognitive games work and considers the robot fully functional and ready for service without need of constant adjustments and extensive maintenance. However, the technical failings discovered during the participant observations show how operational reliability is something that requires continuous attention and maintenance of the robotic system by the Danish stakeholders. The recurrent tuning needed to keep Silbot running is observable and accentuated by participant observations.

4.2 Software problems

Since 2011, the software, i.e. the operating system and the cognitive games, has been adjusted. Upon arrival in Denmark, Silbot's vocabulary was translated into Danish word-for-word to advance the robot's integration into practice. Yet, during the game sessions Silbot turned out quite rude and insensitive to users struggling with solving the games. It used inappropriate language, hurrying and scolding the elderly citizens to make them complete the cognitive games within the pre-set timeframe. Entering a wrong answer would result in preprogrammed loud boos making the players uncomfortable. However, the citizens learned to accept the robot's odd behavior as explained by the first Danish game instructor:

"Initially, they [the elderly citizens] were startled by its use of words, but then they started laughing at it and somehow excused it; as it didn't know better."

In the present version the most critical phrases have been removed and the competitive element of the cognitive games have been de-emphasized. In spite of this reprogramming Silbot continues to use awkward phrases as I have observed:

"Silbot: Buck up! Time is running out."

This instruction made the game instructor excuse the robot and its impatience. She suggested to the players that Silbot might be tired of playing the same games over and over again. New players still find the robot provocative at times, and the present game instructor has explained how she handles such awkward situations with humor to make them more acceptable for the players. This is a good example of how the Danish stakeholders through their talk to and via Silbot imbue the robot with sociality and make it sociably acceptable to the elderly participants of Brain Fitness.

Silbot's synthetic voice has proven problematic in itself, as many of the elderly users experience difficulties making out what the robot says and understanding its game instructions. I have observed several Danish game instructors repeat the robot's statements to make sure that all players had understood the rules. Still, Silbot's pronunciation confuses the players, e.g. when it pronounces "User A" as "Use'er A" or asks if the users are "murdering" ("morder" in Danish) themselves - instead of enjoying ("morer" in Danish) themselves. In one of the games, the players are asked to memorize a story about "Keld den Store" instead of "Karl den Store" (the Danish translation of Charles the Great). Sometimes the users will comment on these mispronunciations but mostly they are focused on solving the games.

4.3 Usability problems

Apart from the hardware and software problems observed by the author and described in depth by the informants, the usability of the robotic system has been a recurrent theme throughout the ethnographic fieldwork. Even small adjustments have proven burdensome, because the Korean developers maintain that they ought to handle all reconfigurations. Everything is hardcoded and the Silbot operating system has no graphical user interface (GUI), which also complicates its control and navigation. In some of the cognitive games the pre-set timeframe remains too short for the players to complete the games, e.g. solving a puzzle with 16 pieces within 10 seconds. In other games it is difficult to end the games after one or two rounds as all three rounds have to be completed. The robot will sometimes continue to tell its story or sing its song even though the game has been shut off. Though having been translated into Danish, the game instructions need to be explained by the game instructors in order to make sense as pointed out by the first Danish game instructor when she introduced Brain Fitness to future game instructors:

"*I will show you how to play the game. If you just had to read the game instructions by yourself, you would run away screaming. They are so miserable, that it is almost impossible to work out how to play the games.*"

I have observed her emphasizing how operators must be able to explain what the games are about and assist the players with understanding them. She stressed to future operators:

"*It [Silbot] is not pedagogical at all. You are the ones who must be pedagogical.*"

She made up for the underdeveloped games by working around the test schedule dictated by the Koreans (i.e. letting the robots do the talking alone) as she estimated that these instructions would be insufficient for the Danish citizens to play the games. By means of a blackboard she explained the rules and benefits of the games thoroughly and made sure that every participant understood the instructions before the game session began. I observed one of the instructors working around the limited timeframe in the games by allowing the players to continue to solve a puzzle after the time had run out. At several instances she repeated Silbot's words making sure everybody understood what the robot said.

The present game instructor describes how she discusses benefits of the games and explains how the players can transfer these game-solving strategies to their everyday lives. She considers the usability problems a recurring challenge that spurs her to act creatively and elaborate her understanding of being an occupational therapist.

Instructions to the games and the usability of the system has been enhanced by the Municipality of Aarhus with their formulation of a comprehensive user manual with detailed descriptions of every game, the cognitive benefits, and the pedagogy to be used by the human instructors. This manual is deemed crucial to the outcome of Brain Fitness by the first game instructor. Without it "Silbot is nothing except for a funny fellow" as she stresses:

"*You will gain nothing from just turning on the robot.*"

The project manager agrees with her and points out that Silbot is not capable of acting on its own:

"*You will always need humans around this system if it has to make sense as well. The system is not capable of delivering the benefits to the world…*"

To the author, it seems clear that the Danish game instructors are engaged in the same type of interactional maintenance that Alač explored in laboratory settings in the US. The qualitative interviews do not reveal exactly how the Danish stakeholders enact the robots, however, observing Silbot in everyday practices and as part of the social practice Brain Fitness renders this enactment visible. Ethnographic fieldwork thus highlights the invisible work that the Danish stakeholders have to do to maintain Brain Fitness as a practice.

4.4 Multiple use cases

Though Silbot has been running day-to-day in elderly care in Aarhus since 2015, and the concept of Brain Fitness has been continually developed and refined since the robot arrived in Denmark in 2011, its function and use are continually evaluated and only somewhat stabilized. The ethnographic observations and interviews reveal that project members keep coming up with new test scenarios and regularly consider new use cases. The robot's effects have been tested on citizens with mental disorders. A new test will study whether the use of Silbot and the participation in Brain Fitness can reduce social isolation among disabled citizens. In the interviews, the stakeholders in Aarhus spoke about their ideas for the future use of Silbot and the need for developing new cognitive games targeting different population groups with various challenges. Ever since the Municipality of Aarhus bought the copyright to the cognitive games and robot a recurrent theme has been the possibility of selling Silbot in Denmark and the rest of Europe. Yet, this scenario has been somewhat obstructed as the municipality cannot lawfully sell any products (except knowledge and know-how). No private company has been willing to sign a seller's contract with the municipality, though several companies have shown interest in the concept of Brain Fitness. The ongoing constructive collaboration with the Korean developers RoboCare and KIST has slowed down since 2016, and the stakeholders in Aarhus do not know whether the Koreans would be willing to provide full technical support for Silbot in the future. In Aarhus, this support is deemed crucial for the continued use of Silbot.

5 Discussion

Aside from furthering in-depth explorations of human-robot interaction and conveying how users anthropomorphize robots in practice, which however, will not be elaborated herein, ethnographic long-term studies of HRI allow for more elaborate understandings of how robots are accepted, adapted, and enacted in practice. It affirms society (or the context of usage) as an active shaper rather than a "passive receptor" of robots [51], reveals users as co-constructors *in situ* [7, 39, 42], and acknowledges robots as agents mediating changes in their natural environments [12, 24]. Such insights can be difficult to derive from controlled environment studies or short-term explorations of human-robotic interaction. I will discuss and clarify how insights from ethnography, such as the ones mentioned above, can benefit future HRI-research.

5.1 Sociality inscribed by users

De Graaf, Ben Allouch, and van Dijk argues that "roboticists need to acknowledge that social robots are essentially not social per se. 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 user." [15]. Other studies likewise stress how the sociality of social robots is constructed in social practices [2, 28, 40, 52]. The ethnographic fieldwork presented in this paper supports these findings. The various observations and interviews reveal the robot's sociality and social acceptability as dependent on the actions of its human operators. They have the ability to explain and excuse the robot's sometimes odd behavior to the users, compensate when the robot seems ill-adjusted in practice, and improvise when the robot does not respond as expected [8]. In the case of Silbot the lack of a clearly defined use case spurred the end-users, i.e. the Municipality of Aarhus, to reconsider the vaguely defined Brain Fitness-concept developed in Korea, further refine it and establish a social practice, where Silbot functions as a material element. In other words, the stakeholders had to make sense of the robot in their everyday practices. Their continuous exploration of possible uses keeps the robot running in Denmark. Based on these observations, I encourage roboticists to explore how the use of their robots remains flexible to interpretation by end-users. By examining contexts of use and by speaking to potential users during the design process and onwards, the robot engineers can improve how their robots are accepted in practice by building robots that supports and eases human work processes already in place. This will allow roboticists to consider how to encourage the users' willingness to interact with and maintain the robots interactionally and thereby keep their robots running.

5.2 Reassessing long-term interaction models

I sympathize with Sung, Grinter, and Christensen's intention that HRI-research must get past novelty effects to understand long-term effects of human-robot interaction, however, I find their stage-model of pre-adoption, adoption, adaptation, and use/retention, called Domestic Robot Ecology (DRE) [53], too limited to account for the ethnographical findings in the case study of Silbot. Though other authors have supported the usability of DRE [19], I do not see any signs of routinization in use after only two to six months, as Sung, Grinter and Christensen do [24]. Their suggestion of a two-month baseline long-term study would not be sufficient to identify the adaptation of Silbot as it took more than five years before any routine usage could be identified, and in the Danish case-study the robot still appears *multistable* in its use [54, 55]. De Graaf, Ben Allouch, and van Dijk [15] present a model of six robot acceptance phases (expectation, encounter, adoption, adaption, integration, and identification). Though similar to the DRE-model it is more elaborate. Yet, both of these models seem too linear to explain the acceptance of Silbot. The reason might be that they are developed from long-term studies of domestic robots (a robot vacuuming cleaner and the Karotz home companion robot), whereas Silbot is a socially assistive robot designed for health- and elderly care services in a public setting where a multitude of users, i.e. health care personnel and elderly citizens are involved in the complex structural setup. Sung, Grinter, and Christensen acknowledge that "different timeframes may be necessary for other robots or routines" [24]. I consider the limitations of the present models used to account for long-term acceptance an obligation for further research of the long-term acceptance of social robots (also robots used outside the home). Such studies, where interviews with users are supplemented with participant observations of everyday usage, would allow for more elaborate understandings of long-term human-robotic interactions and more dynamic and multimodal models of robot implementation than the linear ones in use inspired by Rogers' implementation and diffusion-model [19, 56]. Models that are more "iterative and evolutionary" [57, 58] and capable of accounting for the "change and modification" [59] that is ongoing and apparent in every phase of technology use. Participant observations allow the observer to examine how users actually engage and interact with robots in real-life. Ethnographic studies, as the one presented in this paper, can thus provide the basis for a more "thick" and comprehensive account of long-term HRI. It can equip roboticists with a methodology to explore the sometimes invisible acts that people do, but do not mention when asked, to maintain robots interactionally and to make them social and socially acceptable in real-life situations.

5.3 Design considerations

I agree with de Graaf, Ben Allouch, and van Dijk, that there is a "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" [15]. This will not only help the robot designers explore "natural interactions and human interactions" [15], it will further the realization that technological designs remain multistable and flexible to interpretation by different users in various use contexts [60–62]. Therefore roboticists should avoid making mere assumptions about end-users and possible use-cases during the design phase [63], but instead explore these in their natural settings. This can be done ethnographically as such studies advance contextual understandings of robots as dependent on social relations and not simply replacements for these [12, 16]. Ethnographic studies can also uncover users' trust in various robot designs and the sustainment of human interest in recurrent robot interaction [4, 16, 64] as well as clarifying ethical dimensions of human-robot interaction by describing new forms of normativity, as they are formed in the relations between machines and humans [65].

Roboticists must recognize that robots, like other technologies, are enveloped in social practices [33], and that their use and meaning are constructed in practice and not something that can be designed in advance [27, 39, 52]. If the ideal is to design responsible and understandable robots compatible with the needs of their users [20] then I suggest, besides from constructing the robots, that roboticists must also pay attention to the use case i.e. the social practice in which their design will function as a material element. Roboticists could study the social practices in place in order to assess potential users' ability to receive and adopt robots, but also to understand how their robots could enhance, mediate, and support social practices instead of replacing them. In other words, ideally the roboticist should be concerned with practice design [66, 67]. Paying attention to the future operators and users will likely further the intention of keeping humans in the loop [68] and increase the likelihood of successful long-term acceptance [69]. Although it remains a time-consuming task, ethnography and ethnographic data-gathering methods will enable designers to learn from their potential users and explore possible use practices for their robotic designs – as ethnography can be considered an occasion to study *with* their users [16]. I suggest these design questions can be explored ethnographically (or by including ethnographers early on in the design process [49]) as this will advance the successful adaptation of robots in practice and further a comprehension of design processes as a multimodal, open-ended and iterative [16].

6 Conclusion

In this paper the author has presented the empirical findings of his ethnographic fieldwork conducted over a period of two years. He has followed the Danish implementation and further development of the socially assistive robot Silbot and the performance of Brain Fitness. He has approached questions of human-robot interaction, adoption, and adaption as part of an ethnographic study of the transfer of Silbot to Denmark and Finland.

Such an ethnographic approach to questions of long-term effects of human-robotic interaction and robot acceptance is shown as viable as it is demonstrated how ethnography can yield insights about the adoption, adaptation and routinization of robots in practice, the temporality of HRI and end users' acceptance and use of robots. The author argues that ethnographical studies of HRI can provide the basis for more elaborate and dynamic models of long-term adaptation of robots.

Knowledge generated from ethnography and ethnographic data about robots in natural environments thus seem valuable, not only as an important contribution to the conceptual development of HRI-studies, but also as a way to ground future design of robots and their imagined uses in real life contexts [1, 70].

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