Technological Forecasting & Social Change 167 (2021) 120678

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

The social dimension of domesticating technology: Interactions between older adults, caregivers, and robots in the home

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ARTICLE INFO

Keywords:
Welfare technology
Active assistive living
Gerontechnology
Care robots
Older adults
social robots

ABSTRACT

In this article we look at the home as an arena for care by exploring how care robots and technological care-systems can become part of older adults' lives. We investigate the domestication of robot technology in the context of what in Scandinavia is called "welfare technology" (relating to the terms "gerontechnology" and "Active Assisted Living,") that especially aims to mitigate older adults' challenges with living in their own homes. Through our case study, we investigate a system called eWare, where a flowerpot robot called "Tessa" works in symbiosis with a sensor technology "SensaraCare." Together, they create a socio-technical ecosystem involving older adult end-users living at home, formal caregivers (e.g. healthcare workers), and informal caregivers (normally family members). We analyze our ethnographic fieldwork through the theoretical concept of "domestication of technology," focusing on an established three-dimensional model that includes practical, symbolic, and cognitive levels of analysis. We found that social bonds and different ways of using the same technology ecosystem were crucial, and so we supplement this model by suggesting a fourth dimension, which we term the social dimension of the domestication of technology.

1. Introduction

This paper explores the home as an arena for understanding interactions between older adults, caregivers, and novel technology like robots and sensors used for care-practices. Due to societal changes, issues related to the organization of care—especially for older adults—are especially important (Peine et al., 2015). Aging demographics pose challenges to the current models of care provision in all industrial countries. Globally, the proportion of people aged 60 or older is projected to nearly double from 12% in 2015 to 22% in 2050 (WHO, 2018). This will lead to a dramatic shortage of healthcare workers (Levit et al., 2010; Liu et al., 2016; WHO, 2016) and an increased demand for health and social care services (Eurostat, 2019). In response, governmental authorities have created policies that combine values of "active living" with methods of technological assistance that can postpone older adults' need for institutionally based care (Tarricone and Tsouros, 2008). This includes an increased valuation of "the home", with the support of technology, as the primary site for everyday living and care practices (Oudshoorn, 2011; Neven, 2015; WHO, 2020).

This article adds to a scarce, but fast-developing, interdisciplinary research field on robots in home care settings. Robotics have increased productivity and resource efficiency in the industrial and retail sectors, and there are expectations that a comparable transformation in healthcare can emerge (Cresswell et al., 2018). Many efforts, for instance innovation and design processes to further develop care-delivery models (Hudes, 2017; Staruch et al., 2018) and the testing of new technology in different care and medical treatment contexts (Scassellati et al., 2012; Kamp et al., 2019) are being undertaken to realize this transformation. An extensive literature about everyday life in the home is also emerging from anthropology, human geography, sociology, design, and human-computer interaction research (Pink and Mackley, 2014). Yet, compared to the societal importance of increasing the use and quality of home-based care-delivery, little research has been done on the specific implications of using robots in private homes and what this technological change of the home means for users (Kerr et al., 2018; Moyle et al., 2014). This has multiple explanations. Much of the

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https://doi.org/10.1016/j.techfore.2021.120678
Received 12 May 2020; Received in revised form 12 January 2021; Accepted 14 February 2021
Available online 21 February 2021

technology has not yet been broadly implemented, and a lot of the technology is in the development stage with no clear test bed where related concerns can be assessed. Furthermore, the theoretical understanding of how healthcare technology is domesticated in the home is only at an early stage (Frennert, 2016; Saborowski and Kollak, 2015).

Based on an empirical and theoretical study of how social robots become part of older adults' everyday lives in their homes in Norway, our main research question concerns how novel technology gets entangled with care through complex interactions between technological materialities and different social actors. These social actors include older adults variously occupying the roles of private persons, public care receivers (Pols and Moser, 2009) and "technogenarians" (Loe, 2015) and their caregivers, both formal (Saborowski and Kollak, 2015; Suopajärvi, 2015) and informal (Lopez-Hartmann et al., 2012; Madara Marasinghe, 2016; Moyle et al., 2014; Pot et al., 2012). These actors also interact with more distant actors—policy stakeholders, municipal health and care service management and technology producers—who also shape social interactions in the home through their roles in the larger structural context of public care. When seeking to understand care, technology and social change, taking account of this multiplicity of actors and the different levels they operate on is extremely important.

The article also demonstrates how domestication theory (Berker, 2005; Lie and Sørensen, 1996; Silverstone and Haddon, 1996), a theoretical framework especially associated with the interdisciplinary field of Science and Technology Studies (STS), can be utilized to analyze the social "taming" of robots into home settings. Based on our empirical work, we suggest an extension of this framework through adding a *social dimension of domestication* as a principle of analysis. Peine et al., p.1) urge for a closer focus on how "material practice and materiality [become] an inherent part of later life as constituted in contemporary societies," thereby stating that STS can provide an important theoretical and empirical contribution to the debate on science, technology and aging in relation to practices of technology use and design. We argue that adding this social dimension, in combination with such a focus on materiality, strengthens the theoretical contribution from STS. As shown in our analysis, the physical boundaries of "the robot" are not drawn from its technical material alone, but from the infrastructure of care that is constructed through domestication as both a symbolic and socio-material—i.e., "the constitutive entanglement of the social and the material in everyday organizational life" (Orlikowski, 2007, p. 1438; see also Jones, 2014)—achievement. Thus, we call for taking the larger ecosystem of care into account in order to understand the robot-care-home infrastructure in a more holistic manner.

1.1. Research on welfare technology and social robots

In recent years there has been significant investment on research and innovation on social robots and technologies for active assisted living (AAL), both on a European and a national level. In the Nordic countries, robots in care are most often categorized as *welfare technology* (*velferdsteknologi* in Norwegian and Danish)—an umbrella term for different tools and technical systems for use in public care services. In Norway, this term was integrated into the national health and care policy through a national policy initiative published by the Norwegian Ministry of Health and Care Services in 2011 (Norwegian Ministry of Health and Care Services, 2011), which aimed to increase the capacity of the municipal health and care sector through innovation, the deployment of welfare technology, and the mobilization of voluntary social resources (Tøndel and Seibt, 2019). Thus, welfare technology is a term that reflects the policy context that the initiative originates from: the Nordic social democratic welfare state, which is characterized by a universalistic welfare support system and an egalitarian culture for political and economic equality (Bungum et al., 2015; Esping-Andersen, 1990). Internationally, this group of technologies is often branded under *Gerontechnologies* (which is age-exclusive) or *Active Assisted Living (AAL) technologies* and is partly related to the two broader terms *medical technology* or *e-health technology*. However, there are certain distinctions, as welfare technologies "are a large group of often digital devices with integrated platforms that public services use to promote welfare among patients and caregivers" (Søraa et al., 2020, p. 1). Because they are used in the context of the Nordic welfare state (with its socio-democratically planned market economy) and have increasing their users' welfare as their primary function, they have a distinct identity when compared to the international context. Östlund et al. (2015) also highlight the importance of welfare technology as an innovation policy that can contribute to strengthening the role of older users in the innovation and process.

Welfare technology has, at least at the project and testing level, become integrated into the comprehensive provision of healthcare services, rather than being limited to specific technologies in isolation. According to Östlund et al., 84), most Scandinavian research and policy surrounding aging and technology often relates to the term "welfare technology" as "encompass[ing] demographic developments, the restructuring of the welfare system and the expansion of the IT infrastructure." Investigating welfare technologies can thus illuminate how "new technologies in municipal and specialist services [are] tested out and implemented at a large scale within a health and care context (Moser, 2019, p. 4). Östlund et al. (2015) further argue that, rather than considering individual products and aging as an isolated discourse, one should focus on social change and power relations when analyzing welfare technologies. They warn that if we "do not take such a reflection on board, we will repeat both mistakes and opportunities without really understanding why" (Östlund et al., 2015, p. 89). Relating to Östlund and her colleagues, we explore how social robots—an example of complex welfare technology—are practically, cognitively, symbolically, and socially implemented in the life and homes of older adult users and how the relation-making of the technology, the older adult users, and their caregivers evolves within the home, thereby also shaping the older adult users' everyday life practices.

Among other research findings, it has been argued that welfare technologies hold the potential to contribute to individuals' self-reliance and knowledge of their own health (Dahler et al., 2018). As a social catalyst, these technologies can empower users to be more social, either by increased mobility outside of the home (with the use of physical assistants or robotic wheelchairs) or by bringing the world into the home of the user e.g., through telepresence or communication technology (Nakrem and Sigurjónsson, 2017). Potentially, they can also extend medical interventions from a healthcare professional perspective (Robinson et al., 2016). Yet, Östlund et al., 89) warn that "older people will continue to participate [in welfare technology testing] in the form of constructed hopes of technical solutions and a range of products will land randomly in our everyday lives, some as innovations, others as failures."

Technology can also enter into and become part of our "social interaction." Social robots, which are designed to use cues such as gaze or gestures to give the appearance of expressing and perceiving emotions in order to facilitate learning from and communication with humans (Fong et al., 2003), are an example of this process. The information gathered from interactions can potentially be used to create user profiles to allow for fast, real-time communication. Robots that portray these social abilities to assist or support humans socially are called *socially assistive robots*, and they have been deployed in care facilities (Feil-Seifer and Mataric, 2005). The robots' potential as assistive technology to supplement human contact in care may increase individual autonomy and independence (Agree, 2014; Brose et al., 2010; Fischinger et al., 2016; Riek, 2017; Sparrow and Sparrow, 2006). Robot technology could also serve as an interface to connect older adults to social networks, allowing them to be in contact with relatives, friends, and healthcare workers (Casiddu et al., 2015). In their study of social robots with video call capability, Moyle et al. (2014) found that "visits" between the residents and families facilitated by the robots led to both family and professional caregivers of persons living with dementia experiencing reduced social isolation and increased connection. Additionally, they found that staff members thought that having a face and a voice on the robot made it more real.

1.2. The flowerpot robot Tessa, SensaraCare sensor and the eWare system

One of the newcomers in the social robotics market is the social robot "Tessa." Tessa is made to support the daily routines of individuals with dementia and their informal caregivers through giving suggestions for activities by speaking messages and friendly reminders. Tessa is a non-mobile robot designed to look like a flowerpot, with LED-lit amber eyes that blink at regular intervals, giving the illusion of some autonomy. It is waterproof to sustain accidental watering of its decorative fake flowers—a safety consideration by design given its prospective target user group: older adult users with little experience using advanced technology and who are experiencing the beginning of reduced cognitive function.

This article draws on data from a research project where Tessa was used together with a lifestyle monitoring technology called "SensaraCare." SensaraCare uses passive infrared sensors (PIR) and door contact sensors to monitor the daily activities of older adults living alone. The SensaraCare system is able to learn the behavior patterns of the user by the times when the sensors are activated. Deviations from normal behavior patterns may reflect unwanted situations, e.g., if the older adult user falls asleep in the living room-chair instead of in their bed in the bedroom or develops a pattern of skipping meals (Fig. 1).

Together, the technologies of Tessa and SensaraCare were coupled in a system called "eWare," using cloud computing and connected through a wireless receiver (Casaccia et al., 2019). Both technologies were used as components in the eWare-project, but not all of the functionalities from the products were transferred to the eWare-system. Thus, this article does not provide insights in the use of the robot or sensor system as stand-alone products due to it being part of a specific research project where key components of the technology were what was being tested. During the project, the robot, the sensors, and the eWare system user interface worked in a novel interdependent symbiosis. As seen during the field work, this symbiosis created a socio-technical assemblage of "techno-care practices" (Tøndel and Seibt, 2019) around and with these tools, through the many informal and formal users' mundane efforts to transform "the home" into a safe and social surrounding for the older adult users. The system overview can be seen in Fig. 2 below:

The controller of the system—often a close relative of the older adult user—can make customized "goals" for the older adult user in the eWare system. The goals are activities or routines they seek to implement or reinforce in the older adult's daily life, with the objectives of increasing the older adult's independence. Thus, this system splits the everyday routine up into bits and pieces of activities in order to map and measure the older adult's "success" in fulfilling the goals. Tessa gives spoken reminders to the older adult if the goal has not yet been achieved; if it

Fig. 1. Tessa Robot, picture provided by Kim Sørenssen/NTNU

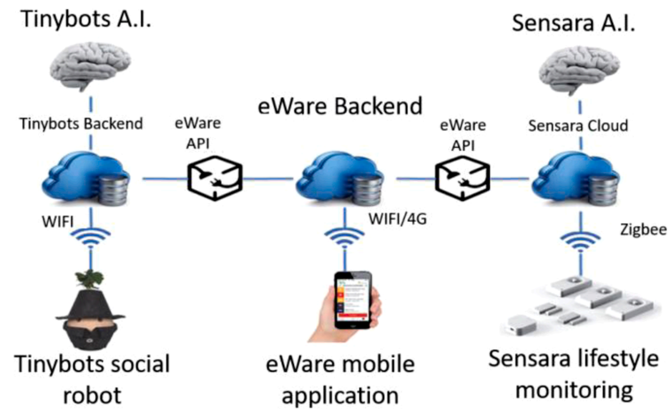

Fig. 2. Illustration of the concept of the eWare ecosystem (www.aal-eware.eu 03.04.2020).

has been achieved it gives positive feedback. Caregivers, through the eWare mobile app, will receive feedback on the achievement of such goals and on the execution of activities performed by the older adult detected by sensor technology. Tessa gives between one and three messages for each goal depending on if and when the user completes the task: up to two reminders if the goal has not yet been achieved and one message for when the goal has been achieved (Casaccia et al., 2019). Tessa knows if the goal has been achieved or not based on the information from SensaraCare and can therefore give reminders based on the user's activities. Through the material presence of these tools in combination with a (re-)programming of the social relations between users and their caregivers, Tessa and its technical infrastructure shall contribute to maintaining the structure of the user's everyday life.

2. Dimensional model of domestication theory

In order to understand how social robots become part of older adults' lives and how experiences of isolation and loneliness are transformed through social robots' emotional care, we theoretically explore the "domestication" of a social robot into private homes from a Science and Technology Studies (STS) approach. For some decades, STS has been opening the "black boxes" of technology, arguing for a social constructivist understanding of how technologies are produced as intricate social processes between producers, users, policymakers, and unintended human and non-human actors (Bijker et al., 1987; Latour, 1999; Lutz and Tamò, 2016). STS challenges technological determinism and investigates the intricacy between science, technology and the social practices and phenomena that emerge within these entanglements (Bijker et al., 1987; Latour, 1987; Lie and Sørensen, 1996; MacKenzie and Wajcman,1999). One strain of STS has been concerned with health and the body, with Oudshoorn's (2017) research on pacemakers as a disruptive bodily negotiating process, and Mol's *The Logic of Care* (2008) and her research on the multiple ontologies of the body (Mol, 2002) as extremely important contributions.

STS research on how technology and care combine has grown quickly during the last two decades, reflecting the increased political and industrial turn to innovation and technology to solve what is often termed "the wicked problems" (Rittel and Webber, 1973) of the modern welfare states. The aging populations and the pressure on the welfare services to fulfill their care obligations (Turnbull and Hoppe, 2018) is an ideal typical example of such a problem. Additional significant contributions to the techno-care assemblage research include Oudshoorn's (2011) prominent study of telecare technologies, where she explores what it means to enable care at a distance. Additionally, a growing strand of STS research investigates the co-constitution of aging and technology, with Peine & Neven (2019) and Peine et al. (2015) as prominent core contributors. A critical motivation behind utilizing an

STS perspective in research on aging and technology is, as Östlund et al. (2015) argue, that STS-inspired design can contribute to a paradigm shift that helps to develop proactive technology that meets the needs and demands of today's older adults. This article contributes to this concern through adding empirical knowledge to how technological and social change can be implemented and understood from a user perspective.

In order to do so, we use the STS concept of *domestication theory*. Originally developed as a sequential model by Silverstone and Haddon (1996) to explore how technology is "tamed" by users, it has since been re-developed in the so-called *dimensional model of domestication* (Lie and Sørensen, 1996). Semantically, domestication draws on the taming of wild animals into the home-sphere (Berker, 2005), which can also be used to conceptualize how technology is acquired and integrated. It has proved to benefit theoretical and methodical discussions of technological and social change (see e.g., Haddon, 2017; Saborowski and Kollak, 2015). However, social change is not a given by simply implementing technology. As Sørensen states, technologies should not be:

> seen as innocent and completely malleable […] technologies should be seen as under-determined and not undetermined. Designers inscribe visions and actions into artifacts […] shaping users' actions. However, this may only be clarified through empirical analysis of the actual use, which is the heart of the matter for domestication approaches. (Sørensen, 2006, p. 57)

Domestication theory studies how technology is being implemented and changed by users and how users change the technology in return, focusing on how users adopt technology through three separate dimensions: practical domestication, symbolic domestication, and cognitive domestication (Berker, 2005; Lie and Sørensen, 1996):

- *Practical domestication* refers to the physical, observable interactions that users have with technology, which could be seen as a collective category of all of Silverstone's sequential model of domestication. This can, for example, be how technology is bought, placed, or used in the physical sense (e.g., in plain language, what buttons are pushed, when, how). This is usually the most natural and straightforward dimension of domestication to observe.
- *Symbolic domestication*, on the other hand, is the unobserved consequences of adopting the technology, i.e., what it means for the user to have the technology in their life. In this sense, technologies and services are often presented in a certain manner to attract users, claiming convenience and easiness of certain tasks. However, it is also often the case that the use of technologies can have unintended consequences, including the ill-being of users (Rosen et al., 2014), for example social media may lead to anxiety scenarios for teenagers. Thus, what the users think about the technology and what it turns out to mean to them are essential questions.
- *Cognitive domestication* refers to how the users learn from and through technology and the mental ontological practices relating to the use of the technology. How is technology enacted, and what change in practices does this entail?

With a dimensional model of domestication, a key feature is that there is no "step-by-step" domestication pathway, but that all the dimensions flow into each other. One aspect that is lacking in the current dimensional model of domestication is what we term *social domestication*, e.g., how a technology is co-produced not only by the individual, but through a wide variety of actors who have agency in how the technology is being adopted into the life of users and others around them. We argue that this fourth dimension is crucial for understanding how technology is not created in a vacuum between the user and technology, but through a social process that connects macro structures with micro agency through their institutional, informal, and formal relations. This point sometimes seems to have been forgotten in STS research with a strong orientation towards studies of domestication of technology at the individual level, where questions of domestication through co-creation are often not solved. This can be emblematic of what can be termed the "flat-critique of STS," that is, the presentation of STS as not oriented towards the social or its many layers due to its strong orientation towards the specificity of single cases (Aradau et al., 2019; Law, 2008). Yet, as we show in this analysis, specificity to a single case can be combined with an analytical orientation towards the multiplicity of the social and its many levels.

Technology, such as the infrastructure in and around social robots, can be seen as actors in the social construction of the conditional matrix (Strauss, 1993) that constitutes the everyday life of technology in the home. This matrix is produced through the hub of formal and informal technology-care production relations that implementation of technology in the home implies. The way in which an environment simultaneously influences the behavior of individuals and interpersonal relationships and yet is shaped by those persons can be referred to as a transactional relationship (Dewey, 1958). The concept of transactional relationships, where technology is seen as an actor impacting the interaction between the end-user and the caregiver (Goodall et al., 2019) can be well explained in the light of the fourth dimension of "social domestication." To analyze social domestication, these inter-contextual relations must be taken into account at every level, not only the individual (Strauss, 1982). As mentioned, Peine et al., 1) further urge for a closer focus on how "material practice and materiality [become] an inherent part of later life as constituted in contemporary societies." We do so by investigating how technology entangles into the social interactions of older adults as public care receivers and their formal and informal caregivers, with stakeholders from municipal management and technology and innovation sectors also present in the background.

3. Methodology

Understanding technology implementation can benefit from empirical studies of technology in action (Pinch and Bijker, 1984). The empirical background for this article is a comprehensive set of interview data focusing on how social robots and older adult users are interacting by utilizing a triangulation of methodologies and data. For the research project as a whole, extensive user testing in Norway, Switzerland, Italy, and The Netherlands was done by the respective national research partners. The user tests of the developed technology followed an iterative process encompassing three phases. The goal was to improve the design—by reducing the number and severity of errors discovered by the user during the interaction with the system—as well as to measure the impact of the technology on everyday life.

This article uses insights from the user testing in Norway. The end-users of the technology were older adults, between the age of 66 to 89 at the time for the data collection, who lived alone with a mild or moderate cognitive impairment. All users lived in the same medium-sized municipality in Norway. The project recruited eight participants in Norway, of which two eventually dropped out before the end of the project. The data used in this article derive from interviews conducted with eight older adult primary users living at home or in independent living care apartments, ten informal caregivers—most commonly family members of the end-user—and three healthcare workers employed by the municipality and acting as formal caregivers. The interviews with the older adults took place in their homes with their informal- or formal caregivers present. The informal caregivers were for most occasions interviewed right after the interview with the older adult and in the same location. Each person was interviewed 1–6 times, depending on the duration of their involvement in the project. A minority of the interviews with informal caregivers had to be done by phone due to practical reasons. All interviews lasted on average 60–90 min.

A mixed qualitative and quantitative questionnaire was used for the interviews, consisting of a socio-demographic checklist, measurement of functional status (IADL - Instrumental Activities of Daily Living), measurement of quality of life (EQ-5D, only VAS Scale), measurement of attitudes toward technology and toward the system, a goal attainment scale, and an Acceptance Scale (based on selected items from the UTAUT scale - Unified Theory of Acceptance and Use of Technology). Due to the condition of some of the users, not all parts of the questionnaires could be completed. Factors such as reduced cognitive function or unfamiliarity with questionnaires impeded some of the users from answering all the questions and adequately indicating their response on a scale. Most of the users spoke quite briefly, often resulting in the scenario where the informal caregivers responded for them. As a response to this, the questionnaire was eventually complemented with qualitative questions in order to get a deeper understanding of how living with robot technology impacted the users' lives.

Additionally, a focus group interview was done with four informal caregivers, three of whom had professional healthcare backgrounds. This interview was done at a later stage of the project to get holistic feedback on the whole project implementation's trajectory, with expert secondary users who had followed the project for most of its duration. These participants exhibited unique insights and experiences of technology interaction, both from the health service perspective and the family perspective. This interview lasted for two hours. The project has received ethical approval from the Regional Committees for Medical and Health Research Ethics (REC) and, accordingly, a signed informed consent was collected from the participants. In case the cognitive decline of the participant did not allow giving express consent, this was done by proxy consent given by the legal guardian. For this article, we have pseudo-anonymized all informants from the individual and group interview(s) by giving them fictive, gender-neutral names.

The data analysis started with an abductive strategy, which is neither inductive nor deductive. Abduction begins by recognizing an anomaly or breakdown in our understanding of the world and proceeds to create a hypothetical inference that dissolves the anomaly by providing a coherent resolution to the problem (Van de Ven, 2007). As Alvesson and Kärreman (2011, pp. 58–59) explain, abduction consists of three steps: 1) the application of an established interpretive rule (theory); 2) the observation of a surprising empirical phenomenon in the light of the interpretive rule; and 3) the imaginative articulation of a new interpretive rule (theory) that will resolve the surprise. Interrogating the data, we found that using the standard framework of domestication theory could not thoroughly explain the importance of social relations among humans using the technology. Thus, a theoretical exploration of this social dimension needed to be added to resolve the mystery of how robots and technology implemented into private homes were domesticated so differently by different users and with such different outcomes. Practically, this means that we worked our way through the analysis through approaching theory and data as a total sum of connections, rather than two individual materials to be combined for inference. We then sorted and categorized the data in a thematic coding based in Grounded Theory (Charmaz, 2014) (even though this methodology is known to be strictly inductive in its orientation) on commonalities between the data gathered, finding themes that were often described by multiple informants. This was done through the categorization of data segments based on thematic keywords that emerged through the data as important, e.g., the social relations, and further explored through focused coding, where we explored subcategories and relations within the social-relations, e.g., between different social actors. This was coupled with memo-writing and discussions between the data analysts on how initial and focused coding categories related to the topic investigated and were then sorted mainly into the three dimensions of domestication as will be described in the results – with the additional finding of social domestication of technology as a broad, important category.

4. Results: when your furniture speaks to you

The socio-material nonlinearity observed in the implementation of the flowerpot robot Tessa, the SensaraCare sensors, and the eWare system into the homes of older adults can be understood using the lens of domestication theory. Implementing technology into a private home is seldom a linear process limited solely to acquisition and placement; it is at the same time a social *and* a technological process. Thus, we present four different dimensions of how users adopt robot technology in their homes. This represents the three standard dimensions of domestication theory: practical domestication, symbolic domestication, and cognitive domestication, along with the novel dimension of social domestication that we argue for. To present our findings we have constructed scenarios to describe real use-cases that occurred during the project, drawn from the interviews conducted, using anonymized, gender-neutral names.

4.1. Practical domestication

For the practical domestication of the technology, we focus on the human-machine interaction with the physical implementation of the technology in the home of the user. Because Tessa and SensaraCare were part of a research project, the road to the home was a bit more complicated than it is for any store-bought technology or do-it-yourself (DIY) project. Additionally, as these two technologies were combined in the novel eWare system, not only did the technologies need to communicate well with human users, but also between themselves and with the wireless network installed at the home.

Firstly, the project team and the collaborating municipal health and care services had to organize and conduct the recruitment of participants. Potential users had to be found and made aware that the technology existed, needed to be tested, and that they could benefit the technology. The inclusion criteria stated that the user had to be aged 65 years or older, live alone at home, and have a slight to moderate cognitive impairment. Since most of the users who already received healthcare services were too sick to participate in the project, the municipality had to find end-users from outside their healthcare services. Different elderly forums were contacted, and articles were published in local newspapers to target the informal caregivers. The recruitment criteria excluded many participants who expressed interest. Additionally, a temporary technical error in the unified eWare system temporarily hindered recruitment, as the municipality did not want to recruit new participants until they could guarantee that the system worked.

Secondly, Tessa and the SensaraCare technology had to be placed in the home of the user. For all the users the living room was the most practical location for Tessa, considering that this was the room they used the most while awake. Tessa was placed in a location in the living room where the user could see and hear it from the seating place they usually used. This was often close to the television, either right next to it or on a table or sideboard some meters away from the television. The sensors were placed around the home. Typically, a passive infrared sensor (PIR) was placed in the bathroom, in the bedroom, and in the living room. Door contact sensors were placed on the refrigerator and the front door. The eWare system was then installed on the formal and informal caregivers' PC, tablet and/or mobile phone, and a tutorial was given on how to use the system.

Thirdly, the technology had to be used after it arrived. There were considerable differences between how the various users made use of the functionalities of the robot and the sensors. The sensors appeared unnoticeable for the users, as they were only small white boxes placed discreetly around the home. In a sense, this could be interpreted as a material instantiation of the power to shape the end-users' organizing of their everyday life routines, yet the invisibility of the sensor did not, in practice, function in this manner, as we describe further later in the analysis. The activities registered by the sensors are shown in an app, and this app was, in our experience, only used by the informal caregivers. The informal caregivers entered the messages to be said by the robot through a website where they had their own password-protected account, and the older adult users were the "receivers" of the messages. The users did not actively use either the robot or the sensors. To illustrate an implementation process and the first impression of Tessa's "blinking", we describe an experience of an informal caregiver and their elderly parent, "Paris":

> I read in the newspaper that they were looking for candidates, and I thought this had to be perfect for Paris who is starting to get demented. In the beginning we just call Tessa the "flowerpot." The home-care nurse was reluctant, asking "let me know, are we being filmed now by it?" and Paris' friends became stressed, commenting "well, she sure is blinking a lot now…" However, Paris became quite used to Tessa being there as part of the home after a while.

Although the blinking initially caused some distress among the people in close contact with the user, after a while, once the user got used to it, the blinking was not reported as very intrusive. However, most other users described the blinking as something positive that made the robot appear more alive. The voice and volume of Tessa constituted a practical issue for several of the users. The results from a preliminary pilot study with end-users of the eWare system shows that users liked Tessa's voice (Casaccia et al., 2019). The pilot study took place in The Netherlands, Italy, and Switzerland, but not in Norway. The interviews with Norwegian end-users gave mixed feedback on Tessa's voice. One of the informal caregivers remarked that the voice was "murky" and "unclear." Others wished for an adjustment to the local dialect spoken in this geographical area of Norway: "She speaks a little funny, and doesn't understand our local dialect… maybe the sound becomes worse here out in the countryside?" (interview, informal caregiver). There were no bandwidth issues, but we heard that Tessa had some grammatical errors when announcing the time of day, and it emphasized some words in an unnatural way, making it more challenging to understand. Moreover, several of the end-users have moderate or severe hearing impairment and are dependent on a hearing aid to understand Tessa's spoken messages properly. One of the end-users disliked using the hearing aid, and another end-user was dependent on a homecare nurse to put on the hearing aid in the morning. These factors reduced the usability of the eWare system, as they limited Tessa's possibility of communicating with the end-users.

4.2. Symbolic domestication

What are the explicit and implicit meanings of the technologies used in people's homes for them? Regarding Tessa, the term "robot" invoked a lot of discussion even before it was deployed into someone's home. Many of the informants described "grandma is getting a robot" was quite the conversation topic. When the robot was finally deployed, it became clear that it symbolized widely different things for the different users. To illustrate what a robot can symbolize, we describe a situation that occurred with the user "Alex," the informal caregiver "Bo," and Tessa:

> Alex has lived their whole life with reduced cognitive abilities and has an older adult family member, Bo, as their closest family. Being a "person of habits," Alex follows the same pattern and activity plans every week. For those recurrent activities, there is no need for help from Tessa's reminders. Yet, during the testing of the eWare system, Bo found other potential advantages of the technology. For instance, Alex seemed to receive advantages from the technology use that weren't in the original "script" of the technology (how technology is intended to be used from the developers' perspectives (Akrich, 1992)). This progress was already visible during the second home visit of the researcher, when Alex expressed concern that Tessa "would be taken away" as a consequence of this new visit. Bo explained that Alex had developed a relationship with the robot and had to be reassured that Tessa would stay, something they both were very happy for. According to Bo, Alex always smiled when asked about Tessa, as it symbolized a pleasant addition in daily routines. Tessa has eyes with lifelike blinking, kindly asks if Alex has eaten breakfast, and gently notifies Alex when it is time to go to bed. These features, which resemble a typical social interaction between humans, seemed to be sufficient to symbolize a pleasant social companionship for Alex, who was used to less social interaction and variance in their daily life.

As can be seen in this story, Tessa quickly became something more than a decorative item. There was a positive connection to the robot as a social agent, "someone" who sparked a degree of being, just by their presence. Alex, as we can see from the story, did not want to give up Tessa, and their informal caregiver Bo was quite happy that Tessa gave some new stimuli in Alex's monotonous social life. Almost all the users have accepted Tessa to some degree, varying from just accepting its presence to wanting increased interaction. However, two users were less accepting of Tessa. During the first, and only, interview with one user, they repeatedly said that "I don't want her to bother me," and even mentioned that Tessa would be thrown out the window if the user got tired of Tessa. This user chose to not follow the project through to the end.

Another user, "Robin," showed signs of disliking the robot. This user described their image of a robot as a walking, mechanical and scary being and was quite weary of having it in their home. However, after some time, the informal caregiver reported that the user was comfortable around Tessa, and Tessa became a part of the user's home. However, as Robin was institutionalized and received assistance from formal caregivers multiple times a day, it was more natural for the informal caregivers to contact the healthcare providers instead of using the eWare system to check in on Robin's health and daily activities. Therefore, the eWare system did not symbolize the same link to family members that other test-cases showed.

Most users and their informal caregivers described Tessa as pleasant and friendly, noticing, in particular, the outfit, flowers, and its blinking eyes. One of the end-users mentioned that the appearance of Tessa is important, seeing as it would be standing in the middle of the living room, thus being part of the users' self-representation of their home. Although few of the users have clear images of how they would imagine or envisage a robot, none of them responded that Tessa looked like one. Tessa received several nicknames from the users. "The doll," "the old lady," "my friend,"[1] or simply just "Tessa" are names that we know have been used for the pot plant robot. The nicknames are words used in a positive context. The nicknames indicated that Tessa had taken a role or become a social character in the users' lives. In the larger discussion on the policy implications of anthropomorphizing technology, framing robots in human-like terms can reflect and reinforce existing biases that are harmful to certain social groups (Darling, 2015). In our experiments, we did not notice such negative connotations, although we see a tendency for users to apply female nicknames, probably reflecting the name given by the robot's creators; Tessa is a common woman's name in Dutch. Why the creators chose this specific name is unclear, but the fact that they did gender the robot, and that many users have followed suit indicates they engaged in a certain level of anthropomorphizing, as robots are more likely to be assigned a gender the more human-like they are (Søraa, 2017).

While Tessa was a visible and noticeable addition with different impacts on the users' lives, the users were not directly affected by the sensors—none of the end-users seemed to notice or be bothered by their presence around the apartment after the installations were completed. This raises important questions about the relationship between data-registration technology, public monitoring practices, and how local health services manage their users' right to privacy. Invisible technologies may over time reduce the frontline workers' awareness of the technologies' functions and products, thus limiting the workers' sensitivity for discretion during encounters with the users, resulting in the

[1] "Dukka", "kjerringa" og "venninna" in Norwegian. "Kjerringa" varies between having a positive and negative value depending on context and local dialects; in our study we understood it as something positive.

storage of intimate data that the users would otherwise not share. Several of the informal caregivers, however, described how it was the SensaraCare sensors and not Tessa that had the highest impact for them. Many users used the SensaraCare sensors as reassuring mechanisms, i.e., to check if the sensors had been activated. The SensaraCare sensor knew, through the activation of the sensors, if the daily activities of the user went on as usual, and the informal caregivers could rest assured that the user had not experienced a fall or other incidents.

The data from sensors could not give detailed indications on what specific activities activated the sensors, not even if it was the user or a visitor that activated them. One example is the door sensor installed on refrigerators. Almost every user had a goal of eating breakfast regularly. The sensor on the refrigerator could only tell that the refrigerator had been opened, but it could not tell whether the user retrieved something to drink, eat, or just opened the door to have a look. Thus, although the eWare system provided an assurance that something was happening, it could not always tell what exactly had happened. It structured a script for action that *might have happened*, but without any guarantees of this being the case exactly. However, the informal caregivers were generally reassured when the sensors detected some activity because, as one informal caregiver said in an interview, no registrations of movements would lead them to "worry that (s)he is laying on the bathroom floor unconscious." Additionally, the level of concern that the informal caregiver had for the user's health generally, rather than concern about how precisely they were following the day's intended activity, dictated how often they would check the app.

The eWare system was a work in progress, and thus the users encountered technical issues during the testing. This negatively affected the level of trust in the system, and often a single technical error was enough to decrease the informal caregiver's trust in the system. One error experienced by some of the informal caregivers was related to time slots for when a reminder or message would be spoken. When inserting reminders of a new routine, the caregivers insert a time slot in which the routine should be executed, the system then calculates when Tessa will say the reminders. Some informal caregivers found that the system indicated that the messages would be given at completely wrong times. For example, if the time slot was written down as from 21:00 to 22:00, the system informed the informal caregiver that the reminders would be in the middle of the night. This made it challenging to add reminders out of fear of waking up the older adult from their sleep, potentially scaring them with "a voice coming from their living room." These errors only happened in the early phase of the testing and were ultimately corrected, but it took a while before trust in the system was fully restored.

Although the SensaraCare sensor technology did not register any errors during the course of the study, users and informal caregivers reported that technical errors did happen. This happened when the system registered unusual activities, such as a front door being opened in the middle of the night, or someone entering when no one was home. Even though the technicians did not find any technical grounds for the sensors registering movement incorrectly, it was assumed by the users that these were technical faults. From the users' perspective, it can be easier just to "blame" the sensors when no other evident explanations are available. One of the informal caregivers told us how they jokingly tried to understand some of the parts of the technology they did not completely grasp:

> They're often up at night, wandering around. I can follow in the app when they finally go to bed. But we had some problems with the sensors and the front-door, according to the sensors it seemed our parent wandered out late around 2am, at the same time they were supposed to be in bed—so we just say, "Oh, it must have been a romantic admirer who came knocking."

For this family, finding a way to describe what had happened with the perceived malfunction of the technology was then translated to a humorous story of what could have been the case. Without camera monitoring, there was no way of proving what actually happened. It is possible that the user was not up at 2am, meaning that the system gave inaccurate information, and the reason for this mistake could not be easily diagnosed. It is also possible that the system was performing correctly: the user was up at 2am, but their informal caregiver didn't believe in the accuracy of the information. They then "blamed" the system for an inaccurate reading while making a humorous story to deal with this perceived inaccuracy. Either way, this shows that the lack of confidence in the accuracy in a particular instance can have a significant impact; trust in technologies can decrease even in the absence of readily apparent technical faults. Believing that the system gives inaccurate, incomplete, or inadequate information reduces trust, and a reduction of trust will then strengthen the belief that the system may give inaccurate, incomplete, or inadequate information in the future.

4.3. Cognitive domestication of Tessa

Implementing new technologies in someone's home implies an inevitable learning process as users change their lives to accommodate the technology, e.g., with new routines and practices. Living with the flowerpot robot required users to learn to live with a new entity in their home, as well as the "invisible" sensors which monitored them. In this study, the cognitive domestication of technology was impacted by the cognitive degeneration of older adults with signs of dementia. One of the symptoms of dementia is becoming forgetful of recent events (WHO, 2019). Thus, the relatively recent introduction of Tessa implied a certain forgetfulness towards the technology and what it was supposed to do. One end-user unplugged the eWare system several times, and the system remained off until the caregivers discovered the issue. Unplugging unused electronic components has generally been advised in Norway in order to save energy and prevent fire, although this user was informed that Tessa needed to remain plugged in. Being forgetful also affects the user's perspective of their own everyday activities, which made it important to plan the goals for the eWare system together with a caregiver. This can be seen in the user story of "Charlie" and "Felix" below:

> Charlie mentioned several times to the researcher doing the interview that they had a cat, Felix, and that the cat was often hiding in the basement when people were visiting. The research team then discussed the possibility of implementing pet care routines in the reminder system—a feat that would be quite difficult. At a later stage, however, one of Charlie's informal caregivers told us that Charlie did not have a cat anymore, as it had passed away years ago. But Charlie had forgotten this and was sure that Felix still existed.

This cognitive dissonance is essential to bear in mind, as creating a system that is trying to facilitate and reinforce the belief of a present situation that clashes with the user's past experiences could be undesirable. More interdisciplinary research with medical practitioners is needed to understand to what extent these systems are suitable for dementia patients and how they should accommodate the particular characteristics of such a mental state. In this sense, it is unclear whether a robot is desirable in such a population or whether there should be an ex-ante assessment on the potential suitability of the system with these populations. The project's main target was to maintain the wanted or relevant activities of users and thus reinforce good routines, which required a different kind of cognitive process. Here, the main goal was not cognitive skill development but cognitive decline mitigation.

The available data reveals that several of the users did not attain their intended goals. The users that saw little improvement in the achievement of goals were hindered by different factors. Some had hearing impairments, which reduced the impact of spoken reminders. Others had more severe cognitive dissonance, to the degree that they did not manage to fully adapt to the technology. In the cases where the user needed daily practical assistance from the health service, we saw that the reminding system became redundant; there was no need to be reminded of making dinner if they received premade food every day. Several informal caregivers mentioned that the system would possibly be very useful if they had it two years before, when the cognitive status was not so deteriorated. One of the users even had to leave the project as a consequence of rapidly decreasing health and increased level of dementia.

Lack of internal motivation is another factor affecting the completion of tasks. The user Alex was already set in their existing routines and neither Alex nor their caregiver Bo saw much need in implementing new routines, reducing the need for the eWare system. This was similarly the case for another user, Paris. When asked if Tessa's recommendation to eat breakfast was followed, Paris responded that "I'll eat when I'm hungry." Some users had an absence of inner motivation, hindering them in completing tasks or implementing new routines. When Tessa told one user to clean their kitchen countertop, they responded by saying: "We'll see about that…"—suggesting that the task would not be completed. This could be interpreted as the adoption of a passive strategy towards the demands of communicating with the robot, yet this is also a strategy that demands energy use and an active *stance* (Corbin and Strauss, 1993) towards the technology. This user was also aware that in addition to receiving support from the municipality in taking medicine and receiving premade meals, their family came once a day to help with some housekeeping. The awareness of this support could lead to a "disobedience" towards Tessa; the user's knowledge that they did not need to do much work themselves reduced their motivation to complete the suggested tasks from Tessa. One of the users, "Kim," improved in one routine and failed in an attempt for another. One of the differences of these tasks might lie in the need for inner motivation:

> Kim's main goal entered into the system was to eat breakfast at a regular time every day. The data collected from the sensors showed that Kim ate breakfast within the suggested time frame almost every day, either after the first or after the second reminder from Tessa. Based on feedback from informal caregivers, we know that Kim improved their general health significantly during the time between the first interview and the follow-up interview. This improved health may be caused by more than the improved breakfast routine; nonetheless this is a good example of how the eWare system can be used. Another goal did not give the same results. To increase activity, the research team suggested entering a goal of walking outside the apartment complex every Sunday. According to Kim, this goal was never achieved due to bad weather. This shows that even if the user can listen and understand Tessa, lack of motivation—in this case resulting from bad weather—can still hinder users in their completion of tasks.

Unlike the end-user's interactions with the system, the interaction between the system and the informal caregivers required some technical competence as they had to enter the goals and messages. Their differing levels of technical competence presented a challenge, as different training plans and amounts of instruction were required for them to use the system correctly. The need of additional training did not necessarily become clear until the system was already being used for several weeks or months. In the early design process, flaws and less user-friendly setups also made the system challenging for the informal caregivers with more technical expertise. Furthermore, the employees responsible for the training had insufficient practical experience of the system, making the training less efficient.

4.4. The social dimension of domestication

The interaction with users and formal and informal caregivers that was prevalent throughout our data but not easily accounted for in our theoretical framework led us to discuss whether previous theorizations of the domestication of technology lacked a fourth and equally important dimension of domestication: the *social dimension*, i.e., how humans relate to other humans when domesticating a technology. In the current three dimensions of domestication—physical, symbolic, and cognitive—one observes the technology in relation to its human users, by, respectively, their interaction with the technology, what it means to them, and how they change and are changed by the technology on a cognitive dimension. However, it can also be fruitful to include an additional dimension where one looks at the technology in relation to both the close and distant social connection between the human users, how it impacts that connection and how this impact will, in turn, transform human behavior. It is thus not only "user and technology" in a unique or familiar setting that is important, but also that of the social interactions between different types of users of the technology. We thus argue for a *fourth dimension* of the domestication of technology, the *social dimension of domestication.*

Technology is not created in a vacuum between user and technology, but through a social process that connects macro structures with micro agency through their institutional, informal and formal relations (Strauss, 1993). The way different users of the technology domesticate it through social processes is of high importance. This process starts even before the technology is adapted into the home; negotiations and convincing of key actors was important to bring the technology home in the first place, as we saw in the practical dimension of domestication. In the case of this system, both informal and formal caregivers and end-users had to agree to test it out.

Dementia can have a physical, psychological, and social impact not only on the people with dementia, but also on their informal caregivers. For the informal caregivers, Tessa played the second fiddle in the testing of the eWare-system while the SensaraCare technology had a larger effect on their daily lives because it reduced feelings of stress. Several reported that they found it comforting to see their family member's daily activities in the SensaraCare app. The informal caregivers indicated that they did not visit or contact the user less during the testing period, but rather describe SensaraCare as a tool to better deal with the challenges of being a caregiver, as described here with the story of "Paris" and "Sasha":

> Paris is an older adult living close to their informal caregiver Sasha, who adjusted their daily life out of fear of leaving Paris unattended for several hours. The SensaraCare technology allowed Sasha to be reassured when seeing in the application that Paris was active and completing their daily activities. "I used to worry a lot about my parent, but after getting the SensaraCare especially, I am much calmer on their behalf. My siblings also notice this and are happy that I can finally leave the house in the evening and not worry that much for my parent." Sasha informed the research team that checking the application was the first thing they did in the morning and the last thing before going to sleep. They still visited Paris, but now more for social purposes rather than constant check-ups, and they experienced a reduction of stress as a caregiver.

This example shows that the informal caregiver Sasha not only experienced a reduction of their own stress from caring, but also a reduction of their own social isolation by shifting from physical check-in visits to technical check-ups, allowing them to live a life less constricted by care duties. Another informal caregiver from a different household described that SensaraCare was a useful tool. Their end-user had started saying that the doorbell rings late at night, and that they had been out to check who rang it: "If that happens much more, I have to institutionalize them and that will be expensive for everyone. It's important also for the municipality to help me have this control." In this case, the informal caregiver could follow up in the system, and, luckily, no doors had been opened. This gave a sense of security and postponed the need for their parent to move into a nursing home. The quote also illustrates the potential for technology to extend older adults' ability to live independently in their own homes.

With the introduction of the technology, the quality of the informal caregivers' visits could be increased; it became more of a happy social engagement and less of a chore. Neither Paris, nor the above-mentioned Kim who had experienced increased health as a result of eating breakfast regularly, experienced a change in the number of social visits they had. The informal caregiver was still involved in Kim's life without having to feel a responsibility for their health by giving daily reminders for all daily tasks. There was a lot of interaction between the system and the informal caregiver. Some users had several close family members that frequently visited and called who were also engaged in the testing of the system.

The social network could, on the downside, have a limiting effect on the research project's results. For example, one of the users has an extensive family network who visits frequently and helps in everyday tasks such as cleaning and maintaining their apartment. In addition, the user receives support from the municipal social service in tasks like taking medicine or bringing premade meals. This limits the data received from the sensors, as the movement sensors only registers movement when there is no more than one person in the room. The situation may also affect the user's motivation, as previously mentioned, when there is no real need for the user to complete tasks. On the other hand, some users did not have close family that could be as involved as informal caregivers, as "Luka" who instead relied on the formal caregiver "Jan"—a professional healthcare worker:

> Luka does not have a close family, but lives in supported housing, where each resident has their apartment under the supervision of formal caregivers. Having no close family, one of the formal caregivers—Jan—was registered as the "informal" caregiver in the eWare system (which is geared towards helping informal, not formal, caregivers). Using only their working hours and having limited time set aside for involvement in the project, Jan had less time for exploring and customizing the app to Luka's needs. Most of the employees working at the supported housing facilities were not well informed of the eWare system. As a result, it is challenging to determine the effect the eWare system has had for Luka. Jan explained that Luka could be difficult to motivate, and hearing the repeated and unchanged reminders from Tessa for a longer period of time did not increase the likelihood of these tasks being completed.

As can be seen in the story above, outsourcing the eWare system to formal caregivers (who are on the clock), was not deemed a good solution in this case, as the formal caregivers did not make use of all functions in the system and already had working routines for helping Luka in their needed tasks. Although it was soothing for relatives using the SensaraCare, and in some cases, soothing for the end-users to have a Tessa robot speak to them, this must be seen as an addition—a supplement—to other care practices. For a formal caregiver, a healthcare professional, time is money (which is highly related to the reported understaffing and underpayment of the profession), thus large amounts of time getting used to new technology is not possible. If mastering new technology is deemed necessary, it should be included in training or continuing education; time and money needs to be invested at an institutional level into deploying it.

Taking a step back and reflecting, we can consider Turkle's (2011) warning that continuous use of companion robots could also intensify and exacerbate the loneliness these people feel. Although they would be "in contact" with other people, they may also experience this as a deprivation of the warmth of human-human encounters. It is not the technology itself that creates change, as it is not enough to insert an electronic object or system, this must be mediated by a social network around to create change, with its own established interaction order (e.g., Strauss, 1993). This is evident in the example with Luka mentioned earlier, who only has formal caregivers with limited time for implementing the eWare system in their home. Furthermore, Luka seems easier to motivate by human contact:

> Jan explained that Luka could be difficult to motivate, and hearing the repeated and unchanging reminders from Tessa for a longer period of time did not increase the likelihood of these tasks being completed. However, if some of the formal users offer to accompany Luka in their tasks, such as going to the store, Luka is much easier to motivate.

Implementing technology into this situation changes its rules of action without control of the output. The insertion of robots into users' homes can lead to some social change, at least at the micro level, but this change is not necessarily formally acknowledged. As we saw in the case of Alex who lived a quite monotonous social life, Tessa expanded the amount of "socialization" happening in their life by symbolizing a social presence in Alex's home. However, for other users—like Paris, who had a very large family living nearby—interactions with Tessa did not constitute a large percentage of the socialization time. How it affects users' feelings of loneliness is, for instance, very difficult for the municipal health and care services to measure and document, as "loneliness'' is such a subjective experience. A danger could be that loneliness is measured in quantitative terms: how many social contacts the user has in their everyday life. In the northern European countries, being social intertwines with its antonym, *being lonely*, which is reported as being on the rise in modern societies (Cacioppo, and Cacioppo, 2018). Thus, care robots and technological care-systems can become part of older adults' lives—but with varying results. The impact technology has on user-experiences of isolation and loneliness is intertwined with their existing social relations—or lack of thereof.

Some informal caregivers had unrealistic expectations that the system would take over the task of reminding the user of individual occurrences or tasks of special importance, a task the informal caregivers normally did by calling the user. One informal caregiver described how they still have to call every night to remind their parent to take their evening medicine: "it doesn't help if Tessa says it, I have to call as well. Some evenings they have taken it, some evenings they haven't." Even though the system allowed for direct messages spoken by Tessa, there was no guarantee that the user was present when the message was spoken, or that they paid attention. A direct phone conversation was thus more certain to get the user's attention. This made it important to clarify that the objective of the system was to improve everyday routines—not to relay reminders for individual occurrences or tasks of special importance.

Tessa's spoken messages had different social meanings for the users. One of the end-users, Charlie, commented on how they perceived the messages from Tessa to come from their adult child, showing an awareness of the social bond via Tessa's messages. Charlie commented that they thought about their family members when hearing Tessa speaking reminders and messages. Thus, Charlie was well aware that the family member created the messages and saw it as something more personally connected to their family member than just an object speaking to them. Another user, Kim, expected Tessa to be able to respond to them, instead of being limited to saying reminders written by informal caregivers. This can be seen by the example below of Kim:

> Kim repeatedly expressed a wish of increased social interactions with the robot. During the first interview they wanted to know the correct way of responding when Tessa spoke, and during the follow-up interview Kim repeatedly mentioned that it would have been better if Tessa could answer back as well. Kim saw Tessa as a social companion, and even preferred increased social behavior.

This example illustrates how human-technology interaction can evolve into a social relationship that contributes to shaping the further trajectory of domestication in a unique way, due to the social dimension. When this relationship is established, the materiality of the technology is no longer the user's main focus; their relational together-work is of more importance. The social dimension also makes the impact of fear and worry on the domestication trajectory visible, including how the entire robot-in-care-infrastructure, the ecosystem, takes care of the user by, among other aspects, producing emotional interaction, negotiations about emotions, and actions grounded in an emotional basis. Therefore, understanding and taking into account the social dimension of domestication of technology enables us to rethink how care technologies for the future can better facilitate social interactions with technologies and between the humans involved in technological domestication.

5. Discussion: "gerontechnology coming home"

Bringing gerontechnology—i.e. technology for older adults—to the private home of end-users provides novel challenges that, in some ways, are completely different from formally institutionalized care settings (Oudshoorn, 2011). The home of older adults needs to be understood holistically and include all relations between end-users, informal and formal caregivers, the technology itself, and the intricate interactions between the different types of users and components of the system in question. As we've seen in the case with the eWare system, it is useful to investigate the experiences of the domestication process from multiple dimensions. Our main findings are conceptualized in Fig. 3, where we summarize important elements of the four different dimensions of domestication. We argue for a holistic approach because the dimensions influence and overlap each other continuously in a seamless web (Hughes, 1986):

This figure combines the practical experience collected during the tests with the four-dimensional model of domestication theory. Each dimension is expressed through the key components of the domestication of technology, enumerated as bullet-points in the figure. These components have, in turn, been illustrated by the real use-case stories given in the previous sections. The bullet-points describe key findings from the empirical data.

For the practical domestication of the technology, the recruitment, placement of the robot and sensors, and their physical appearance is of importance. In Tessa's case specifically, the voice became an important aspect of daily usage. Practical matters such as the volume, relating to hearing loss or distance between Tessa and the TV, were present in the first part of the implementation phase. Furthermore, when installation takes place as part of a municipal service, where achieving equality in service-delivery is of high importance, concerns of time constraints become especially important practical considerations.

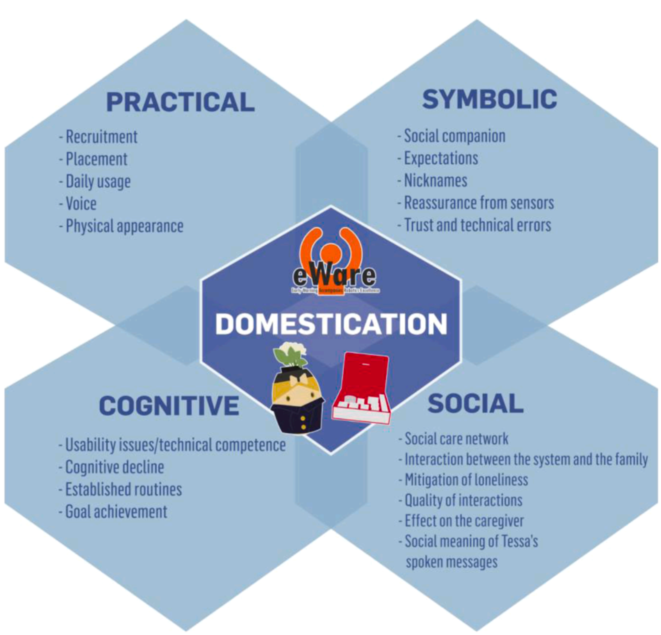

Fig. 3. Illustration summarizing main observations from the data analysis, by Nienke Bruijning.

We have seen that technologies can symbolize different things for different users. For informal caregivers it can be through a reassurance from the daily reminders and sensor monitoring, the presence or lack of trust, or concerns for technical errors or inadequacy. Almost all users were quite positive towards Tessa, as it symbolized a social presence. For the end-user Alex, who was afraid that Tessa would be taken away, the robot symbolized some sort of company. It could be understood as a "social robot" (Fong et al., 2003; Breazeal, 2004), or company by being an active presence in the user's home (Heerink et al., 2010). Some end-users had unrealistic expectations as well; Kim expected that Tessa would be a social presence that could respond and converse. We also saw how nicknames helped shape the symbolization domestication of some users calling friendly terms, while others preferred to make it more impersonal through symbolic naming.

On a cognitive domestication level, usability concerns and technical competence were important aspects for the informal caregiver. The eWare project was a cognitive decline mitigation focused project, relating to how dementia could be mitigated through the reminders of established routines. As a result, the technology had a quite different trajectory of cognitive domestication than what domestication studies normally look at; the focus of the project was cognitive decline as a matter of the domestication process. This we saw in the example of the end-user Charlie and their cat, which, like Schrödinger's was both alive (in the end-user's mind) and dead in the practical sense. Thus, in this case, it was important to facilitate different levels of cognitive inter-implementation, as cognitive decline could impact the system's implementation and usage. As Kerr et al. (2018) write, robots' implementation can imply a technological change of the home and cognitive changes for the user, however, it is also important to keep in mind the cognitive decline mitigation concern. The eWare system was intended for improving routines and, indeed, it was successful on one case in contributing to the user's increased regularity of eating breakfast, and generally improved health reported by their informal caregiver. For cases when the reminders had less effect, factors such as hearing impairments, lack of inner motivation, or the presence of daily assistance from health services or informal caregivers were reported as important factors contributing to their lack of effectiveness.

Finally, by also being aware of the social dimension of domestication, we can broaden how it is not only a one-to-one relation between user and technology that impacts how a person (or a household) relate to the technology; in our digitalized and connected world, a wider assemblage of actors will be relevant to include for analysis. The consequence of the technology use on the informal caregiver's organization of their everyday life is fascinating. And the "ring of effect" is not only concentrated around the informal caregiver, but also their siblings, and, potentially, also around their mundane social network in general—thus leading to a large amount of social change in the "non-technological" side of humans' lives, enabled and enhanced by the robot technology. The impact of worrying about the quality of life of the caregivers is not calculated in the municipal budget, but it certainly makes a difference for those it concerns.

Users with a high degree of cognitive decline did not achieve the best results from using the system. For the eWare-system to have an optimal effect, practices and habits should be learned while the user is at a quite early stage of functional decline, as was discussed in the concluding focus group interview: "This should almost be a technology you get when you reach a certain age. The same with the safety alarm. It's too late now, they should have received them earlier." As mentioned in the introduction, current political guidelines in industrialized societies promote strategies for older adults to live at home as long as possible (de Meijer et al., 2013; WHO, 2018; Tøndel and Seibt, 2019). However, for technology to achieve such goals, a holistic domestication process has to be in place, with the social lives of users taken into account.

We thus argue for a holistic trajectory, where the acceptance of the technology can happen (or not) at different stages for different user-groups, and where sub-components of the technology can be domesticated differently for different user-groups. It is, as Mort et al., 438) describe "a shift in networks of relations and responsibilities […] situated relations [that] people and technologies create together." There are of course questions within the frame of service responsibility concerning what accommodations the municipal services should offer and not. Even given these concerns, there should be room for spontaneous surprises in the municipal service use of the technology, especially in evaluations of ongoing test projects and in documentation of benefits of technology implementation. However, a relevant question to reflect upon is whether the benefit comes from the technology itself or the reorganization of the social relations that the technology produces. If the latter is the case, other organizational strategies than technology implementation could potentially do the same job.

However, moving from the society to the personal level, the individuals' dignity must be preserved when solutions are investigated. In addition to resource savings, sustaining an independent and healthy living at home guarantees a strong support for every individual's perception of a dignified life without becoming a burden to their friends or relatives (Serrano, 2010). Turkle (2011) warns against long-term consequences of care technologies which can end up making us "alone together" as we risk becoming lonelier than we were before we had the technology. Other scholars stress that robots may be the problem they try to solve, exacerbating, for instance, the feeling of loneliness that they aim to bridge (Bauman, 2013; Fosch-Villaronga, 2019a; Fosch-Villaronga and Albo-Canals, 2019).

Whether such technology is also used to replace human contact is currently being critically discussed within social science research on technology in care (Fosch-Villaronga, 2019b; Pols and Moser, 2009; Tøndel, 2018) and is being debated by the European Parliament (2017) and the Council of Europe (2017) to the extent of proposing a new human right of "meaningful human contact." Different distinctive elements of social robots include their social features, natural interaction features, robustness, technical reliability, privacy & security concerns, interoperability, usability, people-centered design, and their socio-demographic factors adhering to individual needs for user acceptance (Flandorfer, 2012), all of which affect the user's values and rights (Fosch-Villaronga, 2019b). Thus, it is imperative that technology is designed, developed, and domesticated in a just and responsible way. As Neven (2015) makes clear, it is important to make the changes that home technology implies to the lives and practices of older people clearly visible.

6. Conclusion

This article has discussed how gerontechnology in the form of care-robots, home monitoring sensors, and technological care-systems can be domesticated in the home of older adults and what it means for gerontechnology "coming home" and extending the reach of care (Oudshoorn 2011). It is necessary to reflect on all dimensions of domestication of technology in a holistic manner, seeing as they overlap and influence each other. Though they are presented separately, they were analyzed—and should be viewed—as interconnected and complementary perspectives. Bringing a robot into the home implies multiple practical domestication issues and needs: the robot must be placed in correct distances to other electronic equipment, and sensors must be put into doors in order to make the home "smarter." Symbolically, users have a wide variety of opinions and interpretations on what having technologies living with them in their home entails—for several informal caregivers, being present through the system was important in order to follow up on daily habits (or lack thereof) by their older relatives. For a robot such as Tessa to be brought into a heterogeneous array of homes, different symbolization, e.g., by naming conventions were to be expected. For cognitive domestication, technology changes the way users live their lives, contributing to facilitating the users' engagement in daily activities—especially by compensating for problems relating to time (Nygård, 2009).

Through our fieldwork and analysis, we observed the importance of seeing the assemblage of users and informal and formal caregivers in a holistic manner—especially considering how successful technological domestication is not an individual process but relies on a wide variety of actors. Therefore, we suggest adding a fourth level to the theory of domestication of technology—that of "social domestication." Through ontological reorganizations of different ways of operating technology, usage was made possible in different manners for different users. The technology to be domesticated holds different meanings for different user-groups. Within our case study, we saw two quite distinct main usages of the eWare system: end-users who mostly related with the flowerpot-plant robot Tessa and informal caregivers who mostly related with the SensaraCare sensors. For the older adult end-users, Tessa was something one could see sitting on their table, it talked to them, and had, as the users described it, a certain personality, which can be reflected in the many names they gave Tessa. The assemblage of caregivers—informal family members and formal healthcare personnel—benefited from the reorganization of the social relations through the technology.

While human contact is an essential aspect of social care that robot technologies cannot replace (Mort et al., 2015; European Parliament, 2017; Council of Europe, 2017), robot technologies may, on some occasions, represent a meaningful interface that facilitates the care relationship between older adults and their informal caregivers and mitigate some of the worrying that take place, if done in an ethical, just, and responsible manner (Fosch-Villaronga, 2019b). While there is a fear that the insertion of robots into the healthcare sector is going to dehumanize caring practices (Pols and Moser, 2009), our study shows that robot technology has the potential of bringing humans closer—but not necessarily in the way it was planned to. Facilitating access to technology that helps mitigate loneliness and bridge the gap between relatives might provide an extra sense of security for family members and healthcare staff, but thorough and early implementation is needed for better results.

Author statement

The manuscript is a revised paper for the same journal, and has not been submitted elsewhere.

Acknowledgements

The data collection on the eWare system was performed within the framework of the eWare project AAL-2016-071, financed by the European Commission, National Ministries (The Netherlands, Italy and Switzerland) and National Funding Agencies (Norway). The article was also partially funded by the LIFEBOTS-Exchange project under the Marie Skłodowska-Curie Grant Agreement No. 824047; and by the LEaDing Fellows Marie Curie COFUND fellowship under the Marie Skłodowska-Curie Grant Agreement No. 707404.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.techfore.2021.120678.

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