Engineering elder care: An analysis of conceptual premises and biases of social robots in elder care

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Abstract

The aim of this PhD dissertation is to understand the conceptual premises and biases of social robots in elder care. First, the conceptual premises are discussed by empirically analyzing the content and construction of social robots in elder care. This informed the creation of a conceptual framework, typology, and definition of social robots in elder care. Second, biases in the field of Human-Robot Interaction in elder care are discussed from a critical perspective. It is relevant to study these issues, since the content and the construction of technologies in this new field are not free of value. The content of 96 academic publications was analyzed qualitatively, using grounded theory in one study, and thematic analysis in two other studies. Results show that social robots in elder care are conceptualized in terms of agents/tools and in care/social settings. Furthermore, ageist and neoliberal bias are embedded in the construction of such technologies. This thesis concludes that 1) social robots in elder care ought to be seen as merely an additional aid to human caregiving, and 2) flexible essentialism, a theory that is developed in this thesis to discuss subject-object relations, reconciles two seemingly opposing camps in the academic literature on the study of sociotechnical agency.

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List of abbreviations

AAL: Ambient Assisted Living

ADL: Activities of Daily Living

AI: Artificial Intelligence

AI4SG: Artificial Intelligence for Social Good

ANT: Actor Network Theory

DoF: Degrees of Freedom

HRI: Human-Robot Interaction

IADL: Instrumental Activities of Daily Living

PBAI: Provable Beneficial AI

PwD: People with Dementia

STS: Science and Technology Studies

SCOT: Social Construction of Technologies

WoZ: Wizard of Oz

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1. Introduction

The first generation of social robots was developed in the 1990's with toy-like robots such as Furby and Aibo. A decade later, the Japanese research organization AIST (Wada et al., 2003a; Wada et al., 2003b) developed Paro, a social robot especially designed for elder care. Since then, a lot of different social robots are developed, some particularly designed for elder care, e.g. FriWalk in Given-Wilson et al. (2017) or the Hobbit project of Frennert et al. (2013), others not necessarily intended for elder care but still tested and implemented in elder care, e.g. Nao in Torta et al. (2014) or Pleo in Perugia et al. (2017a).

This development triggers questions about the implications of such technologies: what does it do to its users? How does it influence their subjective wellbeing? How does it change the work of care professionals and care provision more generally? Is Human-Robot Interaction (hereafter HRI) in elder care ethical? These aforementioned questions reflect an anticipation of social change: the introduction of a technological artifact will influence current practices of care work, family relations, social interactions, or any other relevant social phenomena in one way or another. Indeed, when discussing what it does to subjective wellbeing of older people or caregivers, it implies that users experience a shift in their experiences due to the introduction of a technological object. And discussing ethics implies that there is a new social situation that requires ethical scrutiny.

So far, in order to understand the effects on users and society better, many scholars jumped on the bandwagon to study HRI in elder care empirically. However, few conclusive and exhaustive answers are given due to the contextual nature of HRI.[1] Robots come in different shapes, sizes, colors, hardware, software (i.e. a stimulus with high degrees of variability), and are implemented in different settings (i.e. different older users with different mental/cognitive/physical capabilities, receiving different types of care, in different cultural contexts). Unsurprisingly, studying robots in elder care often results in case study research. For instance, Khosla et al. (2013) studied how PaPeRo influences user's subjective wellbeing. Yamazaki et al. (2014) used the Telenoid to understand how users accept tele-operated communication. And Heerink et al. (2008) used iCat to understand how the acceptance of robots is influenced by robot personality.

Although the field has published a considerable amount of social scientific case studies on HRI, it is not possible to conclude anything about technological reception related to for instance user effects or technological appropriation. The mere difference in hardware material among the robots could completely alter HRI: Paro is fluffy and intended to touch and cuddle (Wada et al., 2003a), while the materiality of Care-O-Bot does not "invite" its users to physically interact with the robot for social companionship. Even when comparing two robots that are intended for human touch, e.g. Telenoid (Yamazaki et al., 2014) and Paro (Wada et al., 2003a), they are radically different in appearance and user operation/control: the former is tele-operated, humanoid (albeit without visual cues of gender and age), made of silicone rubber, and the latter is autonomous, zoomorphic (it resembles a baby seal) and fluffy. In other words, each particular robot has particular qualities that would possibly trigger different interactions.

[1] An occasional meta-analysis or systematic review tries to summarize "effects" of social robots on older adults, but unfortunately, there are few randomized control trials conducted in the field, and of that subsample, few with large enough sample sizes and statistical power (Pu et al., 2019).

One could even hypothesize that the mere change of color or size could possibly evoke different reactions from its users[2].

Since there are so many different robots developed for elder care, it would take a considerable amount of academic perseverance to understand the breadth of possible HRIs in eldercare and its implications. While acknowledging the contextual nature of HRI in eldercare, this dissertation argues that instead of focusing on acquiring data from very particular cases and user studies, understanding general patterns in HRI would advance the field further. Herewith, this dissertation moves away from "the specific" to "the general", and thereby helps to understand *systemic* and *structural* issues in HRI and its field.

Understanding HRI as a whole is a mammoth task if empirically tested on different users and different robots. So, in order to understand HRI in its broader terms, this thesis will not study users as test-subjects or observational units for empirical research. This thesis takes a different approach by understanding the process prior to interaction to get a deeper understanding of HRI with its intentions and assumptions: what are these technologies supposed to do, for whom, and why? What are the underlying assumptions that tie all interactions together? Is it possible to generalize certain features of social robots in elder care? In other words, the main goal of this thesis is to understand HRI in the field of elder care and its fundamental roots by focusing on technology construction and technological content (and how these two are interrelated), instead of technology reception.

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[2] This argument is based on semiotics, and the idea that even attributes such as color signifies meaning (e.g. Kress & Van Leeuwen, 2002).

Specifically, it is argued that there are assumptions made in the field of HRI about aging and elder care in relation to robots that have to be made explicit. Surely, there must be some underlying understandings of what the "social" is in social robots in elder care, and what the "interaction" in Human-Robot Interaction means? For if there is no conceptual understanding of such terminology, these might as well be empty phrases. Furthermore, understanding HRI in elder care and its fundamental roots also allows for studying biases in the field.

The underlying theoretical argument that technological content and the process of technology construction are not immune to biases is not new (e.g. Pinch, & Bijker, 1984). However, with this in mind, it is relevant to understand *the ideas* that help shape and develop technologies in this emerging field of social robots in elder care. With a new field being developed, it is important to understand which ideas are put forward with regard to its conceptual premises and biases. If the field is so driven by the anticipation of social change with innovation, it needs to be understood what type of social change is being advocated with what type of innovation.

Working on these technologies implies working towards a "better" future (Jasanoff, 2015; Peine & Neven, 2019): technologies are seen as problem solvers, and the introduction thereof would lead to a certain desirable future. As mentioned earlier, there are already numerous studies that try to understand how social robots in elder care trigger social change – often implying "better" social situations than before, e.g. in relation to subjective wellbeing such as in the studies of Khosla et al. (2013) and Wada et al. (2003a). If the ideas of "progress" "social change" or "innovation" are taken-for-granted, one could almost forget that technologies are embedded in sometimes very stable environments with rigid cultural norms and expectations. By making explicit what the underlying assumptions in the field of HRI in elder care are, one could become aware of the structural character of the conceptual premises and ideological biases practiced in the field. At its best, this thesis could contribute to building "better" robots, at the very least it could raise awareness about which ideas drive technological innovations in elder care.

But what then is HRI, and how does it supposed to improve the future of elder care and aging? For which older adults are these technologies designed? When answering these issues, this thesis will not reiterate the rather uncontested idea in academia that the social and the technical are intertwined. Rather, the theoretical relevance of this thesis lies in understanding *how* the social and the technical are intertwined in this emerging field. This thesis aims to understand *the ideas* behind the technologies *in a new and emerging field*. By understanding the content of ideas, this thesis is not only *descriptive* but also *critical*, as this thesis analyzes the normative and ideological meaning embedded in these ideas.

One strand of literature that this thesis builds on is the theoretical debate of (non)human agency and subject-object relations. Is agency located in the human, the non-human or both? Ontological positions of (non)human agency are important to understand in the context of this dissertation, as one of the main aims is to understand what social robots in elder care "are". By classifying and conceptually understanding this new technology in chapter four, this thesis is situated in *and* adds to the discussion of what subjects and objects "are".

The second strand of literature mentioned in this thesis are theories that discuss how technology construction and technological content relate to one another in terms of boundary work. Concepts such as inscription and encoding are discussed to understand how particular visions and messages help shape technological content. It is then not much of a stretch to introduce ideas of normativity and the field of critical robotics research (Serholt et al., 2021). For if technology development is not a linear nor inevitable process and not immune to social influences as for instance Bijker (2010) mentions, it leads to the understanding that it is important to know which and normative and ideological biases are embedded in the process since this might have consequences on the overall design of the artifact. In other words, this thesis acknowledges the idea that constructing technologies is inherently a normative activity (Verbeek, 2006). Chapter two specifically describes such theories of boundary work and subject-object relations and how this fits with this overall thesis.

1.1. Research question

This dissertation is divided into two segments: conceptual premises (i.e. descriptive research) and biases (i.e. critical robotics research), as is explained next. The first part of this dissertation (chapter four) looks at how scholars in the field ascribe boundaries to the robots. This is based on the assumption that there must be some underlying understanding of what the "social" "is" in social robots in elder care. Chapter four describes how social robots in elder care are conceptually situated in the field of HRI in order to understand the "social" in social robot. This gives insight about sociotechnical intent: how is the "social" robot supposed to function in elder care?

This dissertation samples academic publications and more specifically, it triangulates operationalizations and general descriptions of the machines in the academic publications. The reason as to look for operationalizations that the scholars in the field of

HRI employ is to understand the frameworks in which these technologies are imagined to operate in, whereas the general descriptions give information on how the robots are supposed to function generally disregarding context. When sampling these ascribed qualities across cases, it allows for results that hint towards the assumed boundaries of such technologies: how users should use it and in which contexts. On the basis of such information, a conceptual framework including a typology and definition is given that illustrates the ascribed functions of social robots in elder care. The exact use of this typology and the rationale for developing one is explained in detail in chapter four.

The second part of this dissertation is situated in critical robotics research, and relies on the work of, for instance, Jasanoff (2015) and Katz (2000). Specifically, chapter five and chapter six respectively discuss ideas that academic scholars in the field of HRI and elder care articulate about; elder care and expenses, care work, and aging; and representations of older adults. Ultimately, it is argued that it is important to understand the ideas behind the machine, as those ideas could embed bias. Especially since people working in HRI most likely do not have the lived experience of a care-dependent elder person, they would need to rely on external representations of older adults (Hyysalo & Johnson, 2016). As engineering is not a linear or inherently logical process, it would be relevant to understand how these scholars in HRI interpret concepts of elder care, aging, and care work.

The two central themes that are discussed in this dissertation are translated into three individual studies that incorporate the following questions: 1) **what** "are" these technologies (chapter four); 2) **why** is there a need for robots in elder care (chapter five) And 3) **who** "are" the older adults scholars in HRI develop robots for? (chapter six). This describes the general gist of each individual study in this dissertation in layman terms. However, as will be explained in the upcoming chapters, the exact wording of each research question is adjusted according to each respective theoretical and conceptual tradition for more academic rigor. Note that "are" is put in quotation marks in the research questions, because 1) representations are studied instead of "real" objects and users (which becomes clearer in chapter three on methods and methodologies) and 2) there is theoretical debate in the social sciences if technologies are only relevant situationally or could be captured in essentialist terms (this latter statement is explained in chapter two, the theoretical framework of this dissertation).

The guiding overarching research question that ties all three studies together reads: How does the field of Human-Robot Interaction in elder care define social robots, justify its objectives, and represent older adults?

1.2. Chapters overview

The remainder of this monograph is structured as follows. Chapter two explains theories in media studies, Science and Technology Studies (hereafter STS), and (post)phenomenology. Key concepts and theories related to boundary work and inter-actional and intra-actional accounts of sociotechnical agency (e.g. Introna, 2014) are discussed then.

Thereafter, chapter three discusses the used research methods and methodology. It explains how researching social robots in elder care carries a very particular methodological challenge: robots are not only a very heterogenous group of artifacts, but most likely also will diversify in the following years. Technologies are always beta, and inherent to engineering disciplines and computer science is the focus on "innovation" and “improvement”. It is therefore expected that robots in elder care will be different in a couple of years from now. Understanding robots and HRI in terms of generalities is difficult since the phenomenon is similar to a moving target. This chapter will not only describe this challenge, but also explain how this thesis aims to partially overcome this. Furthermore, this chapter discusses the research design of the empirical work this dissertation rests on.

Chapter four gives a conceptual framework and definition for social robots in elder care. It is argued that there are no robust definitions of social robots in elder care, and this thesis is an attempt to empirically develop a definition and conceptual framework.

Then, chapter five gives a contextualization for societal developments that preceded the development of robots in elder care. In this chapter the concept of sociotechnical imaginaries (Jasanoff, 2015) is used to understand how societal norms and biases are reflected in the foreseen desired futures that technologies ought to enable.

The following chapter six discusses the representations of older adults. Here bias is discussed in relation to the concepts of third and fourth age. It is argued that the field of HRI in elder care (re)produces ageist assumptions, as is reflected in the representations of older adults.

The thesis ends with a conclusion in chapter seven. It briefly recaps the main findings, sets an agenda for further studies, and discusses limitations. It is argued that the premises related to social robots in elder care relate to issues of agency and communicative dominance, and the organization and standardization of care work. In terms of biases, ideas of ageism and neoliberalism are embedded in the field of HRI. These findings are discussed in a broader framework.

1.3. Publications

For full transparency, it needs to be mentioned which chapters are currently submitted, under review or published in an academic peer reviewed platform. Chapter three is submitted as part of an anthology about social robots in institutional interactions, at Bielefeld University Press. Chapter five is under review at *The International Journal of Ageing and Later Life.* Chapter six is published (Burema, 2021) albeit with modifications at *AI&SOCIETY*. Chapter four will be considered for submission in the future.

It should be noted that chapter two (theoretical framework), chapter three (method and methodology) and appendix A and appendix B are used throughout all the published and submitted manuscripts since all resulting academic publications from this thesis apply roughly the same general method and theoretical framework.

2. Literature Review

The literature in which this dissertation is situated in, relates to two themes: boundary work and the location of sociotechnical agency. In this thesis, boundary work refers to theories and concepts that discuss the active shaping of technological content. It thereby helps to understand not only how content and construction are relational, but also how issues of bias could be part of that process, which is one of the core aims of this dissertation. Furthermore, this dissertation aims to understand conceptual premises that eventually would inform a conceptual framework. By trying to answer what social robots in elder care “are”, this thesis by default engages in the ontologically positioning of subject and object in terms of agency. Therefore, theories from different disciplines are discussed that debate the nature of the artifact: do technologies have agency, is this a fundamentally human quality, or is it wrong to ask this question in the first place? What specifically is of interest in this dissertation is the theoretical debate about agency as described by Introna (2014): inter-actional perspectives of agency (with a dualistic divide between subject/object), and intra-actional perspectives of agency (that relies on a relational ontology).

These issues of boundary work and sociotechnical agency are found across various academic disciplines, most notably in media studies, STS, and (post)phenomenology. Therefore this literature review is not limited to one discipline only, but rather discusses various theories and concepts across disciplines that relate to the themes of boundary work and sociotechnical agency. It should be noted that the discussed concepts and theories are purposefully selected on the basis of their relevance to the two themes. In other words, this chapter is not a systematic or scoping literature review, but rather a purposeful framework that guides the remainder of the dissertation.

The discussion of the literature begins with describing theories and key concepts of boundary work (Paragraph 2.1), followed by ontologies of sociotechnical agency (Paragraphs 2.2 onwards).

2.1. Boundary work

There is a body of literature that argues that the social construction of technology matters in relation to technological content. Before explaining what this means, it should be noted that the discussed concepts and theories all relate to the active shaping of technologies but not all are situated in the same discipline or take the same ontological approach to sociotechnical agency. The following paragraphs discuss such concepts regardless of discipline or ontological position.

In STS, one of the most obvious examples of a theory that describes the active construction of technology is Social Construction of Technology, in short SCOT (Bijker & Pinch, 1984). This theory explains how the path towards a technological artifact is neither neutral, inevitable, nor a linear one, but rather is a result of a complex process in which multiple social groups are responsible for the construction of an artifact.

This theory mentions several concepts that help understand how technologies are made: relevant social groups, interpretative flexibility, stability and closure, and a wider context. When studying a single artifact, one needs to identify relevant social groups in the construction of that particular object because several groups could potentially actively contribute to the shaping of that technology. Related to that, Bijker (2010) mentions “For describing the high-wheeled ‘ordinary’ bicycle in the 1870’s such groups were, for example, bicycle producers, young athletic ‘ordinary’ users, women cyclists and anticyclists" (p.68). This identification of social groups is a first step to understand how it is related to interpretative flexibility, as Bijker (2010) argues "Because of the description of an artefact through the eyes of different relevant social groups produces different descriptions- and thus different artefacts – this results in the researcher's demonstrating the 'interpretative flexibility' of an artefact. There is not one artefact, but many" (p. 68). In other words, different people interpret the same technology in a different manner. However, over time, different meanings and interpretations can converge, some could diminish in their influence over the design, while others establish their dominance. This is a process of stabilization in which eventually closure is reached when the artifact reaches its final form. The wider context, as a final analytical part of SCOT, is the understanding of a wide sociopolitical milieu that structures the social construction of a technology.

Boundary work here refers to different social group's influence over the artifact. As different groups have different readings of the technology, the artifact is interpretatively flexible. "In the case of the 'ordinary' bicycle: there was the 'unsafe' machine (through the eyes of women) and there was the 'macho' machine (through the eyes of the young male 'ordinary' users). For women the bicycle was a machine in which your skirt got entangled and from which you frequently made a steep fall; for the 'young men of means and nerve' riding it, the bicycle was a machine to impress lady-friends" (Bijker, 2010, p. 68). Understanding technological content and its boundaries in SCOT, therefore, is to understand the influence of different people on the artifact's identity. However, as also acknowledged by Klein and Lee Kleinman (2002), this does not mean that different groups have an equal amount of power of the process of technology construction. Not every group is equally represented in the process of attributing boundaries to the technological object, which according to Klein and Lee Kleinman (2002) is not too often emphasized in SCOT. Also, other key criticisms to SCOT refer to the lack of acknowledging technologies' influence on the process of technology construction. Over the years, SCOT has responded to such criticisms by adding concepts such as "technological frame" and "sociotechnical ensemble" to their theory (Bijker, 2010).

Nonetheless, despite its (now more nuanced) social constructivist focus, the key understanding that technologies are malleable lies at the center of this dissertation. Indeed, at its core, this thesis aims to understand the ideas that shape the field of HRI and the boundaries ascribed to social robots in elder care. However, this thesis does not look at several social groups or stakeholders in the analysis in the construction of technologies. In other words, this dissertation does not give a historical account of which actors were involved at what stage of technology development, and which ideas were stabilized and reached closure. Nonetheless, the premise that technologies are malleable and not developed in a vacuum is acknowledged in this thesis. Furthermore, while not *all* stakeholders and social groups are listed, one of the most key influencers in the social construction of technologies are studied in this dissertation: researchers in the field of HRI. Why specifically this group is analyzed is explained in chapter three.

Taking it one step further from a humanist perspective, the concept "scripts" in STS refers not only to social actors (inscribing), but also its technological content (scripts) and its reception by users (describing). Scripts acknowledges that objects have certain assets inscribed in them that invoke certain reactions from its users, while limiting other reactions. Akrich (1992) developed this concept in order to illustrate how designers actively try to "define a framework of action" (p. 208). Scripts make people do something in accordance with the "instructions" embedded in the artifact. Verbeek (2006) illustrates the concept of scripts with a speedbump: it forces drivers of cars to slow down. In other words, scripts refers to technological content and what it does to users. Also, inscribing refers to the worldview behind the script. As Akrich (1992) explains: "A large part of the work of innovators is that of 'inscribing' this vision of (or prediction about) the world in the technical content of the new object" (p.208).

This could be further explained with the concept of delegation (Latour, 1992, as cited in Verbeek, 2014). Referring back to Verbeek's (2006; 2014) example, a speedbump embeds more meaning than just the "instruction" to slow down. The assumption is that people might drive too fast, so it delegates the task of a police officer. It could be strategically placed, for instance in a residential area where children play. It is thereby not a neutral object, but rather part of an actor-network with distributed agency. It should be mentioned that Akrich (1992) also mentions the importance of understanding the (mis)alignment between user and script with the twin-concept of description. Description emphasizes that usage is not necessarily follow naturally from the script. So, technological intent does not follow usage.

With scripts, one could observe the mechanism of boundary work, i.e. the attempts of designers to mold their visions into an object, thereby structuring the technology. Similar to scripts, Woolgar (1990) uses the analogy of machine-as-text in order to describe roughly the same mechanism, but in relation to the active configuration of users by designers. In his ethnographic work in a company producing microcomputers

"DNS", Woolgar (1990) noticed much like scripts how certain actions from users are encouraged while other actions are not, like text writing and readership in which certain parts of the text are made more important than others:

> "Textual organization refers critically, as far as the sense to be made of it is concerned, to the relationships made possible between the entities within and beyond the text. Certain characters become central to the story and others peripheral; groups of actants join forces while others disperse; the activities and achievements of some are highlighted, while others are relegated to the background, silenced and unnoticed (…) The text might be said to be designed (perhaps implicitly, perhaps unconsciously, but always within a context of conventional resources and expectations) for the reader. What sense will she make of this (or that) passage? In configuring the user, the architects of DNS, its hardware engineers, product engineers, project managers, salespersons, technical support, purchasing, finance and control, legal personnel and the rest are both contributing to a definition of the reader of their text and establishing parameters for readers actions. Indeed, the whole history of the DNS project can be construed as a struggle to configure (that is, to define, enable and constrain) the user" (Woolgar, 1990, p. 69).

In other words, configuring the user is about establishing relational boundaries between user and product, much like a script by designers. Certain uses are encouraged, while others are discouraged. Woolgar (1990) interestingly also discusses how designers participate in "othering" of users: when users "fail" to use the product in the way it was intended by designers – they are sometimes blatantly ridiculed by designers for not using it the “correct” way.

If machines could be treated as texts, it is not as big of a stretch to introduce very similar theories in media studies about encoding and decoding (e.g. Hall, 1980/2006). Inspired by Hall (1980/2006), Morely (1980) argues that mediated messages in television have polysemic structures. Polysemy and homonomy are two concepts in linguistics and semantics (e.g. Utt & Padó, 2011), but seem to, rather ironically, have a different meaning in media studies.

In linguistics, homonomy describes how certain word spellings or pronunciations that are similar have different *unrelated* meanings such as bank – it could refer to a financial organization (i.e. institute), or it can relate to a river bank (i.e. nature), whereas polysemy describes how the same word could have different *related* meanings - a chicken could refer to the animal, but also to the meat for dietary consumption (Utt & Padó, 2011). Although polysemic words have different meanings, depending on the context, the root of the word’s meaning is derived from the same thing: a creature (living or dead). However, Morely (1980) uses the term polysemy differently in his interpretation of the encoding/decoding model. According to him, encoders (i.e. people constructing the message) try to get a certain reading of their message across the audience, but the nature of the message always leaves room for interpretation, though the possibilities for interpretation are not limitless:

> “The TV message is treated as a complex sign, in which a preferred reading has been inscribed, but which retains the potential, if decoded in a manner different from the way in which it has been encoded, of communicating a different meaning. The message is thus a structured polysemy. It is central to the argument

> that all meanings do not exist ‘equally’ in the message: it has been structured in dominance, although its meaning can never be totally fixed or ‘closed’” (Morely, 1980, p. 129).

Polysemy in this sense refers to media message itself being multi-interpretable, albeit in a structured way. This notion is similar to the work of Fiske (1986) that discusses how broadcasted messages must be polysemic in order to appeal to a wider audience with different socio-demographic characteristics.

So, similar to theories and concepts developed by Woolgar (1990) and Akrich (1992), the aforementioned scholars argue that mediated texts, much like artifacts, are actively shaped by their encoders – i.e. involvement in boundary work. The decoders, or receivers, of the messages have room to resist or negotiate meaning from the message or thing they interact with, but ultimately the encoded message is the production of boundary work.

This encoding/decoding model was developed in the second half of the twentieth century, i.e. theories about new media and digitalization were not developed then yet. Currently, in media research, datafication as a concept refers to the quantification of everyday life which translates into data, and is being further used as further output (Mejias & Couldry, 2019). The difference between this concept and the other ones listed thus far, is that the actor who is contributing to the construction of technologies by providing data, are the users themselves through e.g. an app or a social networking site. In other words, datafication does not necessarily refer to the *active* construction of technological content by designers, but rather to the shaping of technological content in part by the users themselves. This theory therefore, although relevant in this day and age of big data and the quantification of the self, will not be considered for further analysis – since the type of boundary work in this dissertation explicitly discusses the *active* boundary work of *scholars* working in the field of HRI and their (ideological) expectations and visions, and not necessarily how quantified elements of life are informing the constructions of social robots.

Referring back to theories that discuss the active construction of technologies, Verbeek (2006) argues that designers inherently engage in materializing morality. He therefore takes the discussion of boundary work one step further into normativity compared with the other concepts. In order to understand his ideas in-depth, one needs to understand the theoretical tradition his research is based on, i.e. postphenomenology. The postphenomenological tradition emphasizes concepts such as lived experiences, sensory experiences, perceived experiences, and relational experiences via technological mediation. For Verbeek (2006) and Ihde (2008), technologies and humans ought to not be reduced to certain essentialist viewpoints, as these are relational concepts. A thing has intentions, but these intentions are relational – i.e. they are not inscribed *in* them but come about in contexts as subject and object co-shape each other's realties – thereby aligning with an intra-actional perspective on sociomaterial agency. This notion is often accompanied with two interrelated concepts of technological intentionality and multi-stability.

Technological intentionality refers to the idea that technologies are not neutral (Verbeek, 2006). They are able to actively mediate people's experiences. However, this does not mean that the technology *has* certain qualities embedded in it, as the concept of multi-stability explains (Ihde, 2012): the same artifact could have multiple stabilities, or "identities", depending on the usage in a specific situation. This resembles the concept of interpretative flexibility in SCOT. But whereas in SCOT interpretative flexibility is one step in the process of technology construction that eventually reaches closure through stabilization, multi-stability acknowledges that technologies are never "fixed" and therefore by definition never will reach "closure" in the sense that SCOT articulates.

So, typically, postphenomenologists do not refer to essentialist characteristics of an object, but rather refer to the relational meaning between the human and non-human. Verbeek (2006), however, expands on the notion of intentionality and multi-stability, and concludes in his paper that designers ought to anticipate the usage of artifacts in order to *actively* steer moral and ethical design. In other words, Verbeek (2006) argues for the deliberate attempt to create ethical artifacts. This idea of boundary work as a relational activity is also found in the concepts of configuring the user (Woolgar, 1990) and scripts (Akrich, 1992). Verbeek (2006) also notices similarities between the concepts of "scripts" and "technological intentions". According to Verbeek (2006), these concepts describe different elements of technological mediation: "scripts" focuses on action, while technological "intentions" focuses on perception. In other words, scripts as used in STS literature would make users *do* something, while postphenomenologists focus on *perceptions* of reality.

All the aforementioned concepts have similarities in terms of the articulation of sociotechnical visions in the development of technological content. The core idea underlying each concept is that technologies are not neutral tools to be used as they are actively constructed (by social groups), have material boundaries, configure the user etc. (exact wording depends on the theoretical tradition one works in), but also do not determine human action and perception (with concepts such as de-scription, decoding or multi-stability). While all these concepts enable descriptive research, e.g. understanding *what* technologies embed *which* ideas, it is not a big stretch to also use these concepts to analyze how particular normative visions and expectations are embedded over others. Verbeek (2006) already makes the (very necessary) connection between normativity and inscription in the design of artifacts, but in the context of this dissertation, the relationship between sociotechnical bias needs to be further tailored to the field of HRI. This could be done with the emerging field critical robotics research, as is explained next.

Critical robotics research is a new field that applies critical thinking to the field of robotics (Serholt et al., 2021). It does not exclude the aforementioned concepts and theories that discuss boundary work. On the contrary, concepts and theories that discuss boundary work are a good stepping stone to understand how bias and ideologies relate to the field of HRI. However, critical robotics research as a field makes the *explicit* connection to robotics. This thesis does exactly this: analyzing boundary work to the field of robotics (HRI) through a critical lens. Who designs which machines for whom with which normative ideas in mind? Chapters five and six are discussed via this critical lens.

Nonetheless, boundary work does not always have to be discussed in terms of power and normativity, as chapter four illustrates. In chapter four, different interpretations of technological content by scholars working in the field of HRI are discussed. This research is more descriptive than critical, but still uses the main theoretical understanding of boundary work, i.e. how technological content and technology construction are relational. Additionally, chapter four discusses subject-object relations and agency, as is explained next.

2.2. Inter-actional accounts of agency

In chapter four, social robots in elder care are conceptually clarified. This is done with an empirically constructed conceptual framework, that discusses both inter-actional and intra-actional perspectives of sociotechnical agency. Inter-actional accounts of agency refer to theories that treat the subject and the object as two different entities that interact, while intra-actional accounts of agency refer to relational intra-actions, i.e. the subject and the object cannot ontologically be separated from one another as they co-constitute each other (Introna, 2014).

Introna (2014) mentions Value Sensitive Design (VSD) as an example of an inter-actional theory, as designers are seen as active agents that shape the object according to their values. This theory acknowledges the special position of humans in the design of technologies. Similarly, SCOT acknowledges the relevance of discussing social groups for their influence on technology construction (Bijker & Pinch, 1984). It embeds a humanist, social constructivist position in which the spheres of influence are uni-directional.[3] One of the most fundamental differences between VSD and SCOT, is that the former is rooted in design disciplines, while SCOT is used in STS to describe social processes. Nonetheless, both perspectives embed an inter-actional perspective on sociotechnical agency.

Interestingly, while Introna (2014) limits his discussion to VSD and its social constructivist perspective on subject-object relations, and no other social constructivist theories such as SCOT, one could also argue that equally important in describing inter-

[3] However, over the years SCOT has been introducing concepts that broadens their social constructivist vocabulary (e.g. sociotechnical ensemble) as mentioned by Bijker (2010).

actional subject-object relations are technologically deterministic theories. For instance, one of the most radical technologically deterministic theory is medium theory. Even though Introna (2014) mentions how inter-actional views on agency typically involve allocating agency primarily to humans instead of non-humans (and thereby adheres to a Cartesian notion of subject/object), medium theory typically puts the emphasis on studying structured communication due to inherent features of a medium (Croteau & Hoynes, 2003). Thereby, it still adheres to a dualistic approach of the human/non-human, but it does not necessarily put human agency at the forefront. It is a rather a technologically deterministic theory, that divides the humans from the non-humans, and in that sense could be interpreted as an inter-actional theory of agency.

Specifically, medium theory refers to the technical structures that impact social life in ways that go beyond the content of certain media (Meyrowitz, 2019). In *The medium is the message*, McLuhan (1964/2006) refers to that particular mechanism of how the inherent *structure* of an artifact, in this case a medium, surpasses the relevance of for instance media *content*. This phrase illustrates how medium theorists give mainly credit to the structure of the materiality itself rather other components relevant in communication sciences such audience reception, media content, media diffusion etc. (Croteau & Hoynes, 2003).

Certain types of media allow for certain types of communication (Trenholm, 2011; Balnaves et al., 2009). So in essence, the medium itself structures communication by enabling certain types of information exchange while inhibiting other types. Traditional media, such as television and radio, are examples of broadcasting media, i.e. one-to-many communication (Croteau & Hoynes, 2003; Trenholm, 2011). So there is one sender and many receivers. A telephone call or written letters comprises of one-to-one communication (one sender and one receiver). However, with new media, communication structures can vary with one-to-one, one-to-many, many-to-one, and many-to-many. One could use the Internet to send emails, which could involve one sender and one receiver, but it could also involve one sender and many receivers (Croteau & Hoynes, 2003). Wikipedia, and wiki entries in general is an example of many-to-many communication. Many people work on a message, and many are able to receive that message. Many-to-one communication could occur with for instance feedback on customer services on websites or social media. It should be noted that, social media, or Web 2.0, often comprises a mishmash of all the aforementioned communication structures. In other words, the structure of the medium permits certain forms of communication that is irrespective of the content of communication.

In terms of subject-object relations, this means that the medium influences people in a dualistic manner: media have certain qualities (i.e. essentialism), that exert their influence on another entity (i.e. humans). When taking an inter-actional perspective in mind for the study of HRI and the development of a conceptual framework, one could talk about robots "having" certain qualities of essences "in" them. Specifically when applying medium theory, one could look at e.g. material structures because the material structures of robots could then possibly shape future interactions: Paro is a fluffy robot designed for touch, while the robot coach Bandit used in Fasola and Mataric (2012) relies on other modalities such as visual input and auditory cues. Taking medium theory into account, one could argue that this difference between modalities and other structures inherent to the robot would then ultimately result in different types of interactions possible between humans and robots.

However, one could still argue that this theoretical perspective is too technological deterministic. Indeed, this theory has a very particular position in the debate about human agency, non-human agency, and directionality of influence. It implies that the medium itself, or in this case the robot, has rigid, well-defined, and essentialist characteristics. This is radically different from an intra-actional account of agency, in which “influence” and “agency” is ontologically conceptualized as inherently enmeshed.

2.3. Intra-actional accounts of agency

Compared with the inter-actional approach to agency, the intra-actional approach moves away from the notion that technologies “are” certain things and the strict divide between subject and object, as they are rather co-constitutive or intertwined. Continuing that line of reasoning, the social and the technical cannot be ontologically separated from another when discussing the design of an artifact, hence the term *sociotechnical* (Introna, 2014).

In media research, as Couldry and Hepp (2013) rightfully mention, typically, media are analyzed in terms of three analytical pillars: media production, media content, and media reception. This leads to the separation of the three themes in one’s research instead of viewing them as an inseparable collective, and too often focuses on one medium only. Mediatization offers a different approach by introducing concepts that allow researchers to study media from a holistic perspective (Hepp & Hasebrink, 2018). However, as Kuipers (2018) argues, mediatization echoes arguments already established in other fields, most notably (post)phenomenology, which then is applied specifically to media research albeit with a new vocabulary. For that specific reason, this dissertation now turns to intra-actional accounts in postphenomenology and STS research, as they ought to be considered as foundational building blocks in the establishment of an intra-actional paradigm.

Postphenomenologist Ihde (2008) was already cited, but to briefly recap, he builds on the notion of phenomenologists such as Edmund Husserl and Martin Heidegger who already established in the early years of the 20^{th} century that in order to understand and study “reality” or “the world” one ought to move away from a dualistic divide between subject and object by understanding relational experiences.

Heidegger (1927/2001) famously demonstrated this with his example of a hammer. A hammer on its own does not do much. It becomes only relevant in relation with its use – i.e. by hammer*ing*. But by doing so, humans use the hammer as a tool to do something or achieve something and thereby it is intentional and a means to an end. However, the tool analogy is more than just a means to an end, as it also simultaneously shows how things sometimes are taken-for-granted in our actions. When hammering, one simply does so like an extension of the human body. A person would usually not pick the hammer up and glare at it with amazement. Rather, it is a taken-for-granted activity, and not a very conscious effort to glorify the technology “*an sich*”. Doing something implies directionality. One hammers *something*. The relevance of the hammer for the user is therefore not located in the hammer itself when hammering, but the nail that goes into another object. When this happens, the tool fades into the background, much like the extension of the human body and out of the consciousness of the human user. The tool is then according to Heidegger (1927/2001) ready-to-hand. When this does not happen, for instance, one misses the target or the hammer falls apart, the user becomes conscious of the artifact – i.e. it unveils itself. Heidegger (1927/2001) calls this present-at-hand.

But no matter how these tools are used, according to Heidegger (1927/1962, as cited in Introna, 2014), the intentionality shows our position, or being-in-the-world. This dissertation is not merely a text: it is a document that serves as a piece of evidence that helps the writer to become a certified academic. It is intentional. When the intentions of humans meet with the possibilities of technologies, they become relational. In other words, things on their own do not have much relevance, but are relevant in relation to other things or humans in order to "reveal" a way of being in the world. This text does not "construct" my identity as a scholar, but it "reveals" it. While this latter statement is disputable – is the world and our being-in-the-world really a process of revealing some kind of grander or singular "truth" much like a positivist understanding of reality? – the idea that "being" is in fact a relational "doing" has gotten a lot prominence in the years following his work.

Postphenonomenology also acknowledges the importance of relational interactions between humans and technologies, but rather than viewing technologies as tools to "reveal" the world, the idea of technological mediation and multi-stability is more at the forefront in postphenomenology (Aagaard et al., 2018). Instead of understanding and experiencing the world in a non-mediated manner, as if the tool is an extension of the human body, technologies mediate between humans and the world. Whereas Heidegger ontologically treats technologies as tools, i.e. mute or neutral things that extend the human body that ultimately function to reveal the world for humans, postphenomenology acknowledges that the same object has multi-stabilities, thereby it cannot "reveal" the world in a singular way. So, postphenomenology is pre-occupied with understanding context-specific technology use. Objects furthermore also actively mediate realities. In this process, or interactions, technologies could actively dampen/inhibit, or evoke/accentuate certain experiences from others (Verbeek, 2006). In other words, even though technologies can mean different things to different people, they are never "neutral" or "mute" (Aagaard et al., 2018).

Though this tradition has evolved into one of the pillars in which HRI could be studied in, the abundance of case studies in the field could be partly be ascribed to this and similar traditions that also embrace an intra-actional account of technological agency. Indeed, if interactions with technologies are relational and cannot be described in terms of essences, one ought to only observe interactions in their contexts: specific technologies, with specific users, in specific places, in specific times of elder care reforms. In other words, it paves the way for case study research, by focusing on very specific interactions. Also, since postphenomenology has a tradition rooted in embodiment or hermeneutic experiences, often, the researcher is not only the narrator of their scholarly works (i.e. first-person writing technique), but also functions as their own analytical filter. In other words, postphenomenologists by default do not attempt to describe how others feel or experience technologies, since lived or embodied experiences are reduced the body that experiences it - whatever technology "it" might be (Aagaard et al., 2018).

Other scholars have promoted similar ontological ideas about subject-object relations in different fields – with similar empirical consequences. Anthropologist Suchman (2007) also emphasizes that ongoing relational practices (or reconfigurations) are key for understanding sociomaterial agencies. "Ongoing" implies that agency is a process and not a static characteristic, "practices" implies performativity (i.e. *doing* as a bottom-up activity instead of top-down analyses and observations), and "relational" implies a configuration consisting of humans and/or non-humans. In other words, according to Suchman (2007), agency should be understood as the ongoing enactment of relations. Boundaries exist through relational repetitions, instead of inscribed in subject or object. Her ideas are inspired from Barad's notion of agential intra-action.

Barad (2003) introduces the concept of posthumanist performativity in order to describe how reality is the enactment (or performance) of assemblages of materiality (with or without humans). Entities are according to her *an outcome* of a process or performance within phenomena, instead of inherently distinct pre-existing characteristics: hence *intra*-action (i.e. within) rather than *inter*-action (i.e. between). This means that defining "things" or "humans" as such is a hollow practice: it is merely representational instead of actual. Things only come into being by a so-called "agential cut" (Barad, 2003, p. 815), in which boundaries could be observed. But again, these are not "inherent" or actual boundaries, but rather stable and routinized performances of matter. The performance of materiality is at the core of Barad's (2003) work. To quote Barad (2003) in her own words:

> "Therefore, according to Bohr, the primary epistemological unit is not independent objects with inherent boundaries and properties but rather phenomena. On my agential realist elaboration, phenomena do not merely mark the epistemological inseparability of 'observer' and 'observed'; rather, phenomena are the ontological inseparability of agentially intra-acting 'components.' That is, phenomena are ontologically primitive relations—relations

> without preexisting relata. The notion of intra-action (in contrast to the usual ‘interaction,’ which presumes the prior existence of independent entities/relata) represents a profound conceptual shift. It is through specific agential intra-actions that the boundaries and properties of the ‘components’ of phenomena become determinate and that particular embodied concepts become meaningful. A specific intra-action (involving a specific material configuration of the ‘apparatus of observation’) enacts an agential cut (in contrast to the Cartesian cut—an inherent distinction—between subject and object) effecting a separation between ‘subject’ and ‘object.’ That is, the agential cut enacts a local resolution within the phenomenon of the inherent ontological indeterminacy. In other words, relata do not preexist relations; rather, relata-within-phenomena emerge through specific intra-actions. Crucially then, intra-actions enact agential separability—the local condition of exteriority-within-phenomena” (Barad, 2003, p. 815).

For Suchman (2007) and Barad (2003), the focal point of their work centers around what one could call a “continuous doing”. Another theory that acknowledges a relational ontology between humans and non-humans is Actor Network Theory (hereafter ANT), developed by, amongst others, Latour (2005).

In ANT, humans and non-humans are treated with the same conceptual (un)importance. This does not mean that artifacts are spirited or possess agency. Rather, it means that the often assumed importance of human agency and intentionality is limited, or even non-existent (Verbeek, 2014). In other words, ANT acknowledges that both humans and non-humans do not *have* agency. Agency is rather distributed in a network, much like morality (Introna, 2014; Verbeek, 2014). In the debate whether humans or guns kill people, it is neither. It is the actor-network that does so. But because of this distribution of agency in a network, and the impossibility to locate and allocate responsibility, morality or agency in either human or non-human, it makes it difficult to make any claims about concepts such as “justice” or “ethics”. In the case of whether guns or people kill people, one cannot attribute this to the human alone, how then would this translate into society and its justice system? And what does that mean in terms of user-designer relations?

2.4. Bridging inter-actional and intra-actional theories: Flexible essentialism

Without going into too much detail about the critiques on ANT[4], it suffices for now to state that there is a large body of literature that suggests that humans and non-humans ought to not be studied separately, but rather in relation with each other. Although this ontology of human-machine relations and agency definitely leads to interesting studies, it simultaneously leads to studies with a rather specific empirical focus. As mentioned in the introduction, the field of HRI in elder care is marked by specific cases of HRI. The idea of ontological relationality means having to study unfolding relational performances/networks/mediations etc. (exact phrasing depends on the theoretical tradition), which often leads to ethnographies that go in-detail about very specific and contextual observations. While this undoubtedly gives rich data and thick descriptions, it is one of the issues that has led to the formation of the PhD thesis: the lack of generalizable findings due to the case-specific nature of studying HRI. Exactly why this

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[4] Some critiques relate to “the flatness of networks” (Jasanoff, 2015, p.15). Suchman (2007) for instance briefly discussed the different relational roles between humans and non-humans with her notion of “dissymmetry”, and Jasanoff (2015) argues that ANT lacks a perspective about power and dominance within networks.

unfolds into case studies is explained in chapter three. At the same time, theories that make an analytical distinction between subject/object allow for generalizations but are not sensitive to contexts and situational performances. This framework therefore also unfortunately refers to only one piece of the puzzle when trying to understand the meaning of HRI in the field of elder care. In other words, the inter-actional and inter-actional approaches to (non)human agency have their own ontological and epistemological strengths and weaknesses.

In this thesis, chapter four reconciles both perspectives. An essentialist perspective allows for generalizations while an intra-actional account of agency allows for contextual nuance. They simply answer different questions of the same phenomenon. A reconciliation allows for the introduction of an ontology with more methodological flexibility. This dissertation empirically developed a theory that does exactly so: flexible essentialism.

As explained in chapter four, flexible essentialism consists of the understanding that both essences and relationality are important to study, as they both give different types of information. Flexible essentialism consists of two core concepts: robot versatility and interpretative flexibility. Robot versatility is similar to the discussed concept of polysemy: some robots are more ambiguous in their meaning because of their (lack of) versatility. Whereas Paro and Pleo are plug-and-play type of robots typically used for older adults with cognitive impairments in play-based situations (e.g. Perugia et al., 2017a; Pfadenhauer & Dukat, 2015), Nao and Pepper are robots that were found having different roles, e.g. taking standardized medical tests, or functioning as an interface in for instance smart housing or playing games and quizzes and telling jokes (Boumans et al., 2018; Bechade et al., 2017; Werner et al., 2012). While the former type of robots are single-purpose robots, the latter type are multi-purpose. In other words, it makes sense to differentiate robots in terms of their characteristics, i.e. essences, because that ultimately provides a context for interpretation. Some of these contexts are easier to anticipate due to the lack of versatility coming from the robot, compared with versatile robots.

While this latter statement is inspired by medium theory and polysemy, flexible essentialism simultaneously stresses the relational importance of what technologies “are” with its wider environment. Interpretative flexibility, although already established in the literature as a concept (Bijker & Pinch, 1984; Bijker, 2010) together with numerous other concepts that describe the multi-stable nature of technologies (Ihde, 2012), still has its relevance in understanding the relational importance of technologies. Indeed, applying a postphenomenological perspective, technology is only relevant when in use. A robot might “*objectively*” be more suitable for e.g. touch (e.g. Paro), but this experience can vary in different contexts. For instance, Paro was used as a stimulus for interpersonal conversation, instead of functioning as a fluffy cuddling object in the study of Kidd et al. (2006). In other words, while robots are made of particular structures and content, what it “is” needs simultaneously relational human/non-human scrutiny.

Since flexible essentialism combines both relational ontologies and essentialism of human/non-human agency, it opens up research possibilities that enable the study of situational nuance as well as generalizable statements about “reality” as such. Chapter four elaborates on this latter statement. This reconciliation of two theoretical perspectives is not simply the result of reflecting on the literature and an attempt to creatively combine both perspectives. Rather, flexible essentialism is the empirical result of using grounded theory in the field of HRI. How the empirical work and theory are connected to each other is explained in chapter four and in appendix D. What follows next is a detailed explanation of the methodology and method.

3. Methodology and methods

The aim of this chapter is twofold. It first of all presents arguments as to why the field of HRI in elder care is focused on case study research, and how this thesis aims to foster generalizability. The second objective is to present the research design of the three empirical studies in this dissertation. This section discusses the methods used for this dissertation.

3.1. Methodology

Studying social robots in elder care often results in case study research (e.g. Cortellessa et al., 2018; Damholdt et al., 2015; Jonell et al., 2017; Kidd et al., 2006). Though case study research comes with its own benefits, it taps into old discussions in the social sciences about "the general" and "the specific". Indeed, due to the contextual nature of the phenomenon of social robots in elder care (different robots, different care provision, different users, different cultures, etc.) it complicates matters to conduct studies that foster some type of generalizability.

Even though situating research in its general or specific qualities is one of the most common practices in the social sciences, the field of HRI in elder care poses a very particular methodological challenge when discussing "the general" and "the specific". For the field is not only especially marked by its heterogeneity as the interactions made available depend on e.g. the machines, users, care provision and policies, cultural and national contexts, also the sheer amount of newly developed robots adds to the complexity of the phenomenon. Computer science and engineering are inherently dynamic disciplines. Technologies are always beta and susceptible to change. Newly developed robot could trigger new relational meanings between humans and machines. The methodological challenge of studying HRI in elder care is thereby similar to that of a moving target: as the technological possibilities for HRI diversify due to continuous technological development in the field, the need to capture social outcomes (e.g. wellbeing, acceptance, ethics, caregiving etc.) due to the introduction of new technological stimuli follow (Dautenhahn 2014, as cited in Seibt, 2017).

In other words, when trying to explain human responses to robots, it might be insufficient to solely conduct research on very particular robots with very particular users in very particular care settings: it won't provide insights about "the" effects of HRI, the scope of HRIs possible in elder care, or capture the opinions of "the" users. As HRI is a very dynamic field and new artifacts are continued to be developed, social scientist can only take a snap-shot of how a certain technology relates to social issues in that particular context – i.e. time and place. The question then becomes, why is there an need to generalize, and if needed, how to overcome the contextual nature of HRI in elder care?

Indeed, concerning the former question one could ask why there is a need for general claims: if the field is dynamic and fragmented, then academics ought to be sensitive to case-specific examples. While the level of variance in the field should indeed be acknowledged, understanding general patterns of HRI in elder care would advance the field from both an academic and a societal point of view. From an academic perspective, there is a need for theory development. There is no sociological theory on social robots and the development of theory could inform other researchers about the foundational aspects of HRI in elder care: instead of going through a lot of case studies to understand e.g. which technological possibilities exist in relation to which users, one could directly look up concepts and theories that already aggregated such information. Also, as explained in chapter two, part of this thesis is embracing an essentialist perspective. One then must look at general patterns to understand the “essences” of technologies. From a social perspective, it would be easier to inform the general public and policy makers about the implications of HRI in elder care with general claims, instead of explaining how case-by-case scenarios develop. It therefore has societal value to communicate general findings to a wider audience. General questions about e.g. what robots are able to do for which older users can be answered, but not with research currently available in the field.

So, then, how can we foster generalizability in a field that is in flux and characterized by very specific robot technologies, users, care contexts etc.? In relation to ethnographic research, anthropologist Hasse (2019) already suggested an approach that might overcome the issue of contextuality. As ethnographers usually study their subject in-depth for a long period of time, Hasse (2019) argues for a multi-variation approach: trying to strategically diversify ethnographic cases. Thereby, one still relies on qualitative research methods while being able to compare cases. This comparison enables researchers to look beyond one specific case, and might even tentatively be able to speak about patterns.

Continuing Hasse’s (2019) argument, one could state that this would especially hold true if the cases are carefully selected on the basis of how they represent a particular niche in the field of HRI. For instance, if one were to look for a typical case of a social robot, one could have the criterion for the sales of the robots, or the number of usage as a way to determine the relevance of the case. One could hypothetically then select Paro, Care-o-bot, or Giraff as cases to name a few. Not only do would these robots then represent typical cases, but by selecting specifically these robots, one also notices that they are radically different in technical features. Paro is a toy like robot, most often marketed for older people with cognitive impairments, Care-o-bot resembles more of a robot assistant, and Giraff essentially made for remote communication. If carefully selected, and also depending on the research design and aim, one is able to conduct qualitative research while trying to establish patterns across the field by diversifying cases.

Nonetheless, one might argue that one of the reasons for the numerous of case studies on users emerged due to the expensive nature of the technological artifact. It is simply easier for researchers to work with technology that is readily available by e.g. the university or other affiliated institutions nearby. Related to this argument, Hasse's (2019) approach requires a lot of resources for ethnographers – e.g. financial resources to purchase robots, establish a network that allows access to different robots etc. While understanding general patterns of HRI based on qualitative user studies with for instance ethnography would undoubtedly advance the field further given the contextual nature of HRI, using an ethnographic multi-variation approach is not feasible for most researchers due to financial/logistical constrains. Unsurprisingly, in her work, Hasse (2019) relies on an international team funded by European Commission's Horizon 2020 program to achieve multi-variation case selection. This suggestion, though very promising for established scholars, is not so feasible for academics with little financial resources such as early-stage researchers, who often work on time-restricted projects with a limited budget and a small network.

Another possible route to increase generalizability is a more positivist approach by relying on quantitative research methods such as experiments or survey research. But also here, the case sensitive nature of the field complicates matters of generalizability. To illustrate, experiments often require a stimulus, but if the stimulus would be reduced to one or two robots, it would not say much about "HRI" as a whole. Also, even if a series of experiments with different robots were to be conducted, it would not be a sustainable approach to cover cross-case variance. Robots are expensive stimuli, and furthermore, the stimuli used in experiments are usually reduced to one stimulus, sometimes two stimuli, as an increase in the amount of stimuli also further complicates the research design (e.g. having to increase the amount of groups that are being compared).

Survey research, by contrast, does not capture direct effects of robots on human users. Rather, it allows for measuring opinions and statements by for instance primary users, secondary users, or designers. It, by definition, would not be able to capture direct observations of interactions between human and machine, the design process, or the study of objects. In other words, the study of perception of respondents does not measure things or social relations in a *naturalistic setting*. For this study specifically, the aim is to understand the foundational premise of HRI: its content and its ideological bias. If directly asked for bias, roboticists would probably not admit to it. Designers could be oblivious to the social norms that guide the construction of social robots in elder care. Even if admitted, the data would not describe how bias unfolds "in action" or in a naturalistic setting. In other words, a survey would dig up perceptions and ideas about the machines through a filter, instead of directly observing sites and places where these ideas are being articulated without the presence or the anticipation of an observing scientist.

There is a difference between the *perception* respondents have about the construction of the machine (i.e. what survey research enables), and the actual constructing itself (i.e. a naturalistic setting). Also, even if it were academically relevant for this research to study how experts perceive robots and the construction thereof, the lack of theory makes it difficult to formulate pre-tested survey questions. The whole point of this thesis is to develop sociological theory, as there is little known about what these robots mean and how to conceptualize them.

So rather than purchasing expensive and case specific stimuli or conducting survey research on the opinions of people, one needs a research method that enables the researcher to understand the robot across cases, preferably in naturalistic settings that allow for the development of theory. This brings the study back to qualitative research methods, although qualitative research methods typically do not allow for generalizations. Indeed, having expert interviews with designers would not say much about the construction of "the" social robot in elder care, as much as it would reflect how one particular group of roboticists make sense of their work. This thesis argues therefore to develop creative solutions in qualitative research to overcome this issue of generalization. Hasse (2019) is a good first attempt to do this. Indeed, ethnographies could give a solution to observing interactions, and cross-case variation could be achieved with the right resources. But since the budget and time for this PhD is limited, one has to resort to alternatives.

This dissertation therefore offers a different approach. It aims to foster generalizations, but not by focusing on users as test subjects for empirical research, or asking designers about their expertise in the content and construction of robots in elder care. Rather, this thesis is sampling assumptions about robotic content and information on the construction of machines readily available in academic publications. In academic publications, scholarly roboticists need to elaborate on their choices of design, the rationales, choice of robots, choice of users, choice of research participants (if any) etc. It therefore provides information on for instance how the machines are constructed, why, which methods they use, for whom and with what effects. It would enable the researcher to aggregate a lot of information on very different robots in a relative short amount of time within a sampling site that has clear boundaries in a naturalistic setting (i.e. without an intervening researcher entering the field).

As academic literature has clearly defined parameters, it allows for a sampling strategy with a systematic character. This enables the researcher to make general claims about "robots" in elder care, by aggregating information on so many different types of robots while being able to cover the breadth of the field with systematic sampling strategies. In other words, multi-case variation is easily achieved with this method. Furthermore, this enables understanding the construction of technologies without asking people directly or interfering with their work, i.e. the method is unobtrusive and naturalistic. The academic publications are first-hand documentations of what academics have done, instead of perceptions of what they have done by asking them with a questionnaire or an interview. Also, compared with experiments or ethnographers, the absence of an observer helps the research to be unobtrusive – e.g. there is no bias of a researcher observing roboticists or HRI in an ethnography, thereby possibly influencing observed interactions.

It is chosen to study the content of the academic publications qualitatively, as one of the main aims of this dissertation is to develop theory. There is not much literature that describes what social robots in elder care are able to do and what premises underlie these technologies. The meaning behind these technologies is analyzed, which is typically better understood with qualitative research methods than quantitative research. Also, it is rather impossible to quantify phenomena without pre-existing theories. An iterative, open, and flexible approach is necessary to analyze the data and to develop theory. The exact research methods rely mostly on grounded theory, though two studies were conducted with thematic analysis. The exact details of the data analysis is discussed in the second part of this chapter.

In short, the objective is to understand robots in elder care in their very basic and foundational premises (i.e. the understanding underlying patterns that tie across case variations), which is achieved by sampling academic literature about social robots in elder care systematically. By sampling diverse cases (various robots, various users, various contexts) in a field with clearly defined parameters and boundaries, allows the researcher to make general claims while being sensitive to the contextual nature of HRI by using qualitative research methods. The exact research methods are explained in paragraph 3.2. Although this research is using qualitative research methods to generate theory, it has a positivist undertone due to its aim to generalize instead of understanding situated and context-specific usage of technologies.

A counterargument would be to question the relevance of choosing academic publications as a sampling site. While indeed there might be a lot of robots developed outside of academia, this does not necessarily devalue the relevance of academia. In contrast with other scientific disciplines, in engineering and computer sciences, academia has stronger ties to the industry or other types of organizational institutions. To illustrate, one of the often-used example of a robot in elder care, Paro, has been developed by a team of Japanese roboticists in a research institute outside of academia, AIST. They published their initial tests and prototypes in academia (Wada et al., 2003a; Wada et al, 2003b). Furthermore, contrastingly to the industry, the advantage of academia is that they publish their findings in retrievable documents (e.g. proceedings of conferences or paper publications), which makes it easier to define the field. The industry does not rely on such a system, making it more difficult to capture the breadth of current technological possibilities. Knowing the parameters and framework of a research site, makes it easier to generate a representative sample. Finally, studies in academia sometimes also use robots developed in the industry and tweak it to test certain robotic features, reinforcing the statement that the line between the industry and academia are blurry. For instance, Nao (developed by Softbank robotics[5]) has been used by Prange et al. (2015) to study how older adults use smart pens to communicate.

In sum, this thesis acknowledges the need for multi-case variation when studying HRI in elder care. As the field now comprises of a lot of case studies on very specific settings of HRI, the field lacks a general sociological understanding of what these technologies are able to do and what that means. It is especially relevant create a sustainable theory about social robots in elder care especially due to the temporal aspect inherent to technology development. Studying HRI on a specific case would capture an interaction enabled by a robot that might be less relevant (i.e. studied, implemented, used

[5] For more information about the robot: https://www.softbankrobotics.com/emea/en/nao

etc.) over time. By taking a meta-perspective and aggregating a lot of cases of HRI in a pre-defined field where robot development takes place, e.g. academia, theories would be developed that span across different cases of technologies. While this is a more sustainable approach than conducting a couple of case studies, obviously, a theory derived from such data would need to be updated with every new "disruption" of the field, e.g. a new generation of social robots or a paradigm shift in (social) gerontology (e.g. normative perceptions on elder care and how care and aging "should" be performed and practiced). What is explained next are the three specific studies have been formulated for the purpose of this dissertation.

3.2. Methods

This research is based on a qualitative content analysis of 96 scientific publications. These publications are listed in appendix A. These scientific publications are the foundation for the dataset developed which each study relies on. Even though all studies rely on the same dataset, each empirical study has a slightly different focus, resulting in a different analysis and different codebooks for every study. What follows is a description of the overall design and sample that span across each of the studies.

3.2.1. Overall design and sample

Each study is based on the same constructed dataset. The sampling procedure that needed to build the dataset entails three steps, each with their own selection criteria. First, databases were selected. They were selected on the basis of their size and relevance to the topic, i.e. social robots in eldercare. The databases DBLP, Web of Science, and Scopus were chosen to retrieve those publications. These databases were selected since they include literature in engineering and social gerontology and because they nest other databases such as IEEE, ACM, and Medline in their digital libraries.

Then, search terms were selected. The publications should have incorporated two elements, namely, social robots and older adults. Therefore, terms were selected which referred to both concepts: *Social robot* in combination with age related elements ("*aged*", "*aging*", "*elder**", "*senior**", "*old**", "*dementia*", "**care**", "*Alzheimer*", "*ageing*"). The asterisk refers to search words that could be prolonged, such as "eldercare" or "elders" when looking up "elder*".[6] While there are different ways to refer to social robots as mentioned in the introduction, social robots was specifically chosen because the terminology implies a broader range of robots than for instance specifically "healthcare" or "tele-operated" robots. Also, the word "social" indicates something very interesting to social scientists. The selection of this particular word would result in the study of robots that would resemble the word "social" in one way or another. Chapter four specifically deals with the definition of social robots in elder care. The sampling procedure ended when all hits of the three databases were examined.

There was a couple of exclusion criteria adhered to. First, papers were excluded if studies did not relate to the main theme of this research: elder care and social robots. For instance, the search terms "**care**" in combination with *social robot* also retrieved papers related to pediatric care. These papers were excluded from the sample. Furthermore, literature that was listed double (e.g. when two or more databases were showing the same publication) was only sampled once. The literature was also screened

[6] It should be noted that DBLP is not sensitive to these symbols, making the sample slightly larger than initially hoped for.

on language, only publications in the English language were sampled. Moreover, papers were not selected if they did not develop an artifact or empirically analyzed one (i.e. publications that do not refer to specific technologies were not selected). Related to that, theoretical papers (mostly reviews) were omitted since they do not necessarily construct a technology or test one. The aim of this dissertation is to understand the development of HRI *in action* – i.e. theorizing about robots is not included. In other words, a strict sampling criterion relates to the introduction or development of a specific stimulus. However, within that sample, certain fields and research methods were not prioritized over others. Finally, since this dissertation is conducted by the author solely, i.e. one person, the sample had to be a manageable amount for three years of PhD work, resulting in a search query that took only publications into consideration that had the search words reflected in the title, or in the case of DBLP in the title and the journal's name[7]. This would filter out all the publications that would have the search terms somewhere else listed in the paper (e.g. in the main body of text or in the abstract). This resulted in a narrower search than ideally would be possible due to practical reasons, but it does have a theoretical advantage. For one could be very certain the selected publications really reflect the aim of the sample and the load of the search terms with titles such as: "Social Human-Robot Interaction for the Elderly: Two Real-life Use Cases" by Zlatintsi et al. (2017). The sampling procedure resulted in a database of 96 sampled papers. The sampling procedure was completed in June 2018. The flowchart in appendix B shows how many records were omitted with each step following a PRISMA model. To give a

[7] The journal's name was not initially part of the search strategy, but DBLP does not allow this option to be filtered out, resulting in a slightly larger pool of publications coming from DBLP compared with Web of Science and Scopus.

visual example of how the data was managed, appendix C shows how different publications were labelled as ‘included’ or ‘excluded’ and for what reason.

One could argue that this database is only relevant to its specific time of sampling. While admittedly, new robots might be developed since then, it is questionable whether a new generation of social robots are developed in such a short period of time. Surely, field disruptive new innovations might occur at any given point in time, but until then, this thesis is an attempt to capture technologies that matter in the field currently. Just because new technologies might be developed in the future does not necessarily mean that *current* technologies ought not be studied. Furthermore, while the study could be repeated with every new disruption in the field (e.g. the introduction and development of radically different new technologies), part of this study also relies on systemic and structural elements of HRI that could prove to be stable over time. For instance, ideas that drive innovation are not necessarily innovative in themselves per se. Studying the premise of robots in elder care is not necessarily prone to the content of technological innovation. While indeed, technological innovation might result in different robots in the new future, possibly with field disruptive new technologies, it is possible to look at the static features that enable HRI in elder care, instead of the dynamic features of robotic content. In other words, though the topic under study might change over time, it does not necessarily diminish the relevance of this dissertation – as both static and dynamic elements of this phenomenon are discussed.

These static and dynamic elements are articulated in the following three studies. The first study develops a conceptual framework in which the aim is to understand different types of social robots in elder care. This paper is meant as an overview, to understand the scope of what is currently possible in the field. Here, indeed the data is prone to changes over time. However, as mentioned before, since this dissertation is sampling a large number of robot-cases, it somewhat compensates for that. It gives a robust understanding of what is happening now by sampling a lot of different cases, yet it is not able to incorporate disruptive technologies that might develop in the future.

The second and third study are situated in the field of critical robotics research and looks at ideas that accompany the development of social robots in elder care. Contrary to the first study that is in part susceptible to the dynamic character of the field of HRI, these two studies analyze ideas stated by scholars in HRI that guide innovation. These ideas relate to issues outside of the robotics lab such as aging, elder care policies, care work etc. Ideas about each of those concepts might change over time, but compared with technological change and disruption are more static. Nonetheless, whether or not technologies and the ideas behind those technologies are static or dynamic will not be a central point of discussion in this thesis. Rather, the discussion of static and dynamic elements of the subject of research are mentioned here in relation to the temporal relevance of the sample. Now, each study is discussed in terms of its research design and data analysis.

3.2.2. Study 1: Conceptual framework social robots in elder care

The aim of this study was to understand what is meant with “social robots in elder care”. When reading studies on social robots in elder care, it became clear that there is not much work that tries to capture the field in terms of its technological advancements with cohesive language. This study aims to develop a conceptual framework to foster clarity and cohesiveness. In order to make sense of a relatively new field, a database was constructed (as described in the previous paragraphs on the sample and overall design) to determine how social robots in elder care could be categorized. And since there was no body of work the author could rely on that could guide the data analysis, grounded theory was used as a method of analysis to do so. In other words, there were no sensitizing concepts or theories that guided the analysis. The author read all sampled publications in-depth with no particular theoretical frame of reference in mind, and developed new theory from the data through an elaborate and iterative process as is discussed next.

Based on Strauss and Corbin's (1998) formulation of grounded theory, the data analysis entailed three steps: open, axial and selective coding. Each coding step has its own logic. For open coding, the author printed all documents on paper, read everything, and highlighted all things that seemed necessary with a colored marker. Without a guiding theoretical framework, this proved to be a challenging and iterative process. For instance, it was observed that robots have certain anthropomorphic appearances, and therefore information on appearance was coded. However, it then turned out that this is not necessarily inherently academically interesting: the same type of anthropomorphic robots, for instance zoomorphic robots, can have very different functional features. This makes it difficult, and rather unnecessary, to group robots on the basis of their appearance. For instance, a Paro is a robot seal but rather acts like a sophisticated toy, whereas the iCat, a robot cat, was used by Looije et al. (2010) as a dietary coach. In other words, they both look like animals, but were programmed to behave differently. Also, robots that are different in their anthropomorphic appearance could show the same functions. For instance, Telenoid (e.g. Damholdt et al., 2015) and Giraff (e.g. Cortellessa et al., 2018) are both used for remote communication between two users. However, Telenoid is a small humanoid robot, whereas Giraff has a mechanical appearance. So even though both types of robots have similar functions, they do not look similar. In other words, the categorization of appearance does not seem to correlate one-on-one with the functions.

Another explored unit of analysis was sensory experience. Paro was designed with touch in mind, as the authors deemed that to be an important factor in HRI (Wada et al., 2003a; Wada et al., 2003b), while other robots respond to voice command or visual cues such as Brian 2.1 (McColl et al., 2013). However, while reading more on robots and their technological characteristics, in general, the field of robotics is pre-occupied with receiving sensory data and transforming that into particular action. In other words, during the analysis, it also became clear that focusing on sensory information would not necessarily lead to meaningful codes, as it is an inherent feature to the field of robotics, but not necessarily relevant in relation to elder care.

After some passing of time and multiple iterations later, the author noticed multiple sources of information that could be the basis for further analysis. In particular, two types of information were deemed relevant: general descriptions of the activities of the robot, and quotations that describe which activities of the robots were tested for (i.e. situational information in order to understand the contextual relevance of the robot). It is important to note that there was not a structural comparison made between the two types of data, as they were used for triangulation purposes.

So in essence, there were two types of data triangulated for this research. To illustrate both types of data, Perugia et al. (2017a) describe the robot Pleo in terms of its general characteristics as follows:

> "Pleo is an animatronic pet robot commercialized by UGOBE, which has the appearance of a dinosaur.(…) Pleo is not only able to display a wide range of behaviors (e.g. sing, walk, howl), but also to express its internal drives (e.g. hunger or sleep), and moods (e.g. happy, scared, curious). We selected this robot, since it embodies the traits that Wu et al. [17] described as the most cherished by old people: it is small, it has a creative design, and it has a zoomorphic aspect (thus it is more socially acceptable). Moreover, Pleo, being designed for children, provides a very fast interaction, and this is crucial to interact with people with mild to moderate dementia, which are still able to sustain dynamic changes" [Perugia et al., 2017a, p. 1115] [8][9][10].

The authors also describe how they want to test the level of engagement of people with dementia after interacting with Pleo, by comparing it to a cognitive board game:

> "The study followed a repeated measurement design with two experimental conditions (figure 1): a game based cognitive stimulation, and a robot-based free play (Pleo)" [Perugia et al., 2017a, p. 1115] [11].

In short, the authors Perugia et al. (2017a) gave a general description of Pleo (first citation) and then proceeded to describe what aspect of Pleo they would test for (second

[8] In this dissertation, all the sources within the quotations are not listed in the bibliography, as it does not add any relevant information to the overall argument and is not actively used in the context of this dissertation. However, these secondary sources are not removed from the quotation, because they give information about which parts of the argument is (not) based on the cited authors' own work.
[9] In this dissertation, square brackets indicate quoted data instead of quoted literature. The latter has round brackets.
[10] In this dissertation, grammar and spelling mistakes are not corrected in the cited quotations.
[11] In this dissertation, figures/tables/footnotes of the source are omitted.

citation). In this case, they describe it as a toy that is able to display emotions (and is typically used for children), and then the experimental set up allows older adults to literally play with it. This type of play they tested for was free play, i.e. not structured, which is a particular form of play. What this actually means is in this stage of coding still unclear, as during the next step, i.e. axial coding, it would become clearer if this is a pattern or a stand-alone case, and how it fits into the typology.

In sum, two types of information was retrieved that were signifying something meaningful for further analysis. All publications were printed on paper and the pieces of information were highlighted with a marker and stored in binders. The marked fragments of text were also stored in an Excel sheet together with general information of the publications such as the titles of the publications, authors, year, name of the robot(s), etc. Codes were assigned to the fragments of texts that referred to the operationalization of the study and the general description of the robot. This step is referred to as axial coding, as it is the first step in reducing the amount of data at hand and to develop theory.

During this stage of coding it became clear that the alignment between robot used (in the general description) and the operationalization of the empirical work (i.e. the tested robot functionalities) does not always align. Some texts have a cohesive connection between the robot chosen and the operationalization of the study, as in the case of Perugia et al. (2017a): the robot is described by the authors as intended for play, and in order to measure engagement of People with Dementia (hereafter PwD), the authors tested the robot by having people with dementia play with the robot freely. By contrast, Boumans et al. (2018) were focused on the development of a robot that is able to take administrative tests from people with signs of Mild Cognitive Impairments (MCI) and they used Pepper. But unlike Pleo that is designed for play and is tested by Perugia et al. (2017a) for play, Pepper is not specifically designed to conduct tests to detect MCI. The connection between the description of the robot and the empirical study of Boumans et al. (2018) are therefore not as obviously aligned as Perugia et al. (2017a). As general description Boumans et al. (2018) mention:

> "We programmed the interaction design in the robot Pepper v1.7 from Softbank robotics (Tokyo, Japan) because of its user friendly programming environment, its ability to communicate in Dutch and its friendly human-like appearance, which was expected to appeal to elderly" [Boumans et al., 2018, p. 73].

And the authors tested for:

> "PROMS are regularly acquired by healthcare professionals through administering questionnaires to patients. (...) We used relevant values for supporting patients in the hospital context (i.e., helpfulness, cheerfulness, politeness, responsibility, intellect and logic) to derive the interaction design requirements. Next we selected 15 questions on wellbeing, malnutrition, pain, sleep, and ability to perform certain activities of daily living from existing PROMs. The question types included dichotomous and polytomous items, linear scales, visual analogue scales, and asking for texts, numbers or dates. Robot arm motions were used that support a question and answering (Q&A) interaction, such as spreading your arms low with hands palms up. The robot's tablet was used as screen for Q&A options; all robot interaction was designed for speech" [Boumans et al., 2018, p. 73].

The tested environment does therefore not necessarily directly follow from the general robotic characteristics. To further illustrate this argument, the same robot could be used for different tested scenarios as is the case with iCat. Looije et al. (2010) have used this robot as a robot dietician, advising older adults on diabetes and lifestyle choices. In the study of Heerink et al. (2008), it had the function of an assistant by giving directions to the nearest supermarket or giving the weather report. The functions articulated in the studies therefore are not necessarily always linearly deduced from observing the robot itself, i.e. an iCat does not in itself function in one way or another, but can always be tweaked by the scholars to make it fit for their intended purpose.

For coding, this meant that sometimes multiple codes were assigned to the same case of robot, depending on the information given in the two pieces of texts. Luckily, this added a richness to the data. For, the sometimes not straightforward alignment between choice of robot and rationale of empirical research, gave another piece of information: how the imagined functions articulated in empirical case studies do not one-on-one correlate between the chosen robot. What this exactly means in theoretical terms will be discussed in chapter four where the results are presented. In appendix D it is in-depth described how such (ambiguous) cases were treated in the analysis.

Also, it should be noted that the structure of between papers varies, depending on the publication form. Sometimes, authors were not interested in testing the robot, but were rather developing a new protype, thereby leading to sampling a piece of text that was only related to the general specification of the prototype instead of a description of a test scenario (e.g. Rodić et al., 2016; Merten et al., 2012). Or vice versa, sometimes authors were testing robots, instead of presenting it as a robot with certain features (e.g.

Frennert et al., 2013). Both types of data are used and triangulated.

After understanding the structure of the data better, and having assigned codes to all pieces of texts, certain patterns emerged from the data. Already a tentative conceptual framework emerged, but needed still to be validated. All the codes that were assigned and placed in the excel sheet next to the data about the authors, year, robot etc., were placed in a new excel sheet only listing the codes. Here, it was easy to see which codes overlapped and which did not, thereby enabling the researcher to compare and contrast the initial codes. For instance, the code of “play” that was found in the publication of Perugia et al. (2017a), was also repeatedly found in other papers (e.g. Moyle et al., 2016), signaling a pattern in the data. Understanding that there is a chunk of publications in the sample that refer to play-based HRI, the code “toy” was created.

Selective coding comes when comparing axial codes with one another. One could observe mundane objects vs intervening/intrusive objects, in social or caring contexts, leading to the categorization of social tools, social agents, care tools, care agents. This process of further reducing the wealth of data to a couple of definitive codes is essential to grounded theory. The conceptual framework in chapter four is based on this coding step.

Even though it might appear that this process entailed a rather smooth transition between the different steps of coding, in reality it was more of an iterative process. Though all the steps were exactly executed as presented here, sometimes an axial code did not make much sense. In such cases, it was needed to go back to the original source, read that particular paper, and double check if the code was rightfully assigned, and if not, where the problem was located. In other words, it was a continuous loop of checking and double checking codes. When the final typology scheme was formulated, the author made sure to check all the individual studies once more to see if it fits. This final step was deductive in nature: a typology was created, and tested by re-reading all cases and trying to assign the labels of the typology to each case, and interpreting ambiguous cases. In other words, this final step in the procedure was theory testing. Appendix D gives a detailed overview of all coding steps and includes examples.

3.2.3. Study 2: Rationales for developing social robots in elder care

While the first study for this dissertation was a long and exhaustive one, it was also very rigorous. By the time the analysis for the first study was largely finalized, a pattern emerged from the data that were not of immediate interest for the first study. So, rather organically, ideas for the second (and third study) arose while using grounded theory for the first study in this dissertation. This allowed a second and third research idea that could be explored rather deductively with a pre-defined research aim, i.e. a process similar to theoretical sampling. It should be noted that while the ideas arose when conducting grounded theory, these studies do not aim to produce theory, contrary to the first study. Therefore, arguably, the analysis of study two and study three is more comparable to a thematic analysis (and is also guided with pre-existing theories and ideas, instead of the researcher acting as a blank slate).

To be more specific, it was noticeable that the authors of the sampled publications had very specific ideas about how these technologies are able to do social good once they are widely implemented and disseminated in society. So, the second study developed for this dissertation critically analyzes these rationales put forward by scholars for studying and developing social robots in elder care. It did so by first of all reading all the rationales, putting these rationales in a codebook by sampling literal quotations, assigning codes to those quotations, understanding themes derived from such codes, and thereafter putting these themes into perspective with a critical historical analysis. Appendix E gives a detailed overview of each of these steps and includes examples.

Since there was already an understanding of the content of the data, as grounded theory was already used for the first study, the coding process was more structured and deductive compared with the first paper. In other words, instead of going into the data without pre-defined theories, in this case, it was already known which types of rationales could be anticipated from the data. In essence, three rationales were anticipated: issues related to the labor market, issues related to expenses, and issues related to aging related problems/Quality of Life (QoL). These served as sensitizing concepts. With this in mind, the author read all the publications once more.

Information was already gathered about all the sampled publications in an Excel sheet (title, year, authors, robot etc.) for the first study. Now, additionally, information was added for every publication with their mentioned rationales for developing and studying robots in elder care in a new codebook. These rationales were derived from literal quotations in the texts. These quotations were converted into codes, similar to the process presented for the first study of this dissertation. To illustrate, the publication of Stafford et al. (2014) is sampled for this dissertation. The authors mention the following:

> “The proportion of older persons compared to the proportion of younger persons in the global population is currently increasing [1]. These trends are particularly notable in the more developed regions, and especially in Japan, Germany, and Italy. There have been predictions of shortages of workers to care for this growing

> ageing population [2,3]. It has been proposed that healthcare robots may be able to supplement support for older people, their families and caregivers [4-6]" [Stafford et al., 2014, p. 17].

Here, one can see that the authors mention aging demographics and shortage of care workers as arguments to frame their research in. Once establishing a pattern between other papers and similar codes, one can identify themes. These themes refer to the rationales used in the literature as to why robots in elder care are needed.

It should be mentioned that the sensitizing concepts were most often detailed enough to capture the essence of the rationale. One might ask why there was a need for checking the data again if the codes and sensitizing concepts largely overlapped. There are multiple reasons for this. First of all, even though grounded theory was used before, and the rationales were already familiar with the researcher, themes could have been overlooked. An additional scrutinization of the data was necessary in order to establish the robustness of the data. Related to that, just because the rationales were already known, it does not mean that the researcher is aware of the nuances that would not have been picked up if the data were not have been read again. Appendix E discusses the example of how Quality of Life (QoL) as a code needed some additional refinement. Finally, just because the researcher was familiar with sensitizing concepts, does not mean she had the quotations to prove it. One of the biggest reasons to dive back into the data deductively after conducting grounded theory for the first study, was to collect quotations that serve as the backbone for this study. Also, it should be noted that the purpose of looking for quotations was not solely just a means to prove the sensitizing concepts. Rather, if the sensitizing concepts were incomplete or somehow not representative of the data, analyzing those quotations by reading them and assigning codes to them was a way to explore how (in)correct or (in)complete the initially formulated sensitizing concepts were. As mentioned in Appendix E, sometimes publications mentioned no rationales, something that was not anticipated beforehand with the pre-existing sensitizing concepts.

In sum, though this research rests on qualitative methods, it had a more deductive approach compared with the first study, as ideas were already organically obtained from using grounded theory prior, and used for theoretical sampling. The final step in this paper was to put the results into context by looking at societal and historical events that could be relevant in explaining as to why these rationales are so prominent in the literature. The reason for looking at these events was due to the theoretical framework used in this study: sociotechnical imaginaries (Jasanoff, 2015). As is explained in chapter five, it is crucial to understand wider societal and historical developments in order to understand imaginaries about a “better” or desired future. The events linked to the empirical results are purposefully selected after a (non-systematic) literature search.

3.2.4. Study 3: Representations of older adults in the field of HRI.

Similar to the second study, a third study was developed after observing certain patterns while conducting grounded theory for the first study. This time, the pattern observed concerned the ways in which older adults are represented. Therefore, a paper was written about that subject, using a critical perspective. In order to analyze representations of older adults, all publications were read with the intention of sampling quotations about older people. It should be noted that this does not concern the description of “actual” people, but rather generalizations of what it means to be older.

Similar to the second study, the analysis on user representations was informed with sensitizing concepts. However, compared with the second study, these sensitizing concepts were derived from the literature: information about older adults was sampled with concepts such as the third age and fourth age in mind. These concepts basically refer to how aging could be conceptualized in terms of dependency and frailty, i.e. fourth age, or activity and maximization of potential, i.e. third age (Laslett, 1991). Similar to the process in study two, any information that refers to either sensitizing concept was rather deductively sampled with quotations and put in a codebook. To illustrate, quotes such as the following were sampled (emphasis is inserted by the author of this dissertation):

> "Older adults are *vulnerable* to the experience of *loss*, be it in terms of health, identity, finances, independence and social connections" [Khosla et al., 2013, p. 42][12].

The words "vulnerable" and "loss" are emphasized, as one of the sensitizing concepts, fourth age, relates to these words. Once all quotations were sampled that referred to older adults and the sensitizing concepts, codes were assigned. This is similar to the other studies: it is an iterative process of checking overlap between codes, by comparing and contrasting them, ultimately reducing data. Themes were derived from this process of data reduction (i.e. comparing codes). A detailed description of the analysis is given in appendix F. Results are presented in chapter five.

To briefly summarize, all papers were some forms of qualitative content analyses, although some studies had a more inductive character (study one) than the other studies that had a rather deductive approach (study two and three).

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[12] In this dissertation, italics in quotations are inserted by the author of this dissertation for emphasis.

4. What “are” social robots in elder care?

This chapter in this dissertation focuses on the development of a conceptual framework. For there is no conceptual consensus on what social robots in elder care are *überhaupt*. How can we define social robots in elder care? What “are” the machines? Using social robots in elder care is a fairly recent phenomenon. The academic community started to publish papers about this approximately two decades ago. Scholars from various disciplines try to advance the field, covering a multitude of aspects such as ethics, acceptance, design, effects, machine learning and other subjects in engineering/computer sciences. With the development of a new and interdisciplinary field, a common understanding of what social robots in elder care are, is lacking (Frennert & Östlund, 2014; Rehm et al., 2016).

It seems like there is not much consensus on the appropriate way to address and conceptualize this phenomenon. To illustrate this, various labels are used in the academic community to refer to robots in elder care: socially assistive robots (Khaksar et al., 2015; Tapus & Mataric 2008), mental commit robots (Wada et al., 2003a), social robots (Bartl et al., 2016), healthcare robots (Robinson et al., 2014) etc. Not only the language, also technology is characterized by a high degree of variability – e.g. soft materials, hard materials, tall robots, short robots, the type and level of anthropomorphism, ranges in Degrees of Freedom (DoF), heavy weight robots, light weight robots, automated robots, tele-operated robots, interaction modality etc.

This multitude of interpretations complicates how social robots in elder care can be defined. Furthermore, there are many different care environments the robot could be placed in. Older adults are rather a diverse mix of people, having different care needs. So the exact function of the robot in relation to care types is also open for interpretation. Taken together that social robots in elder care have not been around for a long time and that defining adequate care is not a straightforward task to do, it is no wonder that the phenomenon has been thus far conceptually underdeveloped. This chapter aims to reduce conceptual ambiguity, by understanding how different definitions are performed in the field of HRI. It aims to understand how the interpretations of social robots in elder care in the field differ and overlap, ultimately constructing a conceptual overview.

In order to achieve this, this study sampled 96 academic publications in order to understand how developers define social robots in elder care in action. To briefly recap the research methods presented in chapter three, general descriptions of the robot’s activities, and operationalizations of robots in-use/tested scenarios were chosen over conceptualizations as the focus for the analysis. Contrary to given conceptualizations in academic studies, operationalizations force scholars to think about the precise and empirical usage of the artifact instead of theoretical, sometimes not too well defined, understandings of the machine. Furthermore, operationalizations give information on the boundary work that developers exercise: they articulate which core features of the robots need to be tested and in which contexts. Operationalizations define how social robots in elder care ought to be used. This is different from the general information that scholars in these studies also give about the robots. Most often in these publications, scholars give statements about general features and activities of the robots which they then test. These statements are also sampled, as they although do not give information of boundary work *in action*, they do give information about the general intentionality of the artifact. Essentially, both fragments of texts served as complementary information – i.e. data triangulation.

Taking these two pieces of information together, it becomes clear how boundary work in the field of HRI in elder care works: what “is” the machine and how should it be operated in practice? Bearing this in mind, the guiding research question reads: How are social robots in elder care defined in the academic literature? As mentioned earlier, “defined” in this sense does not relate to conceptualizations, but rather to practices of boundary work: general information on the chosen robot, and operationalizations.

The main rationale for conducting this study is to increase a common understanding and a shared vocabulary among social scientists. Knowing what technologies are “out there” and how they are envisioned to be used, makes it easier for social scientists to better understand how certain technologies ought to trigger certain interactions over others. Obviously, behavior and future use cannot be predicted with definitions and conceptual typologies of phenomena. The developed conceptual framework therefore also does not aim to achieve behavior predicting conclusions and statements. Rather, the conceptual framework offered in this chapter enables other scholars to understand *the premises* of the social robots in elder care. The content of these premises need to be understood in order for other scholars, or people outside of academia such as care providers, policy makers etc. to position and align themselves with certain premises or to distance themselves from others. Some people might just have an interest in one type of robot over another. The results of this work could thereby function as a toolkit (by the means of a cohesive vocabulary) for people interested in the topic, but that have not found an overview yet about the distinct types of technologies.

Before explaining the definition and conceptual framework, a couple of key concepts need to be clarified. It needs to be understood what robots are, how that differs from the neighboring concept AI, and how the literature so far has attempted to conceptualize social robots.

4.1. Robots and social robots

In this dissertation, robots are conceptualized as embodied systems in which a connection is made between perception and action (Siciliano & Khatib, 2008). A more elaborate definition for robotic perception/action and the connection that facilitates this process reads as follows:

> “(…) the action of a robotic system is entrusted to a locomotion apparatus to move in the environment (wheels, crawlers, legs, propellers) and/or to a manipulation apparatus to operate on objects present in the environment (arms, end effectors, artificial hands), where suitable actuators animate the mechanical components of the robot. The perception is extracted from the sensors providing information on state of the robot (position and speed) and its surrounding environment (force and tactile, range and vision)” (Siciliano & Khatib, 2008, pp. 1-2).

So while many different kinds of robots exist, they all have a *body* that is able to *move* with, among others, actuators and sensory input.

Social robots in elder care is a subgroup of robots. Based on the UN survey on robotics, Bartneck and Forlizzi (UN, 2002, as cited in Bartneck & Forlizzi, 2004) distinguish three basic types of robots, related to their domain of applicability: industrial robots, professional service robots and personal service robots. Halfway the twentieth century, the vast majority of robots were applied in industrial settings. Professional service robots were developed to enable people to control areas that are relatively inaccessible (such as minefields). Personal service robots, robots designed to improve the wellbeing of its users, were developed much later than the other two types of robots (around the 1990's). Typically the latter type of robot requires high levels of automation and is used in institutional and domestic settings (Bartneck & Forlizzi, 2004). The users are usually not trained or specialized to operate these robots. The high degree of autonomy usually compensates for the lack of technological know-how according to Beer et al. (2014). Using this typology of robots, one could interpret social robots used in elder care as personal service robots.

The exact definition of social robots is very disputable. Bartneck and Forlizzi (2004) mention that "a social robot is an autonomous or semi-autonomous robot that interacts and communicates with humans by following the behavioral norms expected by the people with whom the robot is intended to interact" (p.592). Interestingly, this definition assumes a degree of contextual sensitivity aligned with the expectations of users ("behavioral norms expected"), and messages with some level of meaning ("communicates" is indicating some level of robotic agency, instead of being a passive object). It is also debatable whether robots indeed align with human norms (i.e. which human norms? And who gets to decide?).

Similarly, Breazeal (2011) assumes robotic agency as she conceptualizes HRI as a form of inter*personal* interaction, as according to her, social robots are "designed to interact with people in a socio-emotional way during interpersonal interaction" (p. 5368). The "personal" in this definition evokes some posthuman understanding of the machines, for interpersonal communication by definition requires two persons, i.e. two humans (Trenholm, 2011). Dautenhahn (1998) develops this concept in relation to agents displaying behavior of human intelligence. Though in a later paper, she acknowledges how the conceptualization is a fragmented practice: “(…) the notion of social robots and the associated degree of robot social intelligence is diverse and depends on the particular research emphasis” (Dautenhahn, 2007, p. 684). In other words, a pick-and-choose conceptualization is put forward as a solution to the lack of a cohesive framework. While indeed different studies might view the role of the subject or object, the human and the non-human, the robot and the user etc. differently and indeed different conceptualizations might cater towards these differences, the mere categorization of “*social”* robots indicates that there are some overlapping or essential qualities embedded in such technologies indicating some sort of social element, as is also argued by Pfadenhauer (2014). Otherwise, they could just be called “robots”.

Digging a bit deeper into the literature on social robots, one can observe two approaches in the current literature for conceptualizing social robots: 1) an approach that focuses on technicalities and 2) an approach that emphasizes the social outcomes the robots (should) enable. Concerning the former, Seibt (2017) developed a taxonomy that mentions five different ways to conceptualize social robots and HRI, namely by: approximating, displaying, mimicking, imitating, and replicating. This general classification relates to the isolated interactions provided by the machines – regardless of social context. While such a conceptualization is helpful in understanding HRI in general and how robots could potentially show “social” behaviors, Seibt (2017) did not construct this typology with specifically elder care in mind. Elder care is a multidimensional concept where pragmatic care provision, activities, and social interactions intersect (Ranci & Pavolini, 2013). This conceptualization therefore is not taken as a point of reference for this study, as it is not sensitive to the particularities of social robots *in* elder care (though to be fair, was not the intention of Seibt (2017) in the first place). Similarly, Onnasch and Roesler (2020) present a taxonomy for Human-Robot Interaction that could help scholars situate social robots, specifically in accordance with: 1) context of interaction 2) robot specifications 3) role of the human and type of communication used. While these are general guidelines that could indeed help describe any robot, it does not specifically help define social robots in elder care.

The taxonomy of Nestorov et al. (2014) also focuses on the machines when describing HRI, but contrary to Seibt (2017) and Onnasch and Roesler (2020), their paper was meant to be specific to the context of elder care. The taxonomy describes technical features that social robots in elder care require: appearance, interaction modality, interaction intelligence, operating mode and task capability. For each type, the authors elaborate on the main features such as the anthropomorphic appearance associated with robot appearance: humanoid, zoomorphic and functional. The authors argue that each appearance relates to certain design principles, e.g. humanoid is more prone to uncanny valley effect, zoomorphic is more based on animal assisted therapy etc.

However, it is problematic to differentiate between social robots in elder care based on robot morphology and other technical aspects inherent to the discipline of robotics. Surely, certain technical choices are more specific to elder care than others. For instance, zoomorphic robots such as Paro are more appropriate for robotic animal assisted therapy than an industrial appearing robot. However, there is not a one-on-one correlation with e.g. morphology and elder care robots. A zoomorphic robot like iCat (Heerink et al., 2006) has different qualities than the robotic seal Paro (Wada et al., 2003a), and is not designed for animal assisted therapy. This same line of reasoning also holds for the other types presented by Nestorov et al. (2014): e.g. the level of intelligence of a robot is not something related to only elder care robots. Every robot has a certain level of intelligence, one or more modes of interaction, and an appearance etc. One cannot state that modes of interaction is a “type” of social robot in elder care.

Whereas the former papers emphasize the technical characteristics of robots in their conceptualization, other papers focus on the social outcomes without referring too much (sometimes not at all) to specific robotic features. For instance, in the systematic reviews of Kachouie et al. (2014) and Kachouie et al. (2017), the authors relate robots in general (i.e. not addressing robot types) to their effects on older user’s wellbeing. Their study in 2014 started out promising by listing per robot what their characteristics are, which outcomes in wellbeing were found, and in which academic study (Kachouie et al., 2014). For example, PaPeRo is a robot that was tested by Sasama et al. (2011), and results showed an increase in communication with family members, number of friends and outdoor activities. Here, Kachouie et al. (2014) make a link between a specific robot and its outcomes[13]. However, the authors disregard this link in their interpretation of their data. Rather, the authors use a pre-existing concept PERMA (positive emotion, engagement, relationships, meaning, accomplishments) that conceptualizes wellbeing, and relate HRI outcomes without discussing robots or robot types to each predefined

[13] This step was omitted in their 2017 publication on the same topic (Kachouie et al., 2017).

PERMA indicator. Where their listing of robots was too specific to get any information about robot *types* in relation to social outcomes in subjective wellbeing, their usage of PERMA to cluster outcomes did the complete opposite by not discussing robotic characteristics at all.

Besides wellbeing, other papers mention other outcomes related to the usage of social robots when trying to define the phenomenon. A lot of studies mention that social robots in elder care ought to contribute to one or more of these domains: companionship and social support, daily assistance, monitoring/safety, physical/mental care, health management (e.g. Bedaf & De Witte, 2017; Hutson et al., 2011; Jenkins & Draper, 2015; Draper & Sorell, 2017). All these categories relate to issues of care or issues of social interactions.

Broekens et al. (2009) also make a distinction between the social uses of robots in elder care. The authors mainly discuss the effectiveness of robots in elder care on the users´ wellbeing and briefly explain their conceptual approach: social robots are conceptualized as service type robots or pet-like companion type robots. Unlike the aforementioned studies, this study combines different types of machines with different types of social outcomes – i.e. the service type robot is an assistive device and the companion type or robot is meant for psychological comfort. However, this conceptualization is not rooted in systematic empirical observations, which is unsurprising given the main aim of the study was not to develop a robot typology. Rather, their study centered on understanding the potential beneficial effects of HRI on its users. Secondly, the authors make the assumption that companion type robots are zoomorphic in nature. It is tricky to establish a correlation between anthropomorphism and function, as the aforementioned Paro/iCat differentiation illustrated: Paro is designed for animal assisted therapy unlike the zoomorphic robot iCat, and furthermore there is no reason to assume that non-zoomorphic robots could not offer companionship to its users.

In sum, there is not much reflection found in the literature on the intersection between social contexts and robotic interaction characteristics. Bearing this in mind, this present study takes social contexts and robotic characteristics into account in the discussion of the results.

4.2. AI and robots

Before moving on to the results and the analysis, a short note should be made between the distinction of artificial intelligence (AI) and robots, since these are neighboring concepts that are sometimes used interchangeably in popular discourse. In this paragraph, some brief and general distinctions between AI and robots are made to roughly indicate how robots and AI are two different, though related, phenomena. It is not the objective of this paragraph to give a detailed definition of AI, but to rather generally understand how it does or does not overlap with the phenomenon of robots in elder care.

The European Commission (High-Level Expert Group on Artificial Intelligence [HLEG], 2019) proposed the following definition of AI:

> “Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the

> best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions. As a scientific discipline, AI includes several approaches and techniques, such as machine learning (of which deep learning and reinforcement learning are specific examples), machine reasoning (which includes planning, scheduling, knowledge representation and reasoning, search, and optimization), and robotics (which includes control, perception, sensors and actuators, as well as the integration of all other techniques into cyber-physical systems)” (HLEG, 2019, p. 6).

Before proceeding to explain this definition, for full disclosure it should be mentioned that this definition has a footnote stating that: “Humans design AI systems directly, but they may also use AI techniques to optimise their design” (HLEG, 2019, p. 6).

This definition of AI is rather broad, but it does illustrate the main components that are often debated in the definition of AI: the differentiation between hardware and software systems, goal setting mechanisms and achievements as an indicator of intelligence, and the discussion of various techniques to achieve this goal. In addition, HLEG also specifically discusses AI as a scientific discipline of which robotics could be considered a related subfield of it, though it is explicitly mentioned in this document that “robotics includes techniques that are outside AI” (HLEG, 2019, p. 5).

While all of this information is up for discussion, two main issues need to be clarified in the context of this dissertation. As a system, i.e. not as a scientific discipline, this definition differentiates AI as a software system that may or may not include hardware (i.e. something inherent to the field of robotics). AI does not need to be embodied per se, whereas robots by definition have bodies that move (Siciliano & Khatib, 2008). In other words, AI does not necessarily have to refer to the embodiment of the artifact, as it could also refer to intelligent *systems* more generally. AI could refer to computers or devices in which the embodiment of the technology does not play a central role in the performed output of the machine. Second and perhaps a more profound difference between AI and robotics, is the role of 'intelligence' in the machines. In the HLEG (2019) definition, this refers to solving a complex task rather efficiently. Legg and Hutter (2007) take a similar approach in their definition, and in addition mention that the ability to adapt and learn in a wide set of environments is often implied in such definitions.

If AI requires its systems to solve complex tasks, the question is if this is inherent to the field of robotics. Simone Giertz is an example of a Youtuber that builds "bad" robots on purpose. Also, in mundane activities, one can think of vacuum cleaning robots to not always understand the environment they are supposed to clean, e.g. not recognizing obstacles or not learning to avoid them. In other words, certainly not all robots are smart or solve complex tasks efficiently. Intelligence is inherent to the discipline of AI, but not inherent to the discipline of robotics, though it definitely could be as also HLEG (2019) mentions.

Just like humans, robots come in various different shapes and sizes, and different forms of intelligence. Not all robots must exhibit a certain level of intelligence in order to be classified as a robot fit for elder care. It is therefore not inherently necessary to understand how intelligence plays a role in social robots in elder care, because just like modalities, automation, actuators, and sensors, the (lack of) intellect (however defined) is just one component of many that make up robots that can differ in form, i.e. intelligence does not *define* robots. This study does not aim to understand the different sensors used, modalities, or intellect of social robots in elder care, as these components are building blocks that can vary in form, and are inherent to the field of robotics. This information does not “reveal” what defines social robots in elder care specifically. Concerning the aim of defining social robots in elder care, the results are discussed next.

4.3. Conceptual framework: Four categories of social robots in elder care

Results indicate that social robots in elder care are situated in the literature along two dimensions (**fig.1**): 1) machine agency and 2) user context. As for machine agency, the data suggested two types of robots: robots that ought to function as a tool and robots that ought to function as an agent. Furthermore, two contexts of usage related to care work are found in the data: care and social interactions. Taking this together, the categorization of social robots in elder care reads as follows: care tool, care agent, social tool, and social agent. This leads to the following definition: A social robot in elder care is a robot used in care or social contexts, in which the robot functions as a tool or an agent. The categories (i.e. care vs social, or tool vs agent) are not mutually exclusive. This statement, as well as the meanings associated with each category is explained in the following paragraphs.

		Machine Agency	
		Tool	**Agent**
User	**Care**	Care Tool	Care Agent
Context	**Social**	Social Tool	Social Agent

Fig. 1: Robot typology elder care

4.3.1. Care tool: Robot assistants

This classification refers to robots in elder care that foster the user’s agency in mundane care routines. The robot is an instrument that helps older people with basic activities of daily living (ADL) or instrumental activities of daily living (IADL). Sometimes the technology is unobtrusive in nature. Smart home systems, occasionally called Ambient Assisted Living (AAL), that rely on ubiquitous computing/pervasive computing/ambient intelligence (related concepts that are often used interchangeably) and cloud computing are examples of technical features that enable unobtrusive care (e.g. Bonaccorsi et al., 2016; Rodić et al., 2016). Such systems could, amongst others, detect falls, detect objects and persons, monitor the user, and alarm others in case of emergency. The robot functions as an interface to the user.

Some other robots are more “intervening”. For instance, physically assistive robots that assist elders with activities as showering, e.g. iSupport (Zlatintsi et al., 2017), or movement, e.g. the robotic wheelchairs NEO-PR45 (Shiomi et al., 2015) and Mobot (Zlatintsi et al., 2017). All these technologies foster the independence of the user in their ADL. Other robotic activities that relate more to IADL concern issues such as health management and interpersonal communication. For instance, the HealthBots robot Charlie used in the study of Stafford et al. (2014) reminds older adults of their medication, measures vital signs, makes phone calls, plays songs and cognitive games. Here, the robot is able to mix features of health management, interpersonal communication, and entertainment. In other words, sometimes robots combine pragmatic features of care with entertaining elements.

Also, some scholars focus primarily on interpersonal communication between older users and caregivers. For instance, Portugal et al. (2015) developed a software network SoCoNet that enables older users to contact a virtual care team consisting of caregivers and other users. Another example of a robot that connects users and caregivers is the telepresence robot Giraff. Cortellessa et al. (2018) used this robot, albeit renamed the robot ROBIN in their study and used the so-called GIRAFFPLUS telecare system, as a vehicle for remote assistance. The robot is able among other things, to provide its users with video calls, and text/audio messages. Additionally, this proposed robotic platform aids communication between caregiver and primary user by gathering physiological data like blood pressure or glucose levels from the older user, as well as environmental data from the house (similar to a smart home system) in order to assess the wellbeing of the older user. The information is stored for the user in order for him/her to have an overview of his/her wellbeing, and additionally, is accessible to secondary users (i.e. caregivers) in the so-called “shared space” module of the robot. Caregivers are able to keep track of the wellbeing of the primary user. Although most of this paper focused on describing the caregiver-patient network and communication characteristics, this case also exemplifies how robotic features are able to be combined: the robotic system is meant to have sensors in the house to monitor the environment and the user in addition to interpersonal communication tools. Also, it should be noted that while these papers mention caregivers as secondary users, these technologies also could support interpersonal communication with a focus on social relationships (e.g. Moyle et al., 2013) or both (e.g. Cesta et al., 2016).

In sum, what all these technologies have in common is that the robots are seen as tools to foster agency of the user in different everyday activities (ADL or IADL). This could be achieved with for instance unobtrusive interface robots in smart homes, robots that physically assist the user, telepresence robots that provide interpersonal communication between older users and caregivers, robots that help with IADL related activities such as managing medication or measuring vital signs, or robots that mix these elements. One could think of care tools as robot assistants: merely aiding users with all kinds of mundane tasks.

However, as mentioned earlier, it is one thing to analyze the technicalities of the robots, and another to analyze how roboticists situate the technologies in action. In the study of Torta et al. (2014), the authors mention the following general characteristics to be realized in their smart house system with NAO as their robotic interface:

> “Employing a ceiling-mounted camera also allows for ubiquitous localization of the person (R1). Compliance with medical treatment (R3) and knowledge of environmental conditions (R5) is realized via a distributed sensory network (Fig. 1, block A). Input data from medical sensors are stored in the central KSERA server (Fig. 1, block B3) and are interpreted (Fig. 1, block B2) according to medical rules (Fig. 1, block B4). This allows establishing when measurements are out of range (R10) and lets the robot approach the user (R1). Data are stored (Fig. 1, block B3) and made available to care givers (R8). Video communication functionalities allow connection between family members, care givers and the user (R9), see Fig. 1 block D” [Torta et al., 2014, p. 60].

In this example, one can observe that the system, in which the robot functions as an interface, is used for very pragmatic care applications. It can localize the user, help with medication management, and analyzing the environmental condition (which was further in the text defined in terms of indoor temperature and humidity), and online communication. Smart housing, with these applications in mind, seems like a way to support older adults in their everyday life and care regimen. However, when testing the robots, in their operationalization, the robot seemed to have a mix a different functions. The robot was not only supposed to be a tool that helps with independent living, but also an agent that takes some decisions on its own in order to facilitate care. This became apparent when the authors articulated five different scenarios that they tested in an experimental setting. These were the five scenarios:

> “– Scenario 1: Getting up in the morning and asking the weather conditions to the socially–assistive robot. – Scenario 2: Preparing breakfast while listening to music. A request for video connection is received while the music is playing. – Scenario 3: Doing some physical exercises after breakfast. – Scenario 4: Receiving an environmental warning after the training. – Scenario 5: Calling a friend to make plans for the evening” [Torta et al., 2014, p.64].

At first sight, these scenarios do not present a narrative deviating too much from the “care tool” categorization. However, when explaining these scenarios in detail, the authors mention for scenario three the following:

> “Scenario 3 (S3): Measuring blood oxygen level and physical training. The KSERA system detects that the user has not performed a scheduled measurement. The robot goes to the user asking him/her to perform the oxygen measurement. If the measurement is interpreted as good the robot motivates the participant to do

> physical exercises, otherwise a video connection with the care center is activated (…)” [Torta et al., 2014, p. 61].

The robot then is not a passive object, reactionary to whatever the user is doing. Rather, the user needs to adhere to a regime, and if the older adult is not compliant to the standards of the robot, a video connection with other care givers is established. In other words, the robot is taking some autonomy away from the older person and functions as an intermediary between the caregiver and the user. Whereas a tool analogy would usually be appropriate to describe a smart home interface, as it would merely be a technology fostering agency of the user in everyday activities, the robot in this case proactively tells the user what to do. In other words, even though one is able to describe technology in general technical terms of what it is able to do (e.g. smart housing with ubiquitous computing and a robot as an interface), when translating it to applications (in this case, tested scenarios), the robot might be envisioned to behave in very particular ways (i.e. enact agency) that would not have been naturally deduced from reading the general features of the robot. Moreover, this means that the tool and agent categorization might not be as rigid as a matrix in fig. 1 would suggest.

To give another example, the Care-O-Bot3 was used as a reference point for the ACCOMPANY project (Draper & Sorell, 2017). According to the authors, this robot was supposed to work as an assistant in a smart home environment. The objective of this project was to develop:

> “(…) a robotic companion as part of an intelligent environment, providing services to elderly users in a motivating and socially acceptable manner to facilitate independent living at home… provid[ing] physical, cognitive and social

> assistance in everyday home tasks, and … contribut[ing] to the re-ablement of the user, i.e. assist the user in being able to carry out certain tasks on his/her own” [Accompanyproject.eu[14], as cited in Draper & Sorell, 2017, p. 50].

The authors furthermore mention that:

> “The ACCOMPANY system used the Careobot3 platform, which is mobile and has a manipulating arm, is capable of working autonomously in a smart home environment and ‘‘co-learns’’ with its user (Amirabdollahian et al. 2013)” [Draper & Sorell, 2017, p. 50] [15].

When looking at the scenarios the authors presented in their work that they discussed in focus groups, the robot was envisioned, again, to challenge issues of autonomy. They present four scenario’s, but to choose one as an example:

> “Marie, who is 78 years old, has lived alone since her husband died ten years ago. She has ulcers on her leg, the dressings for which are changed by a nurse once a week. It is important for the healing of these ulcers that she moves around as much as possible to encourage circulation to her legs and avoid further swelling. Her Care-O-bot knows that she should be encouraged to move about, and suggests several times a day that she walks with it to look out of the window at either the garden or the street below. Marie is reluctant to get up from her chair because she is afraid of falling and walking is uncomfortable. She also uses the Care-O-bot to get drinks for her from the kitchen, even though the nurse has

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[14] The project’s website is offline.

> suggested that she should go to the kitchen with the Care-O-bot but let it carry the drinks back to her chair for her. Also the Care-O-bot can only bring bottles of water to her and the nurse suggests that she would feel warmer if she made herself hot drinks. The Care-O-bot reminds her to take her antibiotics and to keep her leg up on a stool when she returns to her chair after, for example, going to the toilet. She is grateful for the reminders about the antibiotics but feels irritated about the reminders to elevate her leg as she hardly ever forgets to do this but she likes to get comfortable first. She sometimes put her leg down so that her cat can sit on her lap more comfortably. Her ulcers are slow to heal but when the nurse asks if Marie is moving around more she always says that she is, even though she ignores the prompts to come to the window and doesn’t go to the kitchen with the robot” [Draper & Sorell, 2015, p. 53].

In this example one can see, the scholars discuss the interaction in terms of resistance of the user to the robot’s suggestions. Even though Care-O-Bot was earlier presented in terms of an assistive robot, the scenario clearly describes a mix of communicative dominance. The robot suggested her to move around, which Marie is reluctant to do. She does not want to put her leg up all the time or immediately, even though the robot said so. It is presented as more than a tool: it tells her at times what to do and resistance in this scenario is the focal point of discussion.

It should be noted that in this example, the scenarios were the starting points for focus group discussions about ethics. In other words, the authors wanted to explore how experts in the field (such as caregivers) would think about such scenarios that describe resistance and autonomy (among other topics). This means that although the scenarios are not based on actual empirical situations, the authors did envision human-robot interaction in terms of agency, dominance, and resistance. Put differently, even though a robot such as Care-O-Bot appear to be tools due to their described general features, it does not mean they are always envisioned to be applied that way.

4.3.2. Care agent: Robot therapists, robots running medical tests

Another way to conceptualize social robots in elder care is by viewing robots not merely as tools, but as agents. They represent an active caregiver. In other words, the robot is seen as an entity[16] that provides care to its users, instead of merely a tool for independent living. The care responsibility is shifted from the user, to the robot –i.e. the robot is not necessarily only viewed to function as a reactive tool, but also seen as proactive entity. This happens in the form of for instance robot therapists, or robots running medical tests.

The robot therapists are robots that give instructions to the users to perform certain physical movements, complete certain cognitive challenging tasks, or motivate the older users in their lifestyle activities and behaviors. These range from seated arm exercises and gait training, e.g. the robot Bandit used in Tapus et al. (2008) or Fasola and Mataric (2010), to music therapy and cognitive games (Tapus & Mataric, 2008). The robot functions as a motivational trainer that, amongst others, gives compliments and corrections and illustrates the exercises. Other robots function as motivational agents that do not require any physical or cognitive exercise. For instance Looije et al. (2010) used iCat as a tool for motivational interviewing for older adults with diabetes in order to foster certain lifestyle behaviors.

[16] In this paper, “entity” and “agent” are used interchangeably.

Robots running medical tests vary from merely helping taking standardized tests and communicating the results to human professionals (such as Pepper used in the study of Boumans et al., 2018) to robots that ultimately ought to function as clinicians when taking the medical tests (e.g. Furhat in the study of Jonell et al., 2017). These robots are not designed to ease tasks of everyday living as with care tools, but rather have specific caring qualities that resemble more intense human caregiving. What these therapist robots and medical professional robots have in common is that they exhibit machine agency: they instruct users by asking them questions or telling them what to do. The robot is not merely responsive, but also shows elements of proactivity.

Also here, the rigid distinction between tools and agents is able to be blurred, though not as often as with care tools. The tests the scholars performed on the robots illustrate how agents could also rely more on the user's input than the classification initially suggests. For instance, the study of Fasola and Mataric (2012) designed a robot that functions as an instructor for physical and memory exercises. They tested this robot in three different scenarios: in addition to a memory game and a workout game, the authors developed an imitation game, in which the roles of the robot instructor and human participant get reversed. The robot becomes the participant and the human becomes the instructor:

> "Imitation Game: In this game, the roles of the user and the robot from the Workout game are reversed; the user becomes the exercise instructor showing the robot what to do. The robot encourages the user to create his/her own arm gesture exercises, and imitates user movements in real time. As the roles of the interaction are reversed, with the robot relinquishing control of the exercise routine to user,

> the robot no longer provides instructive feedback on the exercises. However, the robot does continue to speak and engage the user by means of encouragement and general commentary. For example, if the robot detects that the user is not moving, it encourages the user to create new gestures by saying, for instance, ‘Mary, try and come up with your own gestures and I’ll imitate you.’ In addition, the robot makes general comments about the game or the user, such as ‘You’re a good instructor, Mary’ or ‘This is my favorite game, thanks for the workout’” [Fasola & Mataric, 2012, p. 2516].

Though to be fair, Fasola and Mataric (2012) were one of the few scholars that did so, as most care entities studied had very clearly defined parameters: e.g. the sole purpose of the Pepper robot in the study of Boumans et al. (2018) was to administer a standardized test to detect cognitive impairments. Even though Pepper is not a robot that is intended to be used in a specific way, i.e. Pepper is a multi-purpose robot and a lot of studies tailor robots such as Pepper and Nao according to their wishes, Boumans et al. (2018) were motivated by one specific issue: alleviating medical staff from conducting standardized tests by allocating it to a robot[17]. The robot asks the questions and administers it. It clearly is giving instructions from the user, instead of the other way around, making it a very clear case of a robot treated as an agent with its communicative dominance.

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[17] This does not mean that all Pepper’s are used in a singular manner. Rather, Pepper is able to do other activities than administrative questionnaires, and is therefore also used in other studies for different activities (e.g. Bechade et al., 2017)

4.3.3. Social tool: Entertainment robots, social networking robots

Similar to care tools, social tools are meant to ease everyday life. However, they focus less on pragmatic issues of care, and more on entertainment (e.g. games, music, e-books), practical gadgets (agenda keeping, reminders, weather report, news), and social engagement (i.e. tools for interpersonal communication). Examples of robots used in the literature for such purposes are PaPeRo (but some authors renamed it in their studies to Mathilda (Khosla et al., 2012; Khosla et al., 2013); Betty (Khosla et al., 2016); Sophie and Jack (Chu et al., 2017); the robot that takes music requests named Eva in the study of Cruz-Sandoval et al. (2018) and the robots (which were unnamed in their study) used in the research by Peri et al. (2016).

It should be noted that these types of robots are similar to the robot assistants described in the category “care tool” since they essentially function as an assistant, and often mix entertainment with mundane pragmatic help (e.g. medication reminders) such as in the study of Pripfl et al. (2016). So while the studies of for instance Khosla et al. (2013) emphasized entertainment features than pragmatic features indicating that some robots ought to focus more on one aspect than the other, most often, a clear distinction between care and social contexts are more difficult to make. This means that robot assistance and entertainment is often mixed when it comes to robot tools. These types of robots often have a lot of features that are practical in daily life, but some are more social and others are more pragmatic. Though what they have in common is that these robots could be seen as *gadgets* in the daily lives of older people. Overall, it is not an overly intrusive type of robot, but sometimes in the case of medication reminders and when acting as game masters, they require the user to respond to their initiated interactions.

In addition to giving entertainment, there are social tools developed for remote communication, i.e. social networking robots. There is a fair amount of robots that have a communication system set-up alongside many other features (e.g. medication reminders or object detection), while some other developed robots and robotic systems have a sole focus on mediated interpersonal communication (i.e. its primary function). In the latter case, this means that robots could be used as a tool to connect people over geographically distant locations. One way to connect older adults with their social network through robots is by using currently available Web 2.0 services (i.e. social networking sites). For instance, Marin Mejia (2014) uses the Homemate Robot and Kobayashi et al. (2017) use Rapiro as an interface for using social networking sites such as Facebook, Twitter, and Youtube. Furthermore, there are robots that enable embodied experiences to bridge communication between geographically distant others. The Telenoid used in the study Yamazaki et al. (2014) is a tele-operated humanoid. It has movable arms, a torso, and a moveable head with movable facial features. The primary user engages with the robot, while the secondary user is remotely located. The secondary user controls the robot’s movement, in which the robot would reenact those movements from the secondary user. This way, older adults are able to perceive the conversation through the embodied motions of the robot. Another way to connect older adults with others is by using Giraff which is mainly used for (video)calls (e.g. Moyle et al., 2013).

In sum, some scholars interpret HRI in elder care as supporting social or entertaining activities instead of pragmatic ones. They are used as entertaining devices or as an interface to foster interpersonal social relations. Contrary to the “robot-as-agent” terminology, these tools are ought to merely enhance interests and social networks of the users. The music, e-books, and games the users are able to select require some pre-existing interest coming from the user. The HRI relies on the older user for input. They would need to actively select a robotic feature and align it with their interests. This same mechanism also holds for robots that foster interpersonal communication, as these technologies rely on the pre-existing social network of the older adult. Without the social network of the older user, communication is not possible. The robot, in other words, relies on the older user for interaction and is therefore defined as a tool.

Here too, occasional discrepancies between operationalizations and general characteristics of the robot were found. A notable example the study of Damholdt et al. (2015). The authors used Telenoid in their studies to test for interpersonal communication:

> “This technology enables two persons, A and B (see Figure 2), to communicate with each other using the robot as a communication channel.(…). The basic idea behind this setup is to empower A with a remote embodiment at B’s site via a wireless network connection” [Damholdt et al., 2015, p. 4].

But when testing this robot, the researchers presented a condition in which they did not tell the participants there was another person talking to them through the robot. In other words, the participants did not know that this interaction was in essence inter*personal* human communication mediated via a robot:

> “In the 3 days following the assessment the participant had lunch (20–40 min) in the company of either a tele-operated robot or a member of staff. Their lunches were video recorded. The participants were randomly assigned to one of three

> conditions: (a) an informed condition (IC; n = 7) where the participants were informed that the social robot would be tele-operated, (b) an uninformed condition (UC; n = 7) where the participants were not given any information about the functionality of the robot, (c) a control condition (CT) where the participant had lunch in the company of a member of staff. In all randomization conditions the conversations and conversation topics were non-scripted and mainly focused on the food, weather, health, the stay at VG etc” [Damholdt et al., 2015, p. 3].

This blurs the line between the tool and entity typology: what if a person is not aware of the nature of communication coming from the robot? Taking it one step further, this triggers the question if people with cognitive impairments or users that are not aware of the communicative nature of the robot should be taken into account when defining a robot. After all, does it really matter if a robot is “objectively” functioning as a tool or an agent while the user might not be aware of its functions or is simply misinformed?

4.3.4. Social agent: Robot toys, conversational robots

Whereas a robot as a social tool functions as an interface or an entertaining device, a robot as a social agent is supposed to represent a social entity. The interaction is not dependent on the user’s social network or personal interests, as is with the robot as a social tool type, but rather *provides* social companionship. Obviously, robotic agency is limited, as robots do not have a “life” of their own. However, this paradigm approximates this notion by framing robots as agents. This interpretation of HRI is found in studies on Pleo (Perugia et al., 2017a; Perugia et al., 2017b), CuDDler (Moyle et al., 2016), and

Paro (Wada et al., 2003a; Wada et al., 2003b). Note that these robots are different from the robot therapists described earlier (care agents), as the type of interaction coming from social agents is rather playful than instructive. Paro and Pleo can be fed, they all can be touched and stroked, CuDDler and Paro have soft outer hardware materials. These robots are similar to toys. Interestingly, it does not seem as too much of a stretch to compare these robots to children’s toys. Some of the authors even mention that explicitly:

> “We selected this robot, instead of other available ones, because being designed for children, it provides a very prompt interaction, and this is very important when working with people with mild to moderate dementia who are still able to sustain dynamic exchanges [24]” [Perugia et al., 2017b, p.1250].

Other robots found in this category are meant as conversational agents. However, such robots are typically not completely automated, as implementing “effective” dialogue systems in robots is extremely challenging. For instance, the eBear that is used by Kargar and Mahoor (2017) to treat older adults with depression was tested in a Wizard of Oz (WoZ) setting. So even though they were testing for the conversational aspects of the robot, the robot itself was not fully automated. When automated, the conversational tasks are kept to a minimum. For instance, Scitos is a service robot used in the study of Hebesberger et al. (2017) to greet people at the reception of a care facility.

In short, the two types of robots that are prevalent in the data in relation to the category of social agents are robot toys and conversational robots. It is also relevant to note, that most of the studies that involve a robot-agent have older people with cognitive impairments as their intended primary users. This suggests that imagining robots as providing companionship is not meant for everyone, but rather a specific group of older people. These robots are not meant for abled bodies, but rather for the cognitively impaired.

Furthermore, while the robots in their own right seem to be very clear cases of agents, sometimes the operationalizations tell a different story. For instance, while the described main feature of such robots is robotic companionship, authors also view these robots in terms of anticipated social interactions between residents of nursing homes. As Kidd et al. (2006) mention:

> “Thus we wanted to explore the Paro as an impetus to conversation and interaction in a group. (…) We created a placebo versus interactive robot comparison in order to measure whether robotic interactions generated more social activity” [Kidd et al., 2006, p.3973].

The robot itself, Paro, does not necessarily change in terms of its technical characteristics, but rather the contextual situation Paro is put in gives information about how robots, while being static in their design, could be envisioned as something different in practice. Indeed, rather than viewing robotic companionship as a one-way street (i.e. robot dominated communication), Paro is supposed to function as a social stimulus between older people (i.e. interpersonal communication triggered by a robot).

Does this mean that Paro, Pleo and other toy like or conversational robots could be categorized as tools? Not really, as these robots have very particular purposes of giving robotic companionship for people with cognitive impairments, i.e. it is not a device meant for maintaining pre-existing social relations. But it does say something about interpretative flexibility of the devices itself as is explained in paragraph 4.6.

4.4. The agent/tool distinction

A robot tool has different connotations than a robot agent. The former implies a device with which the user is equipped with, while the latter implies robot agency. Even though robots do not have “free will” like humans have, the “robots-as-agents” paradigm assumes that robots embed characteristics that resemble humans or other biologically inspired entities. It should be noted, that this does not always correlate with appearance: a mechanical looking robot, rather than a humanoid or zoomorphic robot, could still function as a biologically inspired entity by exhibiting traits that resemble human caregiving or social companionship in their actions, e.g. the robot taking tests for therapists in the study of Azkune et al. (2012) or the robot greeting people in the study of Hebesberger et al. (2017).

These scholars mention actions and activities coming from the robot that resemble some form of agency compared with tool-robots that are seen as merely “complementing” mundane activities. In other words, in order to understand the ontological weight attributed to the robot in terms of human-robot “*interaction*”, one should ask a question of relational human/robotic agency. Who or what is communicating, and who or what is at the receiving end of that message? Who or what is the sender and the receiver? Depending on one´s perspective, the machine is able to be interpreted as a subject (agent) or an object (tool) of communication. HRI is ultimately an interpretation of relational user/machine agency in the role of the sender and receiver. The role of sender/receiver in HRI is a matter of communicative dominance: one speaks and another one is silent in the interaction, one is proactive and one is reactive. A robot such as Giraff that enables videocalls requires a different role from the user than a robot that is a physical therapist. Indeed, a robot designed for remote communication expects some form of activity of older adults such as operating it: e.g. having contacts to reach out to, and being able to communicate interpersonally (i.e. not being too cognitively impaired). It requires social capital and skill. By contrast, a robot therapists that tell users what to do, such as seated exercises, and makes the older user the recipient of communication. The premise of HRI in the latter case, is that of passive users reacting to robotic communication.

However, this does not mean that certain robot types (such as the robot therapist) inherently assume certain communicative roles of humans and machines. For instance, in the study of Fasola and Mataric (2012) the roles of therapist and receiver were reversed with the imitation game. The human performs simple arm gestures, that the robot needs to reenact, thereby challenging the robot-dominated communication ascribed to agent-robots. Also, sometimes the same robot could be used for different purposes, hence altering possible scenarios of senders/receivers. iCat was interpreted by Looije et al. (2010) as an instructive agent (i.e. passive humans, active robot), while Heerink et al. (2006) used it as a tool (i.e. active humans, passive robot). But also within a single robot case, the agent and tool paradigm can overlap, and thereby also the interpretation of communicative dominance. For instance, FriWalk by Given-Wilson et al. (2017) is a robotic walking aid (care tool) that plans a route for its user based on both sensory and medical data (care agent). Additionally, the robot functions as a mediator by connecting to other robot walkers nearby and plans a common destination, and by doing so, enabling interpersonal human communication (social tool) instead of giving robotic companionship. Robot/human agency and communicative dominance is therefore interpretative within and across cases.

4.5. The social/care distinction

Particular to elder care, context of usage is another element essential for the typology. The sampled academic publications defined context of usage in terms care work: pragmatic care and social care. These two elements of HRI are consistent with the literature on care labor (Ranci & Pavolini, 2013), as care work is a multidimensional profession that combines social elements with pragmatic ones. Similar to machine agency, some scholars assign their robots to function in one specific domain, e.g. the robotic wheelchairs NEO-PR45 in Shiomi et al. (2015) and Mobot in Zlatintsi et al. (2017), while other scholars construct a robot that ought to function in both domains, e.g. FriWalk in Given-Wilson et al. (2017). Furthermore, different scholars can re-interpret the same robot in a caring or social context or both, e.g. Giraff in Moyle et al. (2013), Cortellessa et al. (2018), or Cesta et al. (2016). This means that care and social elements are not necessarily mutually exclusive for the development of robots in eldercare, although there are numerous publications that interpret robots to function in one domain or the other.

By attributing care to one of the two contexts of usage, these scholars allow for the standardization of care as a labor, while the practice of care could be interpreted by practitioners as holistic work. This simultaneously shows that robots fall short in this regard: compared to human work, robots are not entities that "can do it all". They are mostly used for one particular domain. Even when used for both social and care contexts, such is the case with Giraff, the functionalities are still limited: Giraff's main function is to connect geographically remote caregivers and/or family members, i.e. it cannot help with showering or lifting objects. Nonetheless, it should be noted that it remains to be seen whether future generational robots are more capable of approximating human caregiving by for instance being sensitive to the needs of users with concepts as robot personalization.

4.6. Flexible essentialism as an ontology for subject-object relations

The conceptual framework is a schematic overview that roughly categorizes the types of robots out there, but reality is often more complex than this matrix in fig. 1 suggests. Indeed, there were instances in the data in which a dichotomy of social/care and tool/agent was not clear cut. This does not undermine the validity of the presented schematic conceptual framework and types of robots presented, on the contrary, it turned out to have great value.

In order to understand why this has value, the data should first be discussed and understood as rich data. There are two types of data that were triangulated for the results. Each type of data was giving information about something else: one type of information stripped-down the robot from its social or contextual relevance, but did elaborate on possible robot activities and functionality. The second type of information involved the scholars actively putting the robots in a social situation by testing for certain features, with certain people, in certain test conditions. This means, that there can be some incongruency between the proposed robot and its function in action. This does not mean that one viewpoint is a “correct” way of understanding social robots in elder care or HRI, but that one needs to understand both the situational relevance of HRI *as well as* the machine *an sich*. While Paro on its own is able to provide its human users companionship, scholars were also testing it as a stimulus for human-to-human social interaction (Kidd et al., 2006). This means that robots are both situational artifacts as well as artifacts with certain inherent features and material boundaries. As is explained later, this result has great value in terms of the theoretical debate in academia in terms of machine agency and subject-object relations. But first a more fundamental question needs to be answered in terms of the usefulness of the conceptual framework: can we really make distinctions between robots if part of the answer is situational?

When looking at the data, one can see patterns of robot types. A conversational robot is very different from a robot therapist. They are distinct in their features and are limited in their own ways: Paro is not able to set up a Skype conversation (i.e. a fully automated robotic toy) like Giraff is able to do so (i.e. tele-operated, social networking robot). In a similar vein, a wheelchair robot (Shiomi et al., 2015) is not a conversational robot. In other words, it makes sense to make such distinctions between these different robot types, and their meta-categorizations of care tools, care agents, social tools, and social agents – as different robots *do* have different distinct premises and material boundaries. So, in part, it makes sense to differentiate between different robot types that are *inherently* different from one another.

However, there are two reasons as to why things get tricky when trying to label a robot. First of all, there is the issue of robot versatility. This concept is introduced in this study based on the previous empirical observations. There are robots such as Pepper, Nao, or iCat that are usually not developed for one specific task, but could be used for multiple occasions and can be easily programmed for specific interactions – i.e. multi-purpose robots. Werner, et al. (2013) for instance used Nao as a physical therapist, but

Prange et al. (2015) used Nao for (medication) reminders and sending out emails. Another example, the iCat in the study of Looije et al. (2010) was used for motivational interviewing. The authors envisioned this robot to help diabetic patients to make better lifestyle choices. By understanding the robot as a persuasive assistant, the authors conceptualized the robot as an agent. However, Heerink et al. (2006) used a different approach with the same robot. The iCat was used to test for the relationship between social abilities of a robot and acceptance. They tested this mechanism by approaching the robot as an assistant (i.e. tool): the robot offered features to its users like setting an alarm or give the weather forecast. While the main aim of their paper was to establish the way robotic behavior could influence users’ acceptance, the authors tested this mechanism by envisioning the robot as merely an artifact that eases everyday living - i.e. a tool. Pleo or Paro, on the other hand are very much focused on a specific aim (single-purpose robots): i.e. play/companionship and may be regarded as less versatile than other robots that were not developed with one specific aim in mind. In other words, and taken inspiration from polysemy as a concept discussed in chapter two, robots have polysemous meanings: some more ambiguous than others.

Second, regardless of how versatile robot objectively “is”, there is the issue of interpretative flexibility which refers to the creative appropriation of the technologies by humans. Just because a robot is intended as something and could be considered less versatile (such as Paro), does not mean there is a linear path to usage. Scholars sometimes are able to take one of the less versatile robots, Paro, and test it as a tool enabling interpersonal human-to-human communication (e.g. Kidd et al., 2006). This does not make Paro less of an agent, but an agent with the potential to be interpreted as a tool in a specific context.

In other words, yes it makes sense to differentiate between different robots, but there should be some room left for situational deviations. Ironically, the interpretation of this schematic model ties in with theories of boundary work as discussed in chapter two, i.e. relating technological objects to its content, and situational interpretations thereof. To briefly summarize, technological content and interpretations do not always align, but certainly there are particular scripts (Akrich, 1992), texts (Woolgar, 1990), or mediated messages that establish a preferred reading/interpretation of object. Relating this to the schematic model, the four different types could guide as *sensitizing concepts* for further analysis – i.e. they are not predictors of robot content, but rather ideal types.

Before illustrating how exactly this study contributes to the field with its findings, it should be kept in mind that representations of robot content were studied, i.e. secondary data. However, while this dissertation sampled *perspectives* of scholars working in the field of HRI, the general descriptions of robot features and their technicalities do help with understanding essences of robots. Admittedly, these essences are not observed first-hand in the field, but nonetheless, the descriptions of such robots do scratch the surface of what these robots are able to do. These scholars are experts in the field, and according to Bijker (2010) have a specific type of knowledge and power in the construction of such artifacts. In other words, these representations matter in relation to the construction of technological content.

Now why are these findings of great value as suggested earlier? The results tap into longstanding debates in academia about how to treat technical objects in terms of their (lack of) agency. In theoretical terms, the findings contribute to the debate of subject-object relations. Just like a robot intended to be of help with showering (Zlatintsi et al., 2017) would probably not function well as an interface for smart housing – i.e. an artifact *has* inherent boundaries - the contextual interpretation and reception of the robot is hard to predict. You can store cookies in a cookie jar (preferred/obvious), milk in a cookie jar (less preferred/less obvious), but not a piano (object is limited to its material boundaries). The mere categorization of *social* robots in elder care already indicates an essentialist viewpoint. It implies that the machine has different qualities than a bicycle or a cookie jar. It also implies that the artifact has more (or at least different) forms of agency than other objects and even robots – since the word *social* is used in the terminology. While other authors also have already established this (e.g. Pfadenhauer, 2014), the agency discussed is often discussed in a situational and relational context (e.g. Alač, 2016). Agency is rarely seen to be located *in* the object itself.

However, this study argues, that we need both perspectives rooted in essentialism as well as intra-actional perspectives on Human-Robot interaction to understand agency and subject-object relations. Indeed, also relational perspectives on HRI are necessary to understand because the content of the machine does not predict how humans (in this case scholars) perceive machine agency. Communicative dominance between humans and machines is not only determined by the object itself: it is a relational and situational phenomenon. The scholars that were studied for this dissertation did not use the robots sometimes in a straightforward manner, indicating the interpretative flexibility of the object itself. Tools were interpreted as agents, and the other way around.

This means, if "even"[18] scholars get creative in interpreting the artifact, that it would be worthwhile to continue studying HRI in other relational and situational contexts. Nonetheless, that does not mean that a blind eye should be turned for classifying and categorizing technologies in terms of their inherent features. This work reconciles those two seemingly opposing camps in the academic literature, by proposing the term *flexible essentialism* as an ontology in subject-object relations that allows for the study of both material essences and relational human/non-human importance. Not only is this relevant from a theoretical point of view, i.e. to study inherent technical qualities and relational practices, but also to enable a research agenda that is not limited to particular methodological dogmas. Indeed, a Latourian perspective does not allow for the reduction of complexity in the form of the matrix shown in fig. 1. Flexible essentialism as a proposed ontology opens up the possibility to study technologies with a wider toolkit of methodological options.

4.7. Communicative dominance as a research agenda

Does this study fulfil the objective of delivering clear language and cohesiveness in a heterogenous field? And if so, how could it help with future work? As mentioned in the results, the different social robots analyzed in this study do have distinct premises and boundaries: (entertainment) assistants, robot therapists, robots running medical tests, social networking robots, robot-toys, conversational robots. The "social" in social robot could therefore refer to a multitude of technologies. Mapping out all these different types

[18] The word "even" is used here, since scholars could be seen as experts in the field (Bijker, 2010), and thereby already aware of the functionalities of the robots. If they already get creative in their interpretations, it would also be worthwhile to study laymen in their interpretations – suggesting the latter group could even get more creative

might help other social scientists, policy makers, or others to understand what is “out there” and to potentially explore individual cases in accordance with one’s interest. In other words, this study has brought a cohesive understanding of what is possible in today’s field with this typology and conceptual framework.

What all social robots have in common is that they can be theorized in terms of machine agency and user context, resulting in the categorization of tool/agent, social/care. What is of special interest here, is that machine agency can be thought of as communicative dominance: some robots are more “demanding” than others. Also, the distinction between the social/care illustrates how HRI scholar differentiate care, and thereby standardize care or at least compartmentalize care, between two aspects: pragmatic help, and social help. A holistic robot does not exist (yet).

Futures studies would have to show if this conceptual framework could be taken up as sensitizing concepts. Though some examples are given here, paragraph 7.1 also discusses some of the following suggestions. One could imagine for instance how this division of robots doing care work and social work implies the standardization of elder caregiving, but is that really the case? One could for instance observe how caregivers “compensate” for a robot that is typically designed to do a certain task, and how that fits within or outside of organizational care work (e.g. a comparison between formal and informal caregiving). Furthermore, the agent/tool paradigm allows for follow-up studies on anthropomorphism. Is an agent perceived as more anthropomorphic than a tool? Furthermore, issues of communicative dominance, resistance, and negotiation could be explored in the context of HRI: do users negotiate autonomy or do they surrender to the instructions given by robot-agents? From this perspective, studies could show possible tensions between autonomy and (in)dependence: agent-robots are perceived by older users in terms of their autonomy, (in)dependence, quality of life etc, compared with tool-robots. Furthermore, the agent/tool analogy also implies some normative interpretation about the activity and passivity of older users. Indeed, there are different connotations of older adults practiced if users are regarded as empowered people in need of a bit of technological aid or as people that are in need of more "intrusive" technological intervention. Related to the aforementioned statement, chapter six in this dissertation specifically discusses normativity in the representation of older adults in such technologies.

Also from a positivist perspective, this model suggested in fig. 1 could be tested in future studies. For instance, if the tool/agent analogy supposes that different technologies envision different users, it could be tested if different robots have different effects on different users. To further illustrate, if tools are merely helping older adults with mundane activities, and agents are more intervening for particular needs, one could hypothesize that tools are better suited for active older adults (third agers) and agents for passive fourth agers. This could be tested by letting different older users with certain pre-existing qualities (e.g. high levels of autonomy or subjective wellbeing etc.) interact with different robot scenarios. What happens if a tool (which typically requires skill and cognitive resources) would be used by fourth agers, and vice versa?

One could also try to apply this conceptual framework to other technologies. Robots are not the only technologies applied in care contexts. The question then becomes, what are the boundaries of the matrix itself? Could it be applied to other technologies in (elder) care, or could the tool/agent distinction in particular also be applied to technologies more broadly? While this study does not have empirical data on other technologies, there is no reason to believe that the tool/agent typology cannot be applied outside the field of HRI. Especially with the rise of AI systems, the complex interplay between non-human/human proactivity/reactivity is very relevant and necessary to study. To give a radically different example outside the field of elder care technologies, is an autonomous car a tool or an agent? While it most definitely could be interpreted as an agent, after all the car drives autonomously (although technically speaking level 5 full-automation is not currently deployed), court rulings of an incident indicate that they could still be interpreted as tools. In the case of a court ruling in 2018 (De Rechtspraak, 2018), the driver was texting while driving. The driver argued that the car was in command, but the judge’s verdict stated that the human still has the responsibility of being a driver (i.e. autonomous car as a tool). In other words, interpreting humans/non-humans in terms of agents/tools has not only academic implications, but also practical ones. This makes illustrates the necessity of the tool/agent model to be further explored and tested, possibly outside the field of elder care, and social robots.

As the examples illustrate, the conceptual framework opens up many different research opportunities: to test the model, expand it, or deepen it both within and outside the field of social robots in elder care. The conceptual framework and its sensitizing concepts presented in this study therefore do not necessarily automatically fall within a certain research tradition or paradigm. Having said that, while future scholars could use this theoretical framework in whichever research field and tradition they feel most comfortable in, this study acknowledges the relevance of both studying 1) machines on their own, and 2) machines in contexts, as the ontology flexible essentialism suggests.

One could choose to do one or the other when using this conceptual framework, as some of the examples described above do fall in one or the other category (e.g. testing the model clearly separates the machine from everyday situational interactions). Choosing one perspective over the other is similar to picking either a qualitative or quantitative empirical approach: one is not better than the other, it just tells a different part of the story. Similarly, focusing on material boundaries tells one part of the story and performativity another. One could also be sensitive to both perspectives and triangulate these perspectives – i.e. use both perspectives in one study. In the latter case, these two worlds would be bridged in order to understand material *boundaries* in *practice*.

5. The “need” for social robots in elder care

“Why?” is a question that arose while writing this thesis. Why do “we”, i.e. as a society, “need” social robots in elder care? Engineering as a discipline is often regarded as “useful”, creating technical solutions to modern problems with concepts such as “beneficial AI” (e.g. Baum, 2017) or “AI for social good” (Cowls et al., 2019). But is elder care really a “problem” needed to be “fixed”? And what is “social good” in relation to elder care? This paper presents a critical analysis of the rationales put forward by the academic community in HRI to develop and study robots in elder care, thereby contributing to the field by giving a counternarrative to the idea of “socially good” gerontechnology. The research question that guides this study reads: What rationales are given in the academic literature for the need of social robots for eldercare? Academic literature is chosen as sources because 1) scholars need to elaborate on the (societal) relevance of the artifacts under study and 2) scholars are regarded as experts in the field. The argumentation is therefore expected to be deliberative. In order to understand the argumentation in its context and the normative assumptions associated with it, the concepts of sociotechnical imaginaries and socially good technologies are explained in the following paragraphs.

5.1. Studying rationales and their sociotechnical imaginaries

The “why?” question clarifies the ideological element of robots in elder care: it is exposing what is “wrong” with the current status quo, and how technological intervention would “fix” these “problems”. Understanding these rationales therefore is an attempt to expose underlying normative associations in the design and development of social robots in elder care. Engineering and ethics are deeply intertwined, as artifacts embed particular visions about the world (Verbeek, 2006). In that same line of reasoning, using robots in elder care is only useful when envisioning robots to have a certain positive, however defined, effects on its users, care environment and caregivers, or care system (i.e. primary users, secondary users, or a broader environment). As Jasanoff (2015) also argues, innovation is inherently linked to making predictions about (un)desired futures: it is about using technologies and innovations to prevent or mitigate certain futures from happening, while allowing for other scenarios to unfold. Related to that, is the concept of sociotechnical imaginaries. According to Jasanoff (2015), sociotechnical imaginaries are claims about ethics and the “good life” in relation to technologies, as imaginaries “encode not only visions of what is attainable through science and technology but also of how life ought, or ought not, to be lived; in this respect they express a society’s shared understandings of good and evil” (p.4). The exact definition of sociotechnical imaginaries reads as follows: (…) “We redefine sociotechnical imaginaries in this book as collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology” (Jasanoff, 2015, p.4).

This concept, sociotechnical imaginaries (Jasanoff, 2015), enables scholars to understand and analyze rationales put forward by people advocating for certain technologies. It helps with understanding how the field of HRI views the status quo of elder care and related concepts such as aging and care work, and how technologies are able to alter it. Thereby, the concept of sociotechnical imaginaries taps into normativity, by showcasing what underlying assumptions about social life are made when imagining a future with supposedly life altering technologies. Developing robots in elder care therefore implicitly answers questions about how life is ought to be: what do “we” (i.e. a contextually variable “we” – society, organization, team of roboticists, individual) think about how social life has been conducted so far, are “we” happy with it, should “we” alter it with technologies, and if so, how could “we” beneficially alter social life with technologies?

One way of analyzing these sociotechnical imaginaries is by looking at how these sociotechnical imaginaries are contextually situated. Jasanoff (2015) refers to the importance of studying historical events. Indeed, ideas about how elder care, care work, and aging are ought to be performed, are long developed before the introduction of robots in elder care. “*An sich*”, i.e. without technological intervention, these concepts have been subject to scientific and public debate over the last decades. As is discussed next, social robots in elder care are intrinsically related to those debates, as sociotechnical imaginaries do not appear out of thin air. For instance, successful and active aging was popularized since the 1980’s (Bülow & Söderqvist, 2014). Similarly, concepts like the standardization of care work and New Public Management (hereafter NPM) largely influenced ideas on care provision in the 1990’s (Ranci & Pavolini, 2013). Related to NPM’s influence, several European countries underwent reforms in their long-term care policies since the 1990’s (Pavolini & Ranci, 2013). When looking at that timeline, one could observe how last decades of the 20th century was a playground for different societal developments related to aging, care work, and care policies. Not too long thereafter, Wada et al. (2003a) published their work on Paro. This does not mean that those societal developments necessarily caused the creation of social robots in elder care, but it might have given the development of robots in elder care fertile ground for certain preferred sociotechnical imaginaries and desired futures. Taking it one step further, one could argue that the social norms developed and maintained around the 1980’s/1990’s indicate the production and reproduction (or rather: co-production to use the concept of Jasanoff, 2004) of a certain Zeitgeist that prefers certain social ideas and norms of elder care, care work, and aging, over others.

Unfortunately, in the social sciences Zeitgeist has rarely been used as an analytical concept. While Jasanoff (2015) does not explicitly uses the word Zeitgeist, she does clearly refer to the same theoretical understanding of time as a contextual factor in sociotechnical imaginaries as is shared in this study. According to her, certain ideas travel well over time (and space) while other ideas do not. Though it is difficult to pinpoint when an era with particular ideas, i.e. Zeitgeist, stops and a new one starts, according to Jasanoff (2015) this could be approximated with historical comparison: “it is only by following ideas through time that one gains a feel for what is fixed and what is changeable in social self-understandings, as well as the reasons why” (p.41). In the analysis, therefore, a connection is made between the rationales for the need of social robots in elder care and historical developments. Before explaining how the rationales relate to their Zeitgeist and what that means in terms of ideology and normativity, the following paragraphs discuss how “beneficial” or “socially good” technologies are part of a larger debate occurring inside and outside of academia.

5.2. Technologies and social good

The concept of sociotechnical imaginaries is an academic and analytical tool, helpful for understanding the normative motivations for constructing/implementing/using etc. new technologies. It is not a plea to make desired futures desirable, but rather to analyze the underlying normative ideas about the sociotechnical and to make these ideologies and imaginaries explicit. However, with the development of technologies that are difficult to understand with respect to its potential usage and effects in several social domains, such as AI systems in law enforcement (Hill, 2020; Larson, 2018) or robots and warfare (Arkin, 2009), normative concepts and movements are developed that call for beneficial AI specifically. For these scholars, it is important to steer new technologies into the *right* direction. As such, robots in elder care could be seen as part of a larger trend in the field that calls for AI and new technologies that in some way do “social good”.

There are numerous examples that illustrate how AI and related fields such as robotics could be used for “social good”. For instance, AI could be used to decrease cybercrime and money laundering (Dilek et al., 2015; Kingdon, 2004); interpret diseases (Alharbi & Alghahtani, 2019); or for sustainable (smart) farming (Eastwood et al., 2019). Using robots to “better” eldercare could be seen as yet another example of “good” technology. These new technologies tap into numerous normative concepts such as beneficial AI, Provable Beneficial AI (hereafter PBAI), and Artificial Intelligence for Social Good (hereafter AI4SG). These (rather interchangeable) concepts stress the social responsibility of researchers and designers to create ethical technologies.

Before discussing these concepts, it should be noted that AI and robots are not synonymous phenomena, as already stated in chapter four. Not all robots must exhibit a certain level of intelligence in order to be classified as a robot fit for eldercare, even though robotics are considered by some scholars as a subfield of AI (e.g. Russell, n.d.; HLEG, 2019). But no matter how the robots express their (lack of) intellect, the categorization of robots as AI is not a necessity in this field in order to understand the overarching premise of how these technologies advance eldercare and are “socially good”: the form of intellect is just means to an end. This chapter discusses the socially constructed nature of the end, and not the means. On that same note, this study focuses on robots specifically but it could be considered that other (non-embodied) technological systems designed for elder care share the same premise, because it would relate to tackling the same “problem”, just with a different technical solution or infrastructure.

So the development of robots in elder care aligns with movements and normative concepts that try to make socially beneficial technologies. The key objective of such movements is to make “good” and “beneficial” contributions intentional in the construction of technology. As Baum (2017) mentions, the focal point is to “encourage technologists to design and build beneficial AI, or to have them avoid designing and building AI that is not beneficial” (p. 544). Even though “beneficial” is not substantively conceptualized in this example, this case shows that technologists are called upon their responsibility. Similarly, this issue of responsibility is raised by Verbeek (2006) when referring to design ethics, although he does not relate his ideas to AI or robots specifically. He argues that “morality” should be deliberately inscribed into artifacts by making informed predictions about the usage. In order to foster a deliberate process of materializing morality, he argues for two different strategies: 1) the designer makes a prediction about the eventual usage by anticipating with imagination, or 2) other stakeholders need to be included in the process of technology construction. So the responsibility is placed on the designers, and if consulted, other social actors such as users and pressure groups.

Similarly, Russell (n.d.) also acknowledges the need for making deliberate attempts to mold AI according to human morality, although he advocates a different instrumental approach with his concept PBAI. He formulated three principles: 1) the machine is supposed to reflect human values, 2) the machine is uncertain what those values are, 3) the machine learns from humans inductively by observing human choices. The responsibility of good AI is placed on the human values from which the machine learns from: machine and human morality should be carefully and purposefully aligned. Also, Cath et al. (2018) continue the argument of responsibility, but shift the focus towards the public sector: “We shall argue that a multi-stakeholder effort, in which governments play a leading role, may be the best way to steer the fast development and widespread dissemination of AI in the right direction, and hence to ensure that the ‘good AI society’ will have the most positive influence on all individuals, societies, cultures, and environments” (p. 507-508).

While it is disputable who or what are responsible for the development of “good AI”, these concepts have two underlying assumptions in common 1) AI and other technologies have the potential to *change* the social and/or natural world, and thereby all actors responsible ought to steer it in the “right” direction 2) the actors responsible, however defined, are responsible because they influence the design, development and/or deployment of the technology. Specifically for AI4SG, the ways in which actors are able to successfully create AI systems, is when they help “reduce, mitigate, or eradicate a given problem of moral significance” (Cowls et al., 2019, p.3). This raises the question: how is elder care defined as “a problem of moral significance” that robots, or AI, are able to “fix”? Surely, the content and assessment of phenomena that are “socially good” or “problems of moral significance” are debatable, as ethics is a social construct itself.

Since the idea of “socially good” is a social construct, it needs to be analyzed how the premise of robots of elder care fits within this narrative. Are the rationales for developing robots in elder care as ethical as they at face value seem to be? Are they really promoting beneficial social change? Or is the premise of the argument reproducing social bias about aging? In short, the relevance of questioning why robots in elder care are needed, has to do with understanding what technological “progress” means: which “desired” futures is the field aiming for? In order to understand the nature of the argumentation and its implied normative content, a qualitative content analysis was conducted on the sampled publications discussed in chapter three. The following paragraphs discuss the results of the qualitative content analysis by relating it to their broader social context.

5.3. The rationales behind elder care technologies

Often, the rationales for constructing and studying social robots in elder care has to do with the foreseen consequences of demographic changes. More specifically, a demographic “imbalance” in which the proportional number of older adults to younger cohorts would increase, and is regarded in the literature as unsustainable. The main consequences put forward in the academic anticipated are an increase in 1) care expenses,

2) a shortage of care staff and burdened nurses/caregivers, and 3) more people with lower (subjective) wellbeing. A small number of publications did not mention a rationale. Before discussing these results, it should be noted that these academic publications often mix two or more of these rationales in their argumentation. What follows, is a description of each rationale with exemplary quotations, which then is put into perspective with a critical discussion.

5.3.1. Cost containment and the welfare state

The academic field of HRI argues that elder care is expensive. With mass aging comes mass dependency. Making users independent would contain care costs, as robots are regarded as main drivers for preserving autonomy and independence. This would delay and reduce the need for (residential) care and enable aging in place. To illustrate, Draper and Sorell (2017) mention the following:

> “*The population of older people is increasing*. Between 2015 and 2020, the number of people in the UK general population aged over 65 is expected to increase by 12% (1.1 million); those over 85 by 18% (300,000); and the number of centenarians by 40% (7000). (…) Accordingly*, welfare states face increasing costs for the care and social support for older people who are unable to live independently*” [Draper & Sorell, 2017, p.49] [19].

[19] All emphases illustrate how the quotations relate to the overall theme.

The authors mention how more older adults need care, but care spending is falling short. Social robots are seen as a solution to counter this. To give another example, Michaud et al. (2007) mention the following:

> “*The demographic imperative of an aging population and its impact on the reorganization of health care systems worldwide create unique opportunities to look at new approaches in delivering health care services*. The concept of teleoperated assistive mobile robots to support the provision of home telehealth services is one solution that is worth investigating (Katevas 2001; Pollack et al. 2002; Cesta et al. 2003). For instance, having sensors and actuators required in assistive tasks made mobile would *decreasing the cost and the complexity associated with instrumenting a home*” [Michaud et al., 2007, Para.1].

This idea of having social robots to not only contain cost but to restructure the elder care system needs to be analyzed in its context. As welfare states are anticipating growth of an older population, several European countries have adopted strategies during the past three decades to make care expenses more manageable. As is argued, the motivations for policy reforms in the field of long-term care aligns with the motivations for developing social robots in elder care since both aim to contain costs. In order to understand this statement, it first needs to be clarified how long-term care is historically situated as a social policy field.

In Europe, elder care has not been until recently part of a major policy field. According to Pavolini and Ranci (2008): “To date, caregiving has been considered not as an ingredient in the social contract, but as an obligation arising from within private relationships and which can only be replaced by public protection if care cannot be given for ‘objective’ reasons (the absence of family carers, insufficient economic means, serious dependency)” (p. 247). So elder care was long time regarded as a domestic matter and not subject to public concern, with the exception of the Nordic countries and the Netherlands as these countries developed a more public strategy in the regulation of long-term elder care since the 1970`s (the Netherlands) or earlier (Denmark and Sweden), according to Ranci and Pavolini (2013).

From the 1990`s onwards, long term-elder care was growing as a policy field in Europe (Pavolini & Ranci, 2013). Countries with residual tradition try to increase their coverage of long-term care to meet the demands of a growing older population. While there is a notable expansion in policy regulation and coverage in central and southern Europe, informal networks and other non-state actors are still valuable assets in care provision (Ranci & Pavolini, 2013). Also countries with a universalistic tradition experienced changes in their approach to long-term elder care (Nordic countries and the Netherlands) during the last three decades. The general tendency here is towards marketization of care (with the increase in the number of private care providers), aging in place, and informalization of care. While each European country certainly has specific care policies with its own unique characteristics, Ranci and Pavolini (2013) mention how care provision in Europe (on the basis on data of 10 European countries) is converging by, among other factors, moving away from costly formal care provision to other ways of providing care and the influence of NPM on formal care provision.

As is argued here, introducing robots to elder care aligns with this narrative of cost containment by promoting cheaper forms of care provision to foster e.g. aging in place. One of the aims of robots in elder care is as presented in the literature to increase or maintain independency and thereby delay or reduce the need for (formal) care as long as possible. The rationale is, similar to the debate on care provision in Europe, rooted in the need for cost containment due to the anticipated rising expenses in elder care (e.g. Bonaccorsi et al., 2016; McColl et al., 2013). The “need” for trying to delay or reduce formal care is therefore shared among both policy makers and the academic HRI community.

It should be noted that HRI scholars do not necessarily make explicit connections between welfare state regimes or long-term care policies and their robotic solutions. Usually, the literature starts with an introduction about how demographics are changing and that it is a costly development for many involved, thereby not always citing what that specifically means for which welfare state. The argumentation is not refined, as the consequences of aging demographics is described in very general terms. To give an example from a study developing the social robot eBear to treat elderly people with moderate depression:

> “*With the increase in the population of the aged people in the United States and all other countries in the world, there is a crucial need for a better personalized health care system.* Socially Assistive Robotics (SAR), as a part of assistive technologies, aims at providing healthcare for people and particularly for the aging population and *decreasing the current healthcare services’ cost*” [Kargar & Mahoor, 2017, p. 756].

The argument that demographics are changing is not put into context. The discourse is fairly generalizing: aging populations and their problematic consequences are regarded as a universal mechanism cutting across different cultures, and a costly burden for everyone.

In sum, the sociotechnical imaginaries guiding these papers reflect a future in which older adults are self-reliant with the help of social robots, which eventually will alleviate costs. This is aligned with three decades of restructuring welfare state policies in Europe that aim to reduce formal and long-term care expenditure, partially under the influence of NPM (Pavolini & Ranci, 2013).

5.3.2. Changing care work

Another rationale for developing robots in elder care has to do with two arguments concerning care work: a shortage of caregivers and burdened caregivers. Concerning the former argument, developing robots is seen as necessary since the literature foresees a shortage of caregivers. The implementation of robots in elder care would change the structure of the sector by filling this void. Hebesberger et al. (2017) for instance claim that:

> “Robot technology could be a future means to *ameliorate predicted staff shortage in elder care* due to the current demographic change” [Hebesberger et al., 2017, p. 417].

According to the authors, user acceptance is necessary for the adoption of such technologies in society to:

> “(…) help to bridge the gap between an ageing society and a lack of staff [4,6,8–11]” [Hebesberger et al., 2017, p. 417].

Another study aims to embed a robot into a smart home environment for similar reasons, but additionally mentions quality of life as a rationale for developing social robots in elder care – a theme taken up in a later paragraph:

> “By 2050 37% of the EU population will be over 60 years of age and it is expected that there will be fewer than two persons of working age per senior of 65 or older. This will lead to both *an increasing demand for care and a shortage of caregivers*. Intelligent home environments are one of the key facets to *counterbalance the reduced number of caretakers and increase QoL (Quality of Life) of older persons.* KSERA is a research project in the EU's 7th Framework Programme that aims to seamlessly integrate smart home technology with socially assistive robots. The main aim is to develop a socially assistive robot that helps older people, especially those with Chronic Obstructive Pulmonary Disease (COPD), with their daily activities, care needs and self management of their disease” [Werner et al., 2012, p. 455].

Second, robots are seen as “socially good” since it would alleviate burdened caregivers. This argument has to do with the idea that care work has low job quality, as it is rather stressful and demanding work. Robots would replace tasks of human caregivers or increase the independence of the users, and thereby not only account for the shortage of caregivers, but also alleviate nurses/caregivers from certain tasks. For instance, Reppou et al. (2016, p. 539) mention:

> “It is a general truth that in the near future, *older people requiring support in their daily life will increase dramatically, overburdening the available caregivers*[27].

> Socially interactive robots can prove helpful, not only by physically assisting people, but also by monitoring their health state and ensuring their safety while also functioning as a companion [4]” [Reppou et al., 2016, p. 539].

To give another example, Piasek and Wieczorowska-Tobis (2018) state how:

> “The upward *trend* of intense ageing in European societies has been observed for several years now. *While the number of elderly individuals is constantly growing up, the number of professional caregivers does not.* This situation presents a challenge for developing and implementing of new solutions, *aimed at reducing the burden on caregivers working in the system.* One of the possible solutions may be based on the technology, especially on use of robots to assist the older people living in the community” [Piasek and Wieczorowska-Tobis, 2018, p. 478].

It should be noted that while the previous examples show how the rationales presented in the publications for studying and developing robots in elder care have to do with the consequences of aging populations, some papers also mention how caregiving could be *inherently* tiresome, burdensome, or repetitive (e.g. Boumans et al., 2018; Rehm et al., 2016; Sung et al, 2015), i.e. regardless of anticipated demographic changes. Nonetheless, whatever the causes of “problematic” care work, the field of HRI assumes that care work can be “fixed” using social robots. This idea of having robots perform certain care tasks is related to the idea that technologies are able to replace human care work. The point of introducing robots in elder care is to conduct tasks that were previously allocated to human workers. If robots were to conduct care work, it would reduce the amount of human intervention, thereby making care more manageable for both the burdened caregiver and the economy of the welfare state with its foreseen shortage of caregivers.

At face value, the premise of restricting care work with technologies might not seem too problematic. The narrative partially feeds into mechanisms of “liberating” care workers from their demanding jobs. But which parts of their jobs are the care workers supposed to be liberated from? In order to answer this question, the care/social distinction in the conceptual framework in chapter four ought to be discussed. To briefly revisit the findings of chapter four, the literature envisioned robots to do tasks that fall in one or the other domain, with some exceptions of robots that cross domains. However, caregiving is a holistic practice, that requires both emotional support as well as pragmatic help (Ranci & Pavolini, 2013). Unfortunately, the premise of the robots thus far, as illustrated in chapter four with the social/care distinction, is typically imagined in particular tasks. These sociotechnical imaginaries of robots doing particular tasks, but not all tasks holistically resembles a broader tendency of care work being standardized. The premise of having robots doing particular tasks in pragmatic care work or emotional social work, does not free workers from their labor, rather, it standardizes it.

Framed differently, the argument of using robots in elder care to alleviate caregivers, and secure the amount of caregivers available in the future is related to ideas about automating and standardizing care work with e.g. NPM. Historically speaking, the standardization of care work developed since the late 80’s/90’s with changes in elder care policies and the popularization of the concept NPM in elder care. Policies have been created in several European countries to foster the standardization of elder care (Ranci & Pavolini, 2013). Denmark, for instance, introduced a tool called *Common Language* (*Fælles sprog*) in 1998, in which care protocols are used as a template to make care more comparable and manageable by means of standardization (Burau & Dahl, 2013; Rostgaard, 2012). As a guideline, certain times are allocated for certain care activities. Common language is a non-legislative tool, but nonetheless is still used by municipalities in Denmark as frame of reference. Besides external policies as a result of the neoliberal push towards elder care regulation in various European countries, management ideologies like NPM make care providers more prone to the logics of the market, paving the way for standardization and automation (Hood, 1991; Ranci & Pavolini, 2013).

By standardizing care work with scheduled routines for particular activities, the holistic features of human care work are thereby undermined. This has similarities with robots performing care work, as robots currently are only able to perform very particular care activities. A universal robot that is able to perform the multifaceted job of care work like a human is able to do does not exist. For instance, Paro (Wada et al., 2003a) is meant for companionship and is not able to help users to shower like in the study of Zlatintsi et al. (2017).

This does not mean that robots are supposed to remain idiot savants in the future or that the field is not trying to create more holistic robots. Rather, the sociotechnical imaginaries articulated in HRI relates to restructuring care work with automation would for now mean the further standardization of care work. Common language introduced in Denmark or in more general terms NPM as a management philosophy both favor the standardization of care work, just like the current generation of robots in elder care. In other words, the premise, or rather the sociotechnical imaginary at work here, i.e. the need for automating care work, in reality aligns with dividing care work into often performed very particular tasks.

5.3.3. Aging, activity, and wellbeing

In addition to care expenses and labor structures, another rationale given in the literature for the need for robotic elder care has to do with the wellbeing of care receivers (mentally, physically, cognitively, socially etc.). Older adults are seen as people who need to care for their wellbeing, by either preserving their already active lives or by fixing it. Robots are envisioned to help with achieving an active lifestyle and increasing the independence of older users, ultimately leading to better quality of life and wellbeing.

For instance, Hammer et al. (2017) state that

> “This work is targeted towards the development of a recommender system *that fosters the well-being of elderly people* in their domestic environment” [Hammer et al., 2017, p. 129].

Furthermore, Sebastian et al. (2014) mention the following statement:

> “Communication and social participation for older adults has become *an increasingly important need within an aging society*. Telepresence robots carry with them a set of technologies that provide a distinct advantage in *helping older adults maintain social inclusion*” [Sebastian et al., 2014, p. 278].

In the latter example, the wellbeing of older adults is also related to changing demographics: more older people means more inactivity and more people with lower quality of life. Though it should be mentioned that not all publications relate the changing demographics to lower wellbeing, but rather view older adults as people that *inherently* need to improve their quality of life and wellbeing e.g. in Zlatintsi et al. (2017) and Agrigoroaie and Tapus (2016).

Although wellbeing and autonomy are probably nice qualities to preserve, this logic is not “in itself” good, as this idea is a product of its time rather than a general “truism”. In the 1950’s, activity theory and disengagement theory were two opposing theories cited in social gerontological literature (Katz, 2000). In the 1980’s, disengagement theory, the assumption that older adults naturally withdraw and disengage from society at an old age, was getting more contested with the popularization of the concept successful aging (Bülow & Söderqvist, 2014).

The concept “successful aging” was discussed in the MacArthur Foundation Study which produced a number of studies between 1984 - 1993, and includes the paper by Rowe and Kahn (1987) “Human Aging: Usual and Successful”. This concept captures the malleability of aging: if people make the right choices they will age “successfully”. Phrased differently, people are responsible for their lifestyle choices. In part, this theory was a reaction to disengagement theory that regards older adults as frail and dismisses the heterogeneity and potentiality of the older population. However, exactly this narrative of potentiality connects active and successful aging with consumerism (Katz & Marshall, 2003) and neoliberal ideas of care work and care policies (Katz, 2000; Mikkelsen, 2017).

Instead of viewing older adults as frail people that withdraw from society as disengagement theory suggests, the interrelated concepts of active and successful aging establish the idea of older bodies as unfinished projects with potential. So older adults are able to actively participate in society but need to make the right consumerist choices to fulfill their utmost potential to age successfully (e.g. being physically active, socially active, and sexually active according to Katz and Marshall, 2003). This paves the way for consumer culture with all its lotions and potions that plays into the idea of preserving the old body as much as possible against signs associated with older age.

Furthermore, active aging could be seen as a disciplinary strategy aimed at preserving neoliberal ideas about elder care work and welfare state policies (Mikkelsen, 2017). To clarify, Katz (2000) mentions the following: “Activity is a part of a positive economy that shapes aged subjects within gerontological knowledge and research as knowable and empowerable, and inside care and custodial institutions as predictable and manageable” (p.148). According to him, the perceived importance of activity at an older age within academia and gerontological research stretches outside that realm, also affecting practices of care work. According to Katz (2000), active aging is a way to control aging bodies. He continues by arguing that in formal care institutions, activity often translates into measurable units of activities, often scheduled, routinized, codified, and assessed. In other words, the understanding that aging is malleable and predictable when controlled for the right circumstances, justifies the purpose of monitoring the behavior of older adults in terms of their (lack of) activity. This monitoring of progress or declines allows for the standardization of care work. In short, the concepts of active aging and successful aging helps with behavior management.

This notion of behavior management aligns with NPM as it allows for the standardization and quantification of aging and elder care with its repetitive and time-restricted behavior management. Furthermore, the perceived importance of successful aging and its associated concepts such as activity and autonomy relates to the narratives put forward in neoliberal social policy making. An active older adult does not require too much help from caregivers and the state (Mikkelsen, 2017). The perceived importance of active and successful aging feeds the narrative of the current neoliberal political climate in terms of elder care policies: active independent older adults are believed to not put such a strain on the welfare state. Active aging is not a good in itself, it is a product of its time with historical roots in the late 20th century that is associated with consumerism and the (self-)management of older bodies.

5.3.4. No rationales

There is a small amount of publications (n=6) that did not discuss the relevance or rationale for the need for social robots in elder care, and therefore cannot be placed in a certain historical framework. However, this does not mean that these publications are free of value or ideology. Rather, three publications studied user acceptance without elaborating on the need for such robots. For instance Heerink et al. (2009) mention:

> “Exploring the possibilities for using robots and screen agents in eldercare [1], we face not only technological issues, but also challenging questions concerning the way elderly people are coping or not coping with this new technology [2-5]. In our research, we address some of those questions by exploring the factors that may influence acceptance of a conversational robot by elderly users [6]” [Heerink et al., 2009, p. 1909].

The authors do not mention why it is necessary to increase the acceptance of a conversational robot. In other words, it does not reflect on its assumptions or reasons as to why robots in elder care are necessary. One could state that this line of argumentation resembles Morozov’s (2013) concept of solutionism, because the implicit argument is that robots in elder care are inherently good.

Besides publications that are embedded in a solutionist perspective, two papers do not discuss the need for robots for different reasons. Namely, Neven and Leeson (2014) and Pfadenhauer and Dukat (2015) use perspectives in STS and postphenomenology to understand and describe social robots in elder care without commenting on its usefulness. As Pfadenhauer and Dukat (2015) explicitly mention:

> “Much has been written—not least in this journal —about the potential, the benefits, and the risks of social robotics. Our paper is based on the social constructivist perspective that what a technology actually is can be decided only when it is applied” [Pfadenhauer & Dukat, 2015, p.393].

Thereby, the authors do not engage in describing why social robots in elder care are beneficial a-priori.

5.4. Aging populations as undesired futures

To conclude, three rationales are given in the literature that explain the “need” for social robots in elder care: to control for care expenses, to change care work, and improve overall wellbeing. Robots are supposed to contain costs, restructure work by automation and standardization, and activate older adults. As explained, each of these technical “solutions” to “problems” of human aging relies on a body of historical developments that embed neoliberal values. A small sub-sample of publications did not state any reasons as to why social robots in elder care are needed.

From a theoretical point of view, Jasanoff’s (2015) concept of sociotechnical imaginaries is at work here. Scholars in HRI make predictions about how things ought to be (i.e. desired futures) and how they are not supposed to be (i.e. undesired futures). It is clear from the literature, that aging populations is regarded as an undesired future. Elder care policies, care work, and even aging itself, are seen by the academic community to become under stress in the future if no technological intervention would appear. Hence the justification for creating and studying social robots in elder care.

One could say that the seed that explains the sociotechnical imaginaries of today that involves robots improving elder care was planted a couple of decades earlier. The policy field of long-term elder care has been restructured throughout Europe since the 1990´s (Pavolini & Ranci, 2013), the standardization of care work in the early 1990’s (Ranci & Pavolini, 2013), and active/successful aging has been popularized since the 1980´s (Bülow & Söderqvist, 2014). This temporal aspect, the popularization of neoliberal ideas about aging, care work, and social policy in recent decades, reflects how the premise of new technologies in elder care is partially explained by its Zeitgeist. Admittedly, the time interval between Paro’s introduction in 2003 (Wada et al., 2003a) and the aforementioned societal changes is not large, but nonetheless indicates that the rationales that the field of social robots in elder care rely on, do not embed new and innovative foundational ideas, as these ideas were developed roughly four decades ago. On a more theoretical level, this shows that even though robots in elder care might seem to promise social change, sometimes new technologies reinvent the ideological wheel. It is important to question the ideologies behind innovations, as innovations might end up reproducing biases under the guise of its technological “newness”. New technologies are too often black-boxed and not questioned for the social biases they represent and reproduce.

In the context of AI4SG and beneficial AI, this research shows how defining “social good” is a social construct in itself and therefore a rather tricky thing to determine. This has implications for the interpretation of machine morality with concepts such as AI4SG, and PBAI. First, the issue of responsibility and intentionality is disputable. As some scholars emphasize the importance of deliberately inscribing morality into products, it does not account for non-intentional non-human forces that drive morality such as Zeitgeist. This means that some agency is stripped away from such concepts that underline the importance of intentional and deliberate ethical design. This does not mean that developers and other actors shaping technologies ought not to try to design it beneficially. Rather, it shows that there are bigger structures that shape technologies other than e.g. human actors, governments, or organizations. Zeitgeist, additionally, matters in knowledge representation and thereby the social construction of technology. And as Zeitgeist is a rather elusive factor partly driving the motivations for developing AI or robots, it poses a challenge for movements such as AI4SG, Beneficial AI, and PBAI, since it rather difficult to be aware how certain ideas current to its Zeitgeist influence one’s design process, and how that translates into the technological system. In other words, responsibility, one of the core principles of movements trying to better AI, does not fully explain the development and construction of a “good” artifact.

This idea that the construction of technology is not free of bias (in this case an elusive source of bias) is of course is not a new finding. However, what is of particular importance here, is the *content* of the ideas that underly the subfield of HRI. They seem to align with neoliberal values of elder care policies, labor, and aging. The question is then, if technologies ought to push such normative agendas instead of looking at underlying structural problems of for instance austerity and low job quality. Also, specifically in relation to the field of elder care, interpreting “social good” in terms of neoliberal understandings of aging, labor, and long-term care policies is ethically questionable. Aging is besides a social phenomenon also a biological and chronological phenomenon. Problematizing aging, i.e. a process inherent to human functioning, in favor of the current political economy is ethically questionable, as it reduces older adults to not only potential recipients of care, but also as expensive citizens.

6. Representations of older adults in the field of HRI[20]

Advancing the field of social robots in elder care involves designing for older adults as primary users or studying older adults as prospective primary users. As most designers and scholars in HRI presumably do not have the lived experience of being a care dependent older adult, they have to rely on additional information about these prospective users (Hyysalo & Johnson, 2016). This present study aims to understand “the imagined older adult” as a prospective user. It does so by sampling academic publications that develop or study a robot or robotic system and analyzing how older adults and their needs are represented. Representation is a concept by default does not refer to “real” people, but rather an image of these people. By doing so, the people working on HRI in elder care *re*present older adults.

Bearing this in mind, the guiding research question reads: how are older adults represented in the academic literature on social robots in elder care? It is important to understand user representations of older adults since bias about older age could be reproduced within the field of HRI an elder care. Furthermore, a large group within the sampled publications actively designs new robots or robotic systems. It is especially important then to understand user representations, as it is inherently an ethical practice (Verbeek, 2006) and bias has thereby the potential to be translated into the design. This latter statement is discussed in the next couple of paragraphs on user representations.

[20] This work is a modified post-peer-review version of an article published in *AI&SOCIETY*. The final authenticated version is available online at: http://dx.doi.org/10.1007/s00146-021-01205-0

6.1. User representations

Much of the theoretical insights on user representations used in this study comes from concepts discussed in the literature review on boundary work (chapter two). To briefly describe the main ideas discussed there, this thesis acknowledges that technological objects not free of value, but rather are products of, amongst others, social, cultural, organizational, and networked processes (e.g. Woolgar, 1990; Pinch & Bijker, 1984; Hyssalo & Johnson, 2016). Specifically in this study, a social constructivist perspective is applied to understand how bias and normativity is embedded in the ideas put forward by scholars working on HRI in elder care.

In STS, a social constructivist perspective on technology is found in Social Construction of Technology, SCOT hereafter (Pinch & Bijker, 1984). As discussed in chapter two, this theory explains how social processes shape the construction of technologies. SCOT started out as a theory that aims to explain how technologies are made. It emphasized the malleability of artifacts and thereby dismissed the idea of technology construction as an inevitable, linear, or technologically deterministic process. Since its development in the 1980's, SCOT has incorporated various other conceptual ideas that acknowledge a less human-centered viewpoint on the construction of technologies by for instance using the concept "sociotechnical ensemble" (Bijker, 2010, p. 66). Nonetheless, this study will stick to the core principles of SCOT: the malleability of artifacts, the rejection of technological determinism, and the research agenda that asks how technologies are made instead of what technologies conceptually "are".

Other scholars in STS have also studied how technologies are made in relation to user representations albeit from a different theoretical angle than SCOT. Woolgar (1990) for instance, uses the analogy of machine-as-text in order to describe the active configuration of users by designers. Configuring the user concerns the active establishment of relational boundaries between users and product based on user representations. Certain uses are encouraged while others are discouraged in the design, much like writers communicate their stories with certain intentions and expectations. In a similar fashion, Akrich (1992) describes how the process of inscription relates to embedding certain worldviews into artifacts. The technical composition is in essence the realization, or rather materialization, of ideas about e.g. users. This present study aims to understand the content of these ideas in relation to older adults as a potential user group. The aforementioned concepts, as also discussed in chapter two, enables researchers to study sociotechnical intentions and worldviews of experts working in the field of HRI in elder care.

6.2. Older adults and older users

In order to understand representations of older adults in the field of HRI, first a couple of interrelated key concepts ought to be clarified: older adults and older users. In this present study both are seen as social categories, but older users are treated as a specific subcategory of older adults. Specifically, older users are older adults who interact with, in this case, social robots. This study would like to capture both user and non-user related assumptions. In the analysis, this may lead to different types of representations, referring to both older adults as a general social category, and older adults as older users. It is therefore necessary to understand literature on both social categories, as is presented in the following paragraphs.

Much has been written in literature on the conceptualization of aging and older adults. In his understanding of the life course, Laslett (1991) refers to four different categories: first age, second age, third age and fourth age. Age categories refer to functionality, experience, maturity, and (in)dependence, rather than the mere passing of time as is illustrated in his definition of the four divisions of the life course: “First comes an era of dependence, socialization, immaturity and education; second an era of independence, maturity and responsibility, of earning and of saving; third an era of personal fulfilment; and fourth an era of final dependence, decrepitude and death” (Laslett, 1991, p. 4). So rather than referring to older age as a specific cut in one’s chronological existence, the life course is divided into four spheres of general functioning. In other words, older age does not start at 65 years, 55 years, or 70 years, but instead refers to e.g. (in)dependence typically associated with the third age and the fourth age.

Similar to Laslett’s (1991) classification of the life course, other concepts and theories such as disengagement theory, successful aging, and activity theory refer to (in)dependence and general functioning at an older age, albeit with a normative stance. While disengagement theory describes aging as a process of inevitable loss and of natural withdrawal from society, the concepts of successful aging and activity theory stress the malleability of aging (Bülow & Söderqvist, 2014; Katz, 2000). According to the latter approaches, older adults are able to actively choose to better their lives by making healthier lifestyle choices, and thereby contribute to their own longevity. Studies in gerontology focus not only in treatment of age related diseases, but also on the prevention of age related diseases. Aging is seen as a process of activity and self-realization instead of a process of decline.

These concepts of activity theory and successful aging are contested. After all, what is “successful” aging and who are the “unsuccessful” older adults? This concept implies that older adults could be classified in terms of winners and losers, thereby establishing a normative hierarchy of an inevitable biological process. Furthermore, scholars who published in the field of critical gerontology, Mikkelsen (2017) and Katz (2000), criticize not only this narrative of accomplishment but also the implicit premise of productivity and enablement that the concepts of successful aging and activity theory carry with them. According to these scholars, these concepts embed a neoliberal perspective on aging.

With active aging and successful aging, the functioning of the individual is reduced to his/her individual responsibilities and lifestyle choices. “Facts” produced by social gerontologists or other experts on how to age “responsibly” help the individual to make “better” choices. Older citizens are thereby called upon their responsibility and accountability instead of shifting this to the welfare state (Katz, 2000). As Mikkelsen (2017) puts it, ideas of self-realization are “closely tied to wider political strategies for minimizing the budgetary strain on public health systems and managing the aging population in the face of the contemporary increase in life expectancy in Western countries” (p. 647). This perspective on aging, i.e. self-governing the older body as an act that serves the interest of the state and its ideologies, does not necessarily describe *how* older adults *ought to* age, which activity theory and successful aging does. Rather, it describes how power is intertwined with knowledge, discourse, and governance. Specifically, both Katz (2000) and Mikkelsen (2017) argue how narratives about active aging backed up by social gerontologists are considered as "truisms", but simultaneously serve as disciplinary strategies for neoliberal political agendas that aim at restraining public spending on elder care.

In sum, while the field of social gerontology has defined older age in terms of functionality and malleability, critical gerontologists Katz (2000) and Mikkelsen (2017) view this perspective in terms of a neoliberal ideology. The question is then how this aligns with the field of HRI in their representations of older adults. This study therefore discusses what narratives of older adults are put forward in the field of HRI concerning functionality and malleability, and what that means in terms of a neoliberal ideology.

6.3. Older users of new technologies

Typically, when discussing older adults and their use of new technologies, the academic literature refers to concepts such as the "digital divide", "have-nots", or "non-acceptance" (e.g. Friemel, 2016; Lüders & Bae Brandtzæg, 2017; Abbey & Hyde, 2009). When studying older adults in relation to such concepts of non-users, the premise is often based on an interventionist logic in which the introduction of a new artifact would lead to some kind of (positive) effect (Peine & Neven, 2019). However, as Peine and Neven (2019) mention, this perspective might be a bit simplistic. An interventionist perspective assumes particular characteristics of older adults that ought to be changed, and then translates these assumptions into design. In doing so, this process *constructs* normativity (Peine & Neven, 2019). It reproduces a normative hierarchy of how older adults ought (not) to age.

This suggests that 1) the sampled representations could refer to an interventionist logic and 2) it ought to be critically understood how this interventionist logic contributes to ageist representations of older users. This study therefore discusses the findings in relation to users, non-users, and ageism, in addition to neoliberalism and the malleability of aging.

Before discussing the results, a brief recap of the methods is needed. The ideas about older age as represented in the academic publications were sampled by marking all pieces of text that referred to older adults and older users. The analysis started with analyzing the content of the text, but as the analysis proceeded, it started to become clear that particular wording used by the published authors to describe older adults also carried a lot of meaning. What resulted is a thematic analysis that clustered those fragments of text according to theme, with additional information on discourse (by emphasizing certain words in the analysis such as "*frail*" or "*abnormal*"). The examples given in the following results illustrate this: themes are described with quotations that sometimes include certain words in italics to emphasize particular discourse. Furthermore, it should be noted that not the publications are coded as such but rather snippets of texts. As such, one publication could include different representations of older age. Rather than stating how publication X represents old people as Y, this present research analyzed different representational themes that are interwoven throughout the field and sometimes in the same text. What follows are the empirical findings of this study.

6.4. Empirical representations of older adults in the field of HRI

Different themes were derived from the analysis: older adults and their general functioning, older adults as users of new technologies, older adults and others, older adults and society. As is discussed in the following paragraphs, these themes represent older adults in terms of essentialist narratives of the third/fourth age, while very few cases offer a counternarrative.

6.4.1. Older adults and their general functioning

Older adults are represented in the HRI literature in terms of a couple of distinctive traits. Their functioning is reduced to narratives of (in)dependence and (loss of) capabilities. Older adults are seen as people who experience loss in social participation, health and mobility, and cogitative and mental functioning – i.e. fourth agers. For example, Sakamoto et al. (2016) mention that:

> "Ageing is *inherently a difficult time in an individual's life*; as the leading risk factor for most human diseases, *the elderly is often besieged on multiple fronts* by physical, psychological and cognitive *frailty*" [Sakamoto et al., 2016, p. 60].

Similarly, Sung et al. (2015) describe loss as an inherent part of older adults experiences, much like a domino effect:

> "As older adults age, they may face and *experience difficult situations and losses*, such as loss in their health and functions, family, friends, and social roles. These situations *may force older adults to become depressed and suffer from mental health problems*, such as depression and social isolation. Depression is prevalent among older adults and *could lead to severe health problems with detrimental impact on their functional status, quality of life, and a poor prognosis* (Licht-Strunk et al., 2007)" [Sung et al., 2015, p. 1] [21].

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[21] All emphases illustrate how the quotations relate to the overall theme.

Social robots are supposed to alleviate or fix these traits of frailty, dependence, and vulnerability. These robots are regarded as being able to activate older adults by, for instance, compensating for social loss by acting as a social companion or by training cognitive functions with games. Activity is viewed as key to countering these losses, and robots are thought of as enablers of activity and overall wellbeing. For instance, one study explicitly mentions how:

> "Older people are *vulnerable* to the experience of *loss*, be it in terms of health, identity, finances, independence and social connections" [Khosla et al., 2013, p. 42].

Their robot Matilda[22] ought to:

> "(…) *improve* emotional well being by *enabling* elderly to be *productive and useful*, helping them become *more resilient and cope better* through personalization of services provided by Matilda. This in turn *enhance their quality of life*" [Khosla et al., 2013, p. 41].

Another example of how a robot is supposed to "fix" the frailty of older adults is presented in the publication of Given-Wilson et al. (2017) with their social robot walker FriWalk:

> "People with impaired physical and mental ability often find it challenging to negotiate crowded or unfamiliar environments, leading to a *vicious cycle of*

[22] The robot is PaPeRo, but was renamed for their study.

> *deteriorating mobility*. This also severely impacts sociability, and increases isolation, that in turn provides *an additional cycle of deteriorating health and well-being*. To address these issues the ACANTO project is developing a robotic assistant (called a FriWalk) that supports its users by *encouraging and supporting them to engage in therapeutic group social activities*" [Given-Wilson et al., 2017, p. 90].

Not all representations explicitly refer to older adults as frail or vulnerable. Sometimes, the narrative was more subtle by referring to issues as maintaining independence, maintaining personhood, self-enhancement, or prevention of aging related processes. Indeed, some publications regard older people as to already have certain active qualities, i.e. third agers, which need to be maintained with the help of social robots. This, however, simultaneously implies that aging ultimately leads to an undesirable future of dependency, frailty, vulnerability etc. For instance, Portugal et al. (2015) mention how their robotic platform is merely an:

> "(…) *intermediate agent* between the elderly and the social care community" [Portugal et al., 2015, p. 812].

The authors developed an interpersonal communication platform that relies on the social network of the older user. The robot is not meant to create companionship, but to enable interaction with the pre-existing social network of the older user. Also, the authors describe how they:

> "(…) consider the elders *as active collaborative agents able to make personal choices* and the care model is *adapted to their lifestyle, personalized needs* and *capabilities changes over the aging process*" [Portugal et al., 2015, p. 812].

While this is a very different representation of older age than discussed earlier in terms of capabilities and functioning, the premise of the aforementioned publication follows an interventionist logic that ought to prevent older adults from becoming frail and needy. For example, consider the following excerpt:

> "Several demographic studies report that Europe's population is aging, as the average life expectancy over the years increase [1]. As a consequence, the elderly care market is growing, revealing a huge unexplored potential. *In order to address these challenges*, there is growing attention for assistive technologies *to support seniors to stay independent and active for as long as possible* in their preferred home environment. Robotic systems are among those initiatives offering functionality related to the support of independent living, monitoring and maintaining safety or enhancement of health and psychological well-being of elders by providing companionship. The SocialRobot Project[1] aims to provide an *answer to this demographic change challenge*. Therefore, an integrated Social Robotics system is under development to address key issues for *improved independent living and quality of life of the elderly people*" [Portugal et al., 2015, p. 811].

While this fragment is not too clear about what is meant with "the demographic change challenge", it clearly shows an interventionist logic. Older adults need technological intervention in order to "better" their lives, stay independent as long as possible, and counter whichever undesirable (and undefined) effect of aging demographics with social robots. While at first the publication of Portugal et al. (2015) seems to touch upon concepts of active aging and the third age, it still adheres to the logic of an inevitable fourth age that ought to be prevented. Therefore, the representation of self-enhancement, improvement, and independence goes hand-in-hand with narratives of frailty and dependence. One does not exclude the other.

In short, two interrelated representations about the general functioning of older adults are found: frailty and dependence; self-enhancement and independence. However, this interrelatedness does not imply neutrality or a balanced representation of older age. Independence and self-enhancement reflects the assumption that without technological intervention, older adults eventually become fourth agers. Generally speaking, older adults are represented as either frail people or people that have the potential to become frail. In other words, older adults are represented as frail by default, and independent by effort.

6.4.2. Older adults as users of new technologies

One particular strand in the representations of older age focuses on older adults as (prospective) users of new technologies. Two, often interrelated, themes are found: silenced prospective users and technologically illiterate people. The former refers to representations mostly found in user acceptance studies, which is research on how to maximize the acceptance of robots. This strand in HRI literature does not question the need for such robots, nor does it ask whether older people want to become older users of social robots *überhaupt*. The goal is to maximize acceptance regardless, thereby silencing the voices of older people regarding technology-use. For instance:

> "Social interaction and interactive communication are recognized as helpful strategies to maintain the abilities of people with dementia (PwD) and *improve their quality of life* [2]. Elderly people need to accept social robots into their home environments to profit from favorable outcomes of social robot use. *However, before we can determine if an interaction with a social robot benefits the PwD, it is necessary to understand the process of acceptance of the robot by the PwD*. (…) The primary aim of the study was to *identify which strategies could have a positive effect on the interaction* between PwD and robot improving the acceptance" [Cruz-Sandoval et al., 2018, p. 95].

By studying how to maximize technology acceptance, the authors do not question the basic premise of using social robots in elder care, its effects, or if older adults want to use robots at all. To give another example:

> "If robotic companions are to be *used in the near future* by aging adults, *they have to be accepted by them*" [Heerink et al., 2008, p. 33].

The authors continue their argument for the need for acceptance based on the assumption that the use of social robots in elder care is both inevitable and inherently good for the older user and for society at large due to aging demographics. However, the authors state that older adults might be reluctant to accept such technologies:

> "Thus, robotic companions are generally considered a potentially major part of the technology that can address the problems of a growing older population and

> increasing labor shortage in the industrialized world. However, there are *challenges to be met - and not only technical ones*. *Elders do not always willingly accept new technologies and it might be crucial to map the psychological requirements that designers of robotic companions have to take into account* [4]" [Heerink et al., 2008, p. 33].

This latter statement connects to the second theme found in the representations of (prospective) older users: the digital divide. A lot of the problems of acceptance are allocated to the users. They are seen as digitally illiterate people who do not understand how to operate new technologies. Therefore, most robots are suggested to require a more intuitive form of interaction that fits the older user (e.g. Looije et al. 2010; Pino et al. 2012). But sometimes, that resulted in very bold statements, such as the following.

> "More understanding is required of factors *that minimise the rejection of eldercare robots and optimize their acceptance*. There is some understanding of robot factors that promote acceptance; notably that the robot is both useful and easy to use. There is also some knowledge of human predictors of acceptance. However, known human predictors of technology acceptance tend to be fixed and/or historical demographics. For example, *female gender* and *older age have been associated with low acceptance of novel technologies* [11][23].There are two issues with fixed demographic factors as acceptance predictors. One issue is fixed factors may predict non-acceptance of technology, but do not explain the

[23] In-text quotation reference: Venkatesh et al. (2003) as cited in Stafford et al. (2014). When fact-checking this statement by looking up the in-text reference, it turns out that gender and age have different motivations for (not) using technologies, which is not synonymous for lower levels of acceptance.

> underlying causes of non-acceptance. The second issue is that, by definition, fixed predictors are fixed. *It is not possible to make older women more accepting of novel technologies by changing their gender and reducing their age.* However, unlike demographics, psychological characteristics of potential technology users may be less fixed. Greater knowledge of potentially modifiable psychological factors associated with the acceptance and rejection of robots in an aged-care context *may assist designers in creating acceptable eldercare robots to help meet the challenges of ageing populations*" [Stafford et al., 2014, pp. 17-18].

This statement implies a normative hierarchy of women and older adults naturally being less capable, for whatever reasons, to adopt new technologies than younger men. While other publications did not focus much on gendered differences, older age was repeatedly seen as a factor for being less capable of interacting with new technologies. To give another example:

> "PROMs is based on the need for providing evidence of performing value-based health care. Up till recently PROM data were mainly collected with paper-and-pencil methods, and since a few years e-health solutions such as apps on tablets or smartphones are used, where answer options can be selected by touch buttons. However, *elderly people often do not have the e-health literacy for using these devices* [6], or find the technology difficult to use due to their disabilities and chronic diseases. A social robot which can conduct a verbal dialogue, supported by gestures and an answer display, *would not require e-health literacy from the patient*" [Boumans et al., 2018, p. 73].

In short, in the literature two representational themes discuss older adults in relation to technology-use. In the first theme, older users have to accept robots due to the "undeniable" foreseen benefits while the voices of older adults themselves are silenced. In the second theme, older users are represented as technologically illiterate, hinting at a characteristic associated with the fourth age.

6.4.3. Older adults and others

In relation to others, older adults are seen as a burden. This is especially relevant when it comes to caregiving, as this is considered to be a stressful activity. One publication claims that older adults are burdensome for others financially.

> "Currently, more than *18.1 billion hours of unpaid care are provided by the family and friends of older adults suffering from dementia which results in a loss of $15, 000 in the annual income of such caregivers* [1]" [Fernandes et al., 2017, introduction, para 1][24].

The introduction of social robots would ultimately:

> "(…) *decrease the financial burden in our health care system*" [Fernandes et al., 2017, introduction, para. 1].

This burden is not only limited to informal caregiving, but also relates to formal care contexts, as explained in the next quotation.

[24] No page numbers are listed in this publication.

> "Medical staff uses Patient Reported Outcome Measurement (PROM) questionnaires as a means of collecting information on the effectiveness of care delivered to patients as perceived by the patients themselves. *Especially for the older patient group,* the PROM questioning poses an *undesirable workload* on the staff" [Boumans et al., 2018, p. 73].

Typically, older adults that are described as burdensome in the literature are people with dementia or Alzheimer's disease (e.g. Salichs et al. 2016) or with mental health issues (e.g. Sung et al. 2015), however these descriptions are not limited to those groups (e.g. Reppou et al. 2016). Robots are supposed to alleviate these "burdensome" aspects of aging by increasing independence and activity of their older users. Similar to the other representations, this theme refers to the fourth age, as the burden is defined by dependency and vulnerability of older adults.

6.4.4. Older adults in society

As a collective, older adults are represented as a potential problem due to the anticipated change in demographics, as also discussed in-detail in chapter five. The relative number of older adults compared with other age cohorts is expected to increase over the years, leading to a number of foreseen problematic societal effects. More specifically, the number of care-dependent people is anticipated to increase, which in turn would lead to an increase in care expenses. Second, the rise of care-dependent people would change caregiving. It would put pressure on the job quality of (in)formal caregivers and also lead to a shortage of caregivers. Third, and related to the other arguments, there would be a relative increase in the number of ill, care-dependent people with a lower quality of life.

Together, these arguments illustrate economic representations of aging. Robots are seen as a solution to decrease costs, make older users more independent from caregivers and hence compensate for the shortage of caregivers/alleviate the care burden from caregivers, and making older adults healthier and happier. To illustrate each of these representations chronologically in terms of finances, care provision, and health and wellbeing:

> "With the increase in the population of the aged people in the United States and all other countries in the world, there is a crucial need for a *better* personalized health care system. Socially Assistive Robotics (SAR), as a part of assistive technologies, aim at providing healthcare for people and particularly for the aging population and *decreasing the current healthcare services costs*. The estimated five-fold increase in the population of people over the age of 85 by the end of 2050 [28] points out the *importance of such technologies*. The ultimate goal is to treat *abnormal social behaviors* caused by stroke, childhood diseases, or depression as well as improving social skills in general" [Kargar & Mahoor, 2017, p. 756].

> "The demographic change causes an *imbalance between the number of elderly in need of support and the number of caring staff.* Therefore, it is important to help older adults *keep their independence*. (…) According to the United Nations Department of Economic and Social Affairs [1] 21 percent of the world's population will be older than 60 years in 2015. This causes an *obsolescence of society and consequently personnel bottlenecks in elderly care*. At this point

> robotic systems can help *foster older adults' autonomy*" [Bartl et al., 2016, p. 681].
>
> "Census data show that in most countries, and particularly in Europe, there is an increase in both the number of elderly people and in the percentage of elderly people among the overall population, leading to *a proportional increase in the number of people affected by mild cognitive impairments* [1], [2]. As the importance of training cognitive abilities *to slow down the progress of dementia* is now an established fact [3], research has focused on the *development of automated systems for the assistance of elderly people in the execution of everyday activities* which require planning capabilities" [Bruno et al., 2013, p. 768].

To briefly summarize, the anticipated demographic shift is seen as problematic. Due to this theme's focus on older adults as a care-dependent demographic cohort that will negatively impact the economy, one could refer to older adults as "the collective fourth age". Robots are regarded as a solution to make older users more active and independent, thereby compensating for all of the foreseen problematic effects of aging populations.

6.4.5. A counternarrative

So far, the results indicate that older adults are portrayed as (potential) fourth agers. Very few counternarratives were provided that did not describe older adults in essentialist terms. To be specific, only two cases were found in which the authors mention to try to describe complexity "as is", instead of reducing older adult's qualities, traits, and experiences to their (in)abilities. Both of these cases were rooted in STS, postphenomenology and anthropology.

In their ethnographic studies, Neven and Leeson (2015) explain that they do not want to describe the experiences of older adults in essentialist terms:

> "It is important to realize that there is a great diversity of social robots and this diversity of designs of robots is more than matched by the diversity of older people. *This makes it impossible for 'robots' to have one clear and unequivocal effect on 'older people' as both categories are grossly oversimplified in such reasoning*" [Neven and Leeson, 2015, pp. 99-100].

Similarly, Pfadenhauer and Dukat (2015), did not engage in discussing general traits of older adults, or how they behave as potential users. Rather, they mention the importance of maintaining complexity instead of reducing it:

> "In what follows, *we shall not be commenting on the potential therapeutic effectiveness of PARO*, which numerous studies have endeavored to prove by means of physiological and psychological testing. (…) Rather, we endeavor to understand the social order into which humans are integrated and which is, at the same time, a product of human activity. In so doing, we do not look at society through a wide-angle lens. *Instead, we zoom in on the institutional framework and the organizational constellations under specific socio-historical conditions and focus on situative encounters between the individuals who make up the universe of*

> *interest to us as sociologists—namely, the social world*" [Pfadenhauer & Dukat, 2015, p. 397][25].

These authors acknowledge the heterogeneity of older adults and study them in a naturalistic setting without ascribing them qualities related to the third or fourth age.

6.5. Bias in the field of HRI

The results indicate that older adults are represented as responsible for many problems. They are viewed as fourth agers or potential fourth agers who could, with the right tools, delay or fix some of the inherent problems associated with older age, i.e. one's own potential frailty, being burdensome to others, and being problematic for society. This discourse assumes the malleability of aging: with the appropriate tools, older adults are able to prevent or fix their older bodies from decay.

It hereby confirms Peine and Neven's (2019) argument that new technologies in elder care serve an interventionist logic. Social robots ought to intervene with the aging process to "save" older adults from themselves, and to "save" society from older adults. Relating this statement to the discussed literature on social gerontology, this discourse aligns with theories that acknowledge the importance of making the "right" lifestyle choices in order to age "successfully". Social robots are key in this narrative of self-enhancement, because they are seen as "enabling technologies". It would activate older adults' inactive lives.

However, this narrative is not unproblematic. Representing older adults as frail and care dependent by default yet fixable with technologies reduces older people to

[25] Two footnotes from quotation removed.

potential burdensome care recipients. This does not only reflect the ageist assumption that older adults are by definition frail, miserable, fourth agers, it also calls on the responsibility of older adults to "fix" themselves. It is exactly this responsibility of the older individual that serves a neoliberal ideology. These representations could be seen as a disciplinary strategy in a Foucauldian sense as echoed by Mikkelsen (2017) and Katz (2000). Instead of shifting care responsibilities to the welfare state, older adults are expected to help themselves with social robots in order to not burden society, others, and themselves. In other words, aging is represented as inherently troublesome, though with the help of "enabling technologies", the individual is imagined to "fix" older age, thereby allocating care responsibilities away from the welfare state. An active older adult, albeit with the help of technologies, is a nonintrusive older adult that does not require too much help from caregivers and the state, and is therefore inexpensive. Additionally, the representation about the collective fourth age specifically addresses economic problems with the anticipated demographic changes. The representations of older adults in the field of HRI, not only hold the individual responsible for their own care provision, older adults are also seen as triggers of economic problems.

From a theoretical point of view, this means that it is still necessary to understand the social construction of new technologies in terms of ethics and critical robotics research. As constructing and studying technologies is a social activity, one needs to be aware of the bias that might slip in that could potentially inform the technological script. One suggestion could be to move away from the essentialist distinction of the third/fourth age as very few cases did. The publications that included such counternarratives were written by authors coming from academic traditions that typically are more sensitive to bias and normativity. Therefore, the present study emphasizes the importance of including perspectives from STS and critical robotics research in a field that otherwise follows an interventionist logic. This would make it possible to critically assess the necessity of new technologies and how they relate to their prospective users.

7. Conclusion

This thesis started with the statement that it is important to understand HRI in elder care in terms of its fundamental roots, specifically in terms of conceptual premises and biases. Results show that, first of all, the conceptual premises relate to ideas about human/non-human agency and care work, as is discussed in chapter four. Second, in terms of bias, ageism and neoliberalism is embedded in the process of technological construction when justifying the objectives of using in HRI in elder care (chapter five) and representing older adults as prospective users (chapter six). Since these findings were found across 96 publications, it indicates a general structure that overarches contextual HRI variance. Indeed, the field of HRI is a fragmented one, with very different robots, used by different users, in different care contexts, making it difficult to make any generalizable statements about "the" technologies and their (biased) premises. This dissertation shows that there are general structures and ideas that guide the process of technology development and technological content.

So, how do these findings relate to the bigger picture? Using robots in elder care says something about social structures. These technologies are envisioned to help older adults in certain ways (e.g. showering), in certain contexts (e.g. at home), but all relating to the active prevention of bodily/cognitive decline and care dependency, ultimately shifting care responsibilities from humans to technologies. Social robots ought to enable older adults to age successfully without the help of others, thereby reclaiming their autonomy and independence with technology. As this narrative was found across cases in a fairly large sample, one can speak of patterns and structures instead of isolated events. This is related to the concept of delegation, which was introduced in chapter two: a welfare state and care institutions delegate their care responsibilities to technologies.

While it is already ethically questionable to reduce older adults to potential care receivers that put an economic and emotional burden on others and the welfare state by making older adults' lives malleable and fixable with new technologies (chapter five and six), one could argue that the imagined consequences might not be as problematic as it might seem. After all, who does not want to age actively and healthy without much help from others? Perhaps a more fundamental question to ask is, contrary to the question of whether or not it is problematic that these technologies embed ageist values that favor certain economic/political ideologies over others, whether such technologies are a one-size-fits-all phenomenon.

To elaborate, while chapter four presented different types of robots, that have particular aims and technological content for very different types of care, chapter five and six showed that despite the large variety of robots available that have radically different premises of care work/machine agency, the aim is fairly uniform: change elder care in ways that makes it manageable for society at large and caregivers too – i.e. make older people independent. That way, older adults do not put a strain on the economy. But does a person with Alzheimer really need to be "independent", and if so, is that independence not radically different from third agers who maintain their independence with these robots? After all, full autonomy will not be restored even with robot therapy for PwD, as severely cognitively impaired people would always require some form of frequent and/or formal caregiving, while "successful" agers could probably benefit from using additional technological help every now and then. A person with Alzheimer who interacts with a robot toy would probably be entertained for a couple of minutes, in which being “independent” would mean not having to rely on caregivers for social contact or entertainment. “Independence” would have a different meaning if a cognitively abled older person would use a social networking robot to videocall their family. Independence in the latter case would refer to making geographical distances and (physical) limitations obsolete, thereby not being dependent on traffic infrastructures, bodily decline and any other possible constraints, and does not refer to making human social interactions obsolete. While the former example refers to cognitively impaired older adults, the latter case refers to older adults with a certain amount of cognitive abilities and social capital. “Independence” means radically different things in both cases, though the literature does not delve deeper into those meanings, and does not discriminate between different types of (hypothesized) effects for different users of different robots. Rather, “independence” is used as an umbrella term without too much reflection on what it means for specific users in specific contexts.

This means two things. First, the academic community needs to reflect more on how their objectives relate to effects of HRI: what is independence and how does it relate to this specific robot, with these specific users? Second, based on the findings of this dissertation, this means that robots in elder care should not be viewed as one type of technology that could erase all “problems” associated with aging and aging demographics by enhancing “independence”. Rather, bits and pieces of caregiving are (semi)-automated with robots (see chapter four for an overview of different robot types), thereby acting merely as an additional aid in the rather broad landscape of caregiving activities. Indeed, a holistic robot does not exist. One robot cannot serve all the care needs of one person, let alone a bigger population of elderly people. Therefore, until other technological disruptive events occur in the field, a social robot in elder care ought to be seen as an additional help, or at its best as an *idiot savant* (on the condition that the robot is intelligent), that can do certain things but not others, unlike human caregiving.

In addition to the discussion on the potential mismatch between the premises of the technological content (chapter four) and the rather uniform objective of user independence (chapters five and six), this thesis also states that the construction of technological content in the field of HRI in elder care relates to questions of agency and context of care. While these findings have been discussed at length in chapter four, the relevance of these findings need to be reiterated in order to discuss how flexible essentialism relates to one of the research problems outlined in the introduction: a minimal focus on generalizable research and a main focus on case studies in the field of HRI.

In terms of agency, the sampled publications showed how scholars in HRI envision humans and machines to collaboratively function and communicate with each other. This says something about anthropomorphism: can a piece of metal and wires be more than simply technological devices? Some experts in HRI interpreted these technologies in terms of agents, and others in terms of tools. Tools rely on human agency, and agents typically enact machine agency. Therefore, the answer to what “social” robots “are” refers in part to issues of communicative behavior and life-like qualities. “What are machines, what are humans, and how should they relate to one another?” are questions answered by these experts (albeit implicitly) in HRI by positioning the robots along the lines of agents and tools. Interpreting things in terms of agents and tools does not only have implications in academia, it potentially also reaches into other spheres such as tort and liability law. For if a machine can be considered an agent, who or what is responsible in case of accidents? This is not only relevant to ask in the field of social robots in elder care, but also especially in relation to AI. To elaborate, AI systems typically show elements of learning and adapting to new situations/environments, thereby arguably exhibiting some form of agency. The case of a human driver getting a fine for texting in an autonomous vehicle is an example of how the interpretation of a technology according to the tool/agent dichotomy has legal consequences: the driver argued that the car is in fact the driver because it is an autonomous vehicle, but the judge argued otherwise (De Rechtspraak, 2018).

In other words, the tool/agent analogy has implications for both within and outside the field of social robots in elder care. Furthermore, the ascribed qualities of social robots relate to issues of care work: as robots are not holistic entities, scholars in HRI needed to make decisions in terms of which care activities would be enabled and supported by the robot. The activities varied greatly, but in general were in line with pragmatic care routines or social support. One could argue that this contributes to the standardization of elder care, as this enables certain types of care to be outsourced to robots whereas other activities still need to be compensated for by human caregivers.

Nonetheless, some robots do not fit neatly into one category over the other, indicating robot versatility. Typically, versatility is found in multi-purpose robots over single-purpose robots. Furthermore, the perceived meaning associated with robots does not linearly follow from such categorizations, as interpretative flexibility illustrates (a concept already established by Pinch & Bijker, 1984). Meaning, if we want to apply the care/tool and social/care dichotomy in future studies, the embedded meaning of robots and the reception of robots are two sides of the same coin that both need academic attention. Bridging both perspectives into one, this thesis introduces flexible essentialism as an ontology that enables future scholars to look at both essences and relational meanings, thereby opening up the possibilities to study HRI from different epistemological traditions. This ties in with the methodological problems discussed in chapters one, two and three: intra-actional perspectives on subject-object relations typically do not allow for research with a focus on generalizations. For if networks are endless, and interactions are situational, the resulting research focuses then primarily on performed and contextual cases. To keep the field of HRI in balance in terms of its methodological landscape, the recognition that things *have* embedded meaning that can potentially guide future interactions allows for generalizable statements. The mere categorization of social tools, social agents, care tools, care agents is already a step towards that direction. Hopefully, future studies will follow the most basic principle of flexible essentialism: the recognition that one could study both intra-actions and inter-actions without treating these perspectives as mutually exclusive.

7.1. Future studies

This work has set a baseline for understanding the embedded meaning of the technological content of social robots in elder care and the social construction of such technologies. With this theoretical focus, by default, this dissertation did not study technological reception or various stakeholders that help shape the field. Fieldwork could elaborate the findings of this dissertation, to see if the theoretical model proposed in this dissertation also translates well “in the wild”. Also, the issue of temporality which is inherent to the study of new technologies needs to be taken into consideration, and could serve as a reason to redo the work in case a new generation of social robots is being developed. These two issues of temporality and technology reception are the main recommendations for future studies as is explained in the upcoming paragraphs. The recommendations are discussed in terms of conceptual premises and biases.

7.1.1. Conceptual premises

In order to understand recommended future studies, results and their relevance are briefly discussed first. They are thematically aggregated on three different levels: a typology, a conceptual framework, and an ontology of subject-object relations.

To summarize the typology, the following robot types were found in the data: (entertainment) assistants, robot therapists, robots running medical tests, robots enabling remote communication, robot-toys, conversational robots. These types give more specific information about what robots are supposed to do. While this does not necessarily predict how users interact with such technologies, it does give information about technological intent. A robot running medical tests, for instance, is not likely to “act” the same as a toy, and its appropriateness in specific contexts would also be different. A toy is not likely to be used by older adults that do not have mental or cognitive issues, while a robot running medical tests would be more suited for older adults who are in need of physical examinations. To understand each of these types more in-depth, chapter four gives a detailed explanation for each type and how it relates to machine agency and context of use.

This ought to help societal actors such as policy makers, journalists, and care institutions to be able to differentiate between robots and their premises, thereby having a more specific understanding of the envisioned boundaries and limits of such robots. For instance when investing in new technologies, institutions and policy makers would be able to know which types are available and how they are envisioned to do different things in different care contexts. It could make decisions easier in terms of which type of care is envisioned to be automated/outsourced. Also, this information makes it in general easier for societal actors to understand what the technological possibilities are. In this current landscape, there are many different robots available and being developed, making it difficult to have a cohesive understanding of the technologies. The robot types presented in this thesis presents a cohesive vocabulary. As for future studies, in order to understand the temporality of this typology and its vocabulary, it would be worthwhile to continuously monitor the field to see if new technologies emerge that need to be added to the typology.

While the typology could especially help societal actors, the interpretation of the conceptual framework is situated in a larger academic debate, and adds information to several strands in the academic literature. From an academic perspective, the tool/agent and social/care dimensions offer the field sensitizing concepts to further explore, deepen, and expand. The conceptual framework, as show in fig. 1 in chapter four, taps into discussions about the automation and standardization of labor with the social/care dimension and machine and user agency with the tool/agent dimension. Concerning the standardization of care work, the distinction between particular care work activities in particular domains shows that robots are not holistic entities that can do all facets associated with care work. Rather, robots typically focus on particular tasks. Future studies could show how exactly *in practice* such technologies do (or do not) aid towards the standardization and automation of elder care. How do caregivers experience such technologies, how do they appropriate them, and is there difference per robot or per type of care offered, i.e. formal compared with informal care?

Furthermore, the agent/tool distinction taps into different issues, specifically, user/robot agency and communication. The tool/agent assumes asymmetrical communicative relations. It opens up questions about communicative dominance, in which social roles are dependent on whether or not the robot is supposed to function as a tool where the agency is placed on users, or agents where the robot is supposed to function as a biologically inspired entity. The robot-agent has the potential to be interpreted as a subject of communication instead of merely a mediating object. It could assume passivity from its human users, by telling humans what to do. In this latter case, it is not merely a mute machine, but an active communicator. One could even take it one step further by stating that agents are more anthropomorphic than tools, albeit not in terms of their appearance but rather in terms of their communication. The tool, on the other hand, assumes humans to actively use the technologies in accordance with their own intentions, i.e. agency is required from the user. Similar to the care/social distinction, it would be relevant to know how tools and agents are used in practice. Robot activity could be challenged, negotiated, accepted etc. Also, if agents are indeed perceived as more anthropomorphic or embodying agency, what does that say about trust in HRI? Are tools or agents more trusted? And how does this relate to the appearance of the robot? Also, future research could explore is how this framework applies to non-robotic technologies. Though it is assumed and argued that there is no reason to believe this framework cannot be applied outside of the field of HRI, it would be worthwhile to empirically test this assumption. Especially now with AI technologies, it could be interesting to see if such a distinction could be made, given the attributed agency of such systems. More recommendations for future studies are discussed in chapter four.

On an ontological level, this thesis reconciles two opposing camps in the literature on inter-actional and intra-actional perspectives of subject-object relations and agency. Besides communicative dominance, chapter four discusses how social robots in elder care do have distinct material boundaries – a perspective denied in intra-actional theories on agency and subject-object relations. Distinct robot typologies were found such as: (entertainment) assistants, robot therapists, robots running medical tests, social networking robots, robot-toys, and conversational robots. These typologies were placed along the tool/agent and social/care dimensions. However, certain robots can do more than other robots, indicating their versatility, and thereby adding ambiguity to their meaning. Moreover, results also indicate how each robot and its interpretation of its agency and social context is situational, aligning with intra-actional theories of subject-object relations and agency. Just because a robot is meant to function in a certain way, does not mean it will be interpreted as such in practice. Indeed, scholars in the field of HRI sometimes used ready-made robots and tested them in very creative scenarios. This is reminiscent of the concept interpretative flexibility by Pinch and Bijker (1984), as the same object could come to mean different things to different people. So even though a typology could map out different types of functionalities (i.e. a robot-toy is different than an assistant robot), it does not grasp the complexity of the "real world" and the interpretations that follow from introducing a robot into a particular setting (i.e. interpretative flexibility).

Flexible essentialism is proposed in this dissertation as a term to acknowledge the relevance of both perspectives (intra-actionality and inter-actionality). Future studies that follow flexible essentialism do not prioritize one perspective over the other. Most importantly, this ontology allows for different types of research methods and epistemologies. Relational ontologies typically do not allow for a strict separation of the social and the technical and therefore, most studies that follow this logic end up using research methods that are locally/situationally relevant. On the other hand, essentialism is not too sensitive towards relational understandings and performed/situational relevance, allowing for generalizations of certain features but without contextual nuance. Combining both perspectives allows for an epistemology and research agenda that allows for both the study of generalizations and the study of nuance. Ideally, future studies could follow triangulation methods or a mixed method approach in doing so. However, positioning one's research in one or another camp is possible with the realization that there are two pieces of the puzzle that do not cancel each other out per se.

7.1.2. Biases

In terms of biases, neoliberalism and ageism were found in narratives about the construction of the technologies. Similar to the study on conceptual premises, it would be relevant to understand the reception of such technologies in relation to ageism and neoliberalism. One could for instance, try to understand if older adults themselves find these technologies ageist. This thesis argues that the social construction of such technologies puts ageist assumptions at the forefront, but how do older adults themselves view those technologies once they interacted with them? Similarly, this thesis argues that these technologies are embedding a neoliberalist notion of elder care. But how do policy makers and care institutions make sense of such technologies? What kind of sociotechnical imaginaries do they envision? In other words, future studies could also conduct a study on other stakeholders in the construction of such technologies.

Another suggestion is to bridge different findings of this dissertation. Can the standardization of care work and the reduced role of the welfare state be observed in institutions where social robots are used? Does it alter care work by making older users independent, as is the articulated premise of such technologies? If so, can a difference be observed between different types of robots, i.e. care/social - tools/agents, and different types of older users? Is there a difference between formal and informal care and the standardization of care work? Do older adults perceive such technologies as ageist, one could think of the infantilization of older adults when they interact with robot toys, and is there a difference between social/care - tools/agents? In other words: how do the robot types and/or conceptual framework in this dissertation relate to perceived ageism?

7.2. Limitations

The biggest limitation in this study is its sample. Due to feasibility issues, the sample needed to be limited to four years of PhD work. This lead to a restricted sampling strategy. First of all, the keywords relate to social robots only. A bigger sample could have been chosen if merely the word “robot” would have been included. Second, this dissertation sampled papers that had the search terms in the title. Also, the databases were limited to three databases, i.e. DBLP, Web of Science, Scopus, that typically include positivist papers although from varying fields (e.g. psychology, social gerontology, and engineering/computer science). This does not necessarily diminish the relevance of the findings, however, it operationalized the field of HRI to studies that typically are not situated in the arts and humanities. In order to make statements of HRI in its broadest sense, i.e. including the arts and humanities, one would need to actively look for databases that includes such disciplines. Finally, DBLP has updated the database and its indexing (as is explained in appendix B), thereby diminishing the replicability of this dissertation.

8. References

Aagaard, J., Friis, J. K. B., Sorenson, J., Tafdrup, O. A., & Hasse, C. (2018). An introduction to postphenomenological methodologies. In J. Aagard, J.K.B. Friis, J. Sorenson, O.A. Tafdrup, & C. Hasse (Eds.), *Postphenomenological Methodologies: New ways in mediating techno-human relationships* (pp. xi–xxv). Lexington Books.

Abbey, R., & Hyde, S. (2009). No country for older people? Age and the digital divide. *Journal of Information, Communication and Ethics in Society*, *7*(4), 225–242. https://doi.org/10.1108/14779960911004480

Agrigoroaie, R. M., & Tapus, A. (2016). Developing a healthcare robot with personalized behaviors and social skills for the elderly. *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 589–590. https://doi.org/10.1109/HRI.2016.7451870

Akrich, M. (1992). The De-Scription of Technical Objects. In W.E. Bijker & J. Law (Eds.), *Shaping Technology/Building: Society Studies in Sociotechnical Change* (pp. 204-224). MIT Press.

Alač, M. (2016). Social robots: Things or agents? *AI & SOCIETY*, *31*(4), 519–535. https://doi.org/10.1007/s00146-015-0631-6

Alharbi, A., & Alghahtani, M. (2019). Using Genetic Algorithm and ELM Neural Networks for Feature Extraction and Classification of Type 2-Diabetes Mellitus. *Applied Artificial Intelligence*, *33*(4), 311–328. https://doi.org/10.1080/08839514.2018.1560545

Arkin, R. (2009). Ethical robots in warfare. *IEEE Technology and Society Magazine*, *28*(1), 30–33. https://doi.org/10.1109/MTS.2009.931858

Azkune, G., Orduña, P., Laiseca, X., López-de-Ipiña, D., & Loitxate, M. (2012). Semantic Based Self-configuration Approach for Social Robots in Health Care Environments. In J. Bravo, R. Hervás, & M. Rodríguez (Eds.), *Ambient Assisted Living and Home Care* (Vol. 7657, pp. 354–361). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-35395-6_48

Balnaves, M., Donald, S., & Shoesmith, B. (2009). *Media theories and approaches: A global perspective*. Palgrave Macmillan.

Barad, K. (2003). Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter. *Signs: Journal of Women in Culture and Society*, *28*(3), 801–831. https://doi.org/10.1086/345321

Bartl, A., Bosch, S., Brandt, M., Dittrich, M., & Lugrin, B. (2016). The Influence of a Social Robot's Persona on How it is Perceived and Accepted by Elderly Users. In A. Agah, J.-J. Cabibihan, A. M. Howard, M. A. Salichs, & H. He (Eds.), *Social Robotics* (Vol. 9979, pp. 681–691). Springer International Publishing. https://doi.org/10.1007/978-3-319-47437-3_67

Bartneck, C., & Forlizzi, J. (2004). A design-centred framework for social human-robot interaction. *RO-MAN 2004. 13th IEEE International Workshop on Robot and Human Interactive Communication (IEEE Catalog No.04TH8759)*, 591–594. https://doi.org/10.1109/ROMAN.2004.1374827

Baum, S. D. (2017). On the promotion of safe and socially beneficial artificial intelligence. *AI & SOCIETY*, *32*(4), 543–551. https://doi.org/10.1007/s00146-016-0677-0

Bechade, L., Duplessis, G. D., Pittaro, G., Garcia, M., & Devillers, L. (2017). Towards Metrics of Evaluation of Pepper Robot as a Social Companion for the Elderly. In M. Eskénazi, L. Devillers, & J. Mariani (Eds.), *Advanced Social Interaction with Agents—8th International Workshop on Spoken Dialog Systems, IWSDS 2017* (Vol. 510, pp. 89–101). Springer International Publishing. https://doi.org/10.1007/978-3-319-92108-2_11

Bedaf, S., & De Witte, L. (2017). Robots for Elderly Care: Their Level of Social Interactions and the Targeted End User. In P. Cudd & L. De Witte (Eds.), *Harnessing the Power of Technology to Improve Lives* (pp. 242-472). IOS Press.

Bedaf, S., Draper, H., Gelderblom, G.J., Sorell, T., & de Witte, L. (2016). Can a Service Robot Which Supports Independent Living of Older People Disobey a Command? The Views of Older People, Informal Carers and Professional Caregivers on the Acceptability of Robots. *International Journal of Social Robotics*, *8*(3), 409–420. https://doi.org/10.1007/s12369-016-0336-0

Beer, J. M., Fisk, A. D., & Rogers, W. A. (2014). Toward a Framework for Levels of Robot Autonomy in Human-Robot Interaction. *Journal of Human-Robot Interaction*, *3*(2), 74. https://doi.org/10.5898/JHRI.3.2.Beer

Bijker, W. E. (2010). How is technology made?—That is the question! *Cambridge Journal of Economics*, *34*(1), 63–76. https://doi.org/10.1093/cje/bep068

Bonaccorsi, M., Fiorini, L., Cavallo, F., Saffiotti, A., & Dario, P. (2016). A Cloud Robotics Solution to Improve Social Assistive Robots for Active and Healthy Aging. *International Journal of Social Robotics, 8*(3), 393–408. https://doi.org/10.1007/s12369-016-0351-1

Boumans, R., van Meulen, F., Hindriks, K., Neerincx, M., & Olde Rikkert, M. (2018). Proof of Concept of a Social Robot for Patient Reported Outcome Measurements in Elderly Persons. *Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, 73–74. https://doi.org/10.1145/3173386.3177013

Breazeal, C. (2011). Social robots for health applications. *2011 Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 5368–5371. https://doi.org/10.1109/IEMBS.2011.6091328

Broekens, J., Heerink, M., & Rosendal, H. (2009). Assistive social robots in elderly care: a review. *Gerontechnology*, *8*(2), 94-103.

Bruno, B., Mastrogiovanni, F., & Sgorbissa, A. (2013). Functional requirements and design issues for a socially assistive robot for elderly people with mild cognitive impairments. *2013 IEEE RO-MAN*, 768–773. https://doi.org/10.1109/ROMAN.2013.6628406

Bülow, M. H., & Söderqvist, T. (2014). Successful ageing: A historical overview and critical analysis of a successful concept. *Journal of Aging Studies*, *31*, 139–149. https://doi.org/10.1016/j.jaging.2014.08.009

Burau, V., & Dahl, H. M. (2013). Trajectories of Change in Danish Long Term Care Policies—Reproduction by Adaptation through Top-Down and Bottom-Up Reforms. In C. Ranci & E. Pavolini (Eds.), *Reforms in Long-Term Care Policies in Europe* (pp. 79–95). Springer New York. https://doi.org/10.1007/978-1-4614-4502-9_4

Burema, D. (2021). A critical analysis of the representations of older adults in the field of human–robot interaction. *AI & SOCIETY*. https://doi.org/10.1007/s00146-021-01205-0

Cath, C., Wachter, S., Mittelstadt, B., Taddeo, M., & Floridi, L. (2018). Artificial Intelligence and the 'Good Society': The US, EU, and UK approach. *Science and Engineering Ethics, 24*, 505–528. https://doi.org/10.1007/s11948-017-9901-7

Cesta, A., Cortellessa, G., Orlandini, A., & Tiberio, L. (2016). Long-Term Evaluation of a Telepresence Robot for the Elderly: Methodology and Ecological Case Study. *International Journal of Social Robotics*, *8*(3), 421–441. https://doi.org/10.1007/s12369-016-0337-z

Chang, R. C.-S., Lu, H.-P., & Yang, P. (2018). Stereotypes or golden rules? Exploring likable voice traits of social robots as active aging companions for tech-savvy baby boomers in Taiwan. *Computers in Human Behavior*, *84*, 194–210. https://doi.org/10.1016/j.chb.2018.02.025

Chu, M.T., Khosla, R., Khaksar, S. M. S., & Nguyen, K. (2017). Service innovation through social robot engagement to improve dementia care quality. *Assistive Technology*, *29*(1), 8–18. https://doi.org/10.1080/10400435.2016.1171807

Cortellessa, G., Fracasso, F., Sorrentino, A., Orlandini, A., Bernardi, G., Coraci, L., De Benedictis, R., & Cesta, A. (2018). ROBIN, a Telepresence Robot to Support Older Users Monitoring and Social Inclusion: Development and Evaluation. *Telemedicine and E-Health*, *24*(2), 145–154. https://doi.org/10.1089/tmj.2016.0258

Couldry, N., & Hepp, A. (2013). Conceptualizing Mediatization: Contexts, Traditions, Arguments: Editorial. *Communication Theory*, *23*(3), 191–202. https://doi.org/10.1111/comt.12019

Cowls, J., King, T., Taddeo, M., & Floridi, L. (2019). Designing AI for Social Good: Seven Essential Factors. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3388669

Croteau, D., & Hoynes, W. (2003). *Media Society: Industries, Images, and Audiences*. Sage Publications.

Cruz-Sandoval, D., Favela, J., & Sandoval, E. B. (2018). Strategies to Facilitate the Acceptance of a Social Robot by People with Dementia. *Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, 95–96. https://doi.org/10.1145/3173386.3177081

Damholdt, M. F., Nørskov, M., Yamazaki, R., Hakli, R., Hansen, C. V., Vestergaard, C., & Seibt, J. (2015). Attitudinal Change in Elderly Citizens Toward Social Robots: The Role of Personality Traits and Beliefs About Robot Functionality. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.01701

Dautenhahn, K. (1998). The art of designing socially intelligent agents: Science, fiction, and the human in the loop. *Applied Artificial Intelligence*, *12*(7–8), 573–617. https://doi.org/10.1080/088395198117550

Dautenhahn, K. (2007). Socially intelligent robots: Dimensions of human–robot interaction. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *362*(1480), 679–704. https://doi.org/10.1098/rstb.2006.2004

De Rechtspraak. (2018). Mens is feitelijke bestuurder auto, ook in Tesla met autopilot. Retrieved from: https://www.rechtspraak.nl/Organisatie-en-contact/Organisatie/Rechtbanken/Rechtbank-Midden-

Nederland/Nieuws/Paginas/Mens-is-feitelijke-bestuurder-auto-ook-in-Tesla-met-autopilot.aspx

Dilek, S., Cakır, H., & Aydın, M. (2015). Applications of Artificial Intelligence Techniques to Combating Cyber Crimes: A Review. *International Journal of Artificial Intelligence & Applications*, *6*(1), 21–39. https://doi.org/10.5121/ijaia.2015.6102

Draper, H., & Sorell, T. (2017). Ethical values and social care robots for older people: An international qualitative study. *Ethics and Information Technology*, *19*(1), 49–68. https://doi.org/10.1007/s10676-016-9413-1

Eastwood, C., Klerkx, L., Ayre, M., & Dela Rue, B. (2019). Managing Socio-Ethical Challenges in the Development of Smart Farming: From a Fragmented to a Comprehensive Approach for Responsible Research and Innovation. *Journal of Agricultural and Environmental Ethics*, *32*(5–6), 741–768. https://doi.org/10.1007/s10806-017-9704-5

Fasola, J., & Mataric, M. J. (2010). Robot exercise instructor: A socially assistive robot system to monitor and encourage physical exercise for the elderly. *19th International Symposium in Robot and Human Interactive Communication*, 416–421. https://doi.org/10.1109/ROMAN.2010.5598658

Fasola, J., & Mataric, M. J. (2012). Using Socially Assistive Human–Robot Interaction to Motivate Physical Exercise for Older Adults. *Proceedings of the IEEE*, *100*(8), 2512–2526. https://doi.org/10.1109/JPROC.2012.2200539

Fernandes, F.E., Do, H. M., Muniraju, K., Sheng, W., & Bishop, A. J. (2017). Cognitive orientation assessment for older adults using social robots. *2017 IEEE International*

Conference on Robotics and Biomimetics (ROBIO), 196–201. https://doi.org/10.1109/ROBIO.2017.8324417

Fiske, J. (1986). Television: Polysemy and popularity. *Critical Studies in Mass Communication*, *3*(4), 391–408. https://doi.org/10.1080/15295038609366672

Frennert, S., Eftring, H., & Östlund, B. (2013). Older People's Involvement in the Development of a Social Assistive Robot. In G. Herrmann, M. J. Pearson, A. Lenz, P. Bremner, A. Spiers, & U. Leonards (Eds.), *Social Robotics* (Vol. 8239, pp. 8–18). Springer International Publishing. https://doi.org/10.1007/978-3-319-02675-6_2

Frennert, S., & Östlund, B. (2014). Review: Seven Matters of Concern of Social Robots and Older People. *International Journal of Social Robotics*, *6*(2), 299–310. https://doi.org/10.1007/s12369-013-0225-8

Friemel, T. N. (2016). The digital divide has grown old: Determinants of a digital divide among seniors. *New Media & Society*, *18*(2), 313–331. https://doi.org/10.1177/1461444814538648

Given-Wilson, T., Legay, A., & Sedwards, S. (2017). Information Security, Privacy, and Trust in Social Robotic Assistants for Older Adults. In T. Tryfonas (Ed.), *Human Aspects of Information Security, Privacy and Trust* (Vol. 10292, pp. 90–109). Springer International Publishing. https://doi.org/10.1007/978-3-319-58460-7_7

Glende, S., Conrad, I., Krezdorn, L., Klemcke, S., & Krätzel, C. (2016). Increasing the Acceptance of Assistive Robots for Older People Through Marketing Strategies Based on Stakeholder Needs. *International Journal of Social Robotics*, *8*(3), 355–369. https://doi.org/10.1007/s12369-015-0328-5

Hall, S. (2006). Encoding/Decoding. In M.G. Durham & D.M. Kellner (Eds.), *Media and Cultural Studies: Keyworks* (pp. 163-173). Blackwell Publishing. (Original work published 1980)

Hammer, S., Kirchner, K., André, E., & Lugrin, B. (2017). Touch or Talk?: Comparing Social Robots and Tablet PCs for an Elderly Assistant Recommender System. *Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction*, 129–130. https://doi.org/10.1145/3029798.3038419

Hasse, C. (2019). The multi-variation approach: Cross-case analysis of ethnographic fieldwork. *Paladyn, Journal of Behavioral Robotics*, *10*(1), 219–227. https://doi.org/10.1515/pjbr-2019-0017

Hebesberger, D., Koertner, T., Gisinger, C., & Pripfl, J. (2017). A Long-Term Autonomous Robot at a Care Hospital: A Mixed Methods Study on Social Acceptance and Experiences of Staff and Older Adults. *International Journal of Social Robotics*, *9*(3), 417–429. https://doi.org/10.1007/s12369-016-0391-6

Heerink, M., Krose, B., Evers, V., & Wielinga, B. (2006). The Influence of a Robot's Social Abilities on Acceptance by Elderly Users. *ROMAN 2006 - The 15th IEEE International Symposium on Robot and Human Interactive Communication*, 521–526. https://doi.org/10.1109/ROMAN.2006.314442

Heerink, M., Kröse, B., Evers, V., & Wielinga, B. (2008). The influence of social presence on acceptance of a companion robot by older people. *Journal of Physical Agents (JoPha)*, *2*(2), 33–40. https://doi.org/10.14198/JoPha.2008.2.2.05

Heerink, M., Kröse, B., Evers, V., & Wielinga, B. (2009). Influence of Social Presence on Acceptance of an Assistive Social Robot and Screen Agent by Elderly Users.

Advanced Robotics, *23*(14), 1909–1923. https://doi.org/10.1163/016918609X12518783330289

Heidegger, M. (2001). *Being and time*. Blackwell. (Original work published 1927)

Hepp, A., & Hasebrink, U. (2018). Researching Transforming Communications in Times of Deep Mediatization: A Figurational Approach. In A. Hepp, A. Breiter, & U. Hasebrink (Eds.), *Communicative Figurations* (pp. 15–48). Springer International Publishing. https://doi.org/10.1007/978-3-319-65584-0_2

High-Level Expert Group on Artificial Intelligence. (2019, April 8). *A definition of AI: Main capabilities and disciplines.* Digital EU. https://digital-strategy.ec.europa.eu/en/library/definition-artificial-intelligence-main-capabilities-and-scientific-disciplines

Hill, K. (2020, January 18). *The secretive company that might end privacy as we know it.* New York Times. https://www.nytimes.com/2020/01/18/technology/clearview-privacy-facial-recognition.html

Hood, C. (1991). A public management for all seasons? *Public Administration*, *69*(1), 3–19. https://doi.org/10.1111/j.1467-9299.1991.tb00779.x

Hutson, S., Lim, S. L., Bentley, P. J., Bianchi-Berthouze, N., & Bowling, A. (2011). Investigating the suitability of social Robots for the wellbeing of the elderly. In S. D'Mello, A. Graesser, B. Schuller, & J.-C. Martin (Eds.), *Affective computing and intelligent interaction* (Vol. 6974, pp. 578–587). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-24600-5_61

Hyysalo, S., & Johnson, M. (2016). User representation: A journey towards conceptual maturation. In: S. Hyysalo, S, T.E. Jensen, & N. Oudshoorn (Eds.), *The new* *production of users: Changing innovation collectives and involvement strategies*. Routledge, Taylor & Francis Group.

Ihde, D. (2008). Introduction: Postphenomenological Research. *Human Studies*, *31*(1), 1–9. https://doi.org/10.1007/s10746-007-9077-2

Ihde, D. (2012). *Experimental phenomenology: Multistabilities* (2nd ed). State University of New York Press.

Introna, L. D. (2014). Towards a Post-human Intra-actional Account of Sociomaterial Agency (and Morality). In P. Kroes & P.-P. Verbeek (Eds.), *The Moral Status of Technical Artefacts* (Vol. 17, pp. 31–53). Springer Netherlands. https://doi.org/10.1007/978-94-007-7914-3_3

Jasanoff, S. (2004). The idiom of co-production. In S. Jasanoff (Ed.). *States of knowledge: the co-production of science and the social order* (pp. 1-12). Routledge.

Jasanoff, S. (2015). Future imperfect: Science, technology, and the imaginations of modernity. In S. Jasanoff, & S.H. Kim, (Eds.), *Dreamscapes of modernity: Sociotechnical imaginaries and the fabrication of power* (pp. 1-33). University of Chicago Press.

Jenkins, S., & Draper, H. (2015). Care, Monitoring, and Companionship: Views on Care Robots from Older People and Their Carers. *International Journal of Social Robotics*, *7*(5), 673–683. https://doi.org/10.1007/s12369-015-0322-y

Jonell, P., Mendelson, J., Storskog, T., Hagman, G., Ostberg, P., Leite, I., Kucherenko, T., Mikheeva, O., Akenine, U., Jelic, V., Solomon, A., Beskow, J., Gustafson, J., Kivipelto, M., & Kjellstrom, H. (2017). Machine Learning and Social Robotics for

Detecting Early Signs of Dementia. *ArXiv:1709.01613 [Cs]*. http://arxiv.org/abs/1709.01613

Kachouie, R., Sedighadeli, S., & Abkenar, A. B. (2017). The Role of Socially Assistive Robots in Elderly Wellbeing: A Systematic Review. In P.-L. P. Rau (Ed.), *Cross-Cultural Design* (Vol. 10281, pp. 669–682). Springer International Publishing. https://doi.org/10.1007/978-3-319-57931-3_54

Kachouie, R., Sedighadeli, S., Khosla, R., & Chu, M.-T. (2014). Socially Assistive Robots in Elderly Care: A Mixed-Method Systematic Literature Review. *International Journal of Human-Computer Interaction*, *30*(5), 369–393. https://doi.org/10.1080/10447318.2013.873278

Kargar, B. A. H., & Mahoor, M. H. (2017). A pilot study on the eBear socially assistive robot: Implication for interacting with elderly people with moderate depression. *2017 IEEE-RAS 17th International Conference on Humanoid Robotics (Humanoids)*, 756–762. https://doi.org/10.1109/HUMANOIDS.2017.8246957

Katz, S. (2000). Busy Bodies: Activity, aging, and the management of everyday life. *Journal of Aging Studies*, *14*(2), 135–152. https://doi.org/10.1016/S0890-4065(00)80008-0

Katz, S., & Marshall, B. (2003). New sex for old: Lifestyle, consumerism, and the ethics of aging well. *Journal of Aging Studies*, *17*(1), 3–16. https://doi.org/10.1016/S0890-4065(02)00086-5

Khaksar, S. M. S., Khosla, R., & Chu, M.-T. (2015). Socially assistive robots in service innovation context to improve aged-care quality: A grounded theory approach. *2015 IEEE 7th International Conference on Cybernetics and Intelligent Systems (CIS)* *and IEEE Conference on Robotics, Automation and Mechatronics (RAM)*, 161–166. https://doi.org/10.1109/ICCIS.2015.7274614

Khosla, R., Chu, M.T., Kachouie, R., Yamada, K., Yoshihiro, F., & Yamaguchi, T. (2012). Interactive multimodal social robot for improving quality of care of elderly in Australian nursing homes. *Proceedings of the 20th ACM International Conference on Multimedia - MM '12*, 1173. https://doi.org/10.1145/2393347.2396411

Khosla, R., Chu, M.-T., & Nguyen, K. (2013). Enhancing Emotional Well Being of Elderly Using Assistive Social Robots in Australia. *2013 International Conference on Biometrics and Kansei Engineering*, 41–46. https://doi.org/10.1109/ICBAKE.2013.9

Khosla, R., Nguyen, K., & Chu, M.T. (2016, August 24-26). *Socially Assistive Robot Enabled Personalised Care for People with Dementia in Australian Private Homes* [Conference Presentation]. The 25th International Conference on Information Systems Development (ISD 2016), Katowice, Poland. http://aisel.aisnet.org/isd2014/proceedings2016/CreativitySupport/8.

Kidd, C. D., Taggart, W., & Turkle, S. (2006). A sociable robot to encourage social interaction among the elderly. *Proceedings 2006 IEEE International Conference on Robotics and Automation, 2006. ICRA 2006.*, 3972–3976. https://doi.org/10.1109/ROBOT.2006.1642311

Kingdon, J. (2004). AI fights money laundering. *IEEE Intelligent Systems*, *19*(3), 87–89. https://doi.org/10.1109/MIS.2004.1

Klamer, T., & Allouch, S. B. (2010). Acceptance and use of a social robot by elderly users in a domestic environment. *Proceedings of the 4th International ICST Conference on Pervasive Computing Technologies for Healthcare*, 1-8. https://doi.org/10.4108/ICST.PERVASIVEHEALTH2010.8892

Klein, H. K., & Lee Kleinman, D. (2002). The Social Construction of Technology: Structural Considerations. *Science, Technology, & Human Values*, *27*(1), 28–52. https://doi.org/10.1177/016224390202700102

Kobayashi, T., Katsuragi, K., Miyazaki, T., & Arai, K. (2017). Social Media Intermediation Robot for Elderly People Using External Cloud-Based Services. *2017 5th IEEE International Conference on Mobile Cloud Computing, Services, and Engineering (MobileCloud)*, 31–38. https://doi.org/10.1109/MobileCloud.2017.18

Kress, G., & Van Leeuwen, T. (2002). Colour as a semiotic mode: notes for a grammar of colour. *Visual Communication*, *1*(3), 343-368. https://doi.org/10.1177/147035720200100306

Kuipers, G. (2018). Communicative Figurations: Towards a New Paradigm for the Media Age? In A. Hepp, A. Breiter, & U. Hasebrink (Eds.), *Communicative Figurations* (pp. 425–436). Springer International Publishing. https://doi.org/10.1007/978-3-319-65584-0_18

Lane, G. W., Noronha, D., Rivera, A., Craig, K., Yee, C., Mills, B., & Villanueva, E. (2016). Effectiveness of a social robot, “Paro,” in a VA long-term care setting. *Psychological Services*, *13*(3), 292–299. https://doi.org/10.1037/ser0000080

Larson, C. (2018). China’s AI imperative. *Science*, *359*(6376), 628–630. https://doi.org/10.1126/science.359.6376.628

Laslett, P. (1991). *A fresh map of life: The emergence of the Third Age*. Harvard University Press.

Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford University Press.

Legg, S., & Hutter, M. (2007). A Collection of Definitions of Intelligence. *ArXiv:0706.3639 [Cs]*. http://arxiv.org/abs/0706.3639

Looije, R., Neerincx, M. A., & Cnossen, F. (2010). Persuasive robotic assistant for health self-management of older adults: Design and evaluation of social behaviors. *International Journal of Human-Computer Studies*, *68*(6), 386–397. https://doi.org/10.1016/j.ijhcs.2009.08.007

Louie, W.Y.G., Li, J., Vaquero, T., & Nejat, G. (2014). A focus group study on the design considerations and impressions of a socially assistive robot for long-term care. *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*, 237–242. https://doi.org/10.1109/ROMAN.2014.6926259

Louie, W.Y.G., McColl, D., & Nejat, G. (2012). Playing a memory game with a socially assistive robot: A case study at a long-term care facility. *2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication*, 345–350. https://doi.org/10.1109/ROMAN.2012.6343777

Lüders, M., & Brandtzæg, P. B. (2017). 'My children tell me it's so simple': A mixed-methods approach to understand older non-users' perceptions of Social Networking Sites. *New Media & Society*, *19*(2), 181–198. https://doi.org/10.1177/1461444814554064

Marin Mejia, A. L. (2014). Social networking sites photos and robots: A pilot research on facebook photo albums and robotics interfaces for older adults. *Proceedings of the Second International Conference on Human-Agent Interaction - HAI '14*, 287–291. https://doi.org/10.1145/2658861.2658944

McColl, D., Louie, W.-Y. G., & Nejat, G. (2013). Brian 2.1: A socially assistive robot for the elderly and cognitively impaired. *IEEE Robotics & Automation Magazine*, *20*(1), 74–83. https://doi.org/10.1109/MRA.2012.2229939

McLuhan, M. (2006). The medium is the message. In M.G. Durham & D.M. Kellner (Eds.), *Media and Cultural Studies: Keyworks* (pp. 107-116). Blackwell Publishing. (Original work published 1964)

Mejias, U. A., & Couldry, N. (2019). Datafication. *Internet Policy Review*, *8*(4). https://doi.org/10.14763/2019.4.1428

Merten, M., Bley, A., Schroeter, C., & Gross, H. (2012). A mobile robot platform for socially assistive home-care applications. *ROBOTIK 2012; 7th German Conference on Robotics*, 1–6. https://ieeexplore.ieee.org/document/6309513

Meyrowitz, J. (2019). Medium theory. In R. Hobbs, & P. Mihailidis (Eds.), *The International Encyclopedia of Media Literacy* (pp.1-7). Wiley.

Michaud, F., Boissy, P., Labonte, D., Corriveau, H., Grant, A., Lauria, M., Clouties, R., Roux, M.A., Iannuzzi, D., & Royer, M. P. (2007). Telepresence Robot for Home Care Assistance. *AAAI spring symposium: multidisciplinary collaboration for socially assistive robotics*, 50-55. https://www.aaai.org/Papers/Symposia/Spring/2007/SS-07-07/SS07-07-012.pdf

Mikkelsen, H. H. (2017). Never too late for pleasure: Aging, neoliberalism, and the politics of potentiality in Denmark: Never too late for pleasure. *American Ethnologist*, *44*(4), 646–656. https://doi.org/10.1111/amet.12563

Morely, D. (1980). The nationwide audience: Structure and decoding. In D. Morely, & C. Brunsdon (Eds.), *The Nationwide Television Studies* (pp. 117-299). Routledge.

Morozov, E. (2013). *To Save Everything, Click Here: The Folly of Technological Solutionism.* Public Affairs.

Moyle, W., Bramble, M., Jones, C., & Murfield, J. (2018). Care staff perceptions of a social robot called Paro and a look-alike Plush Toy: A descriptive qualitative approach. *Aging & Mental Health*, *22*(3), 330–335. https://doi.org/10.1080/13607863.2016.1262820

Moyle, W., Jones, C., Cooke, M., O'Dwyer, S., Sung, B., & Drummond, S. (2013). Social robots helping people with dementia: Assessing efficacy of social robots in the nursing home environment. *2013 6th International Conference on Human System Interactions (HSI)*, 608–613. https://doi.org/10.1109/HSI.2013.6577887

Moyle, W., Jones, C., Sung, B., Bramble, M., O'Dwyer, S., Blumenstein, M., & Estivill-Castro, V. (2016). What Effect Does an Animal Robot Called CuDDler Have on the Engagement and Emotional Response of Older People with Dementia? A Pilot Feasibility Study. *International Journal of Social Robotics*, *8*(1), 145–156. https://doi.org/10.1007/s12369-015-0326-7

Neven, L., & Leeson, C. A. P. (2015). Beyond determinism: understanding actual use of social robots by older people. In D. Prendergast, & C. Garattini (Eds.), *Aging and the digital life course* (pp. 84 – 102). Berghahn Books.

Nestorov, N., Stone, E., Lehane, P., & Eibrand, R. (2014). Aspects of Socially Assistive Robots Design for Dementia Care. *2014 IEEE 27th International Symposium on Computer-Based Medical Systems*, 396–400. https://doi.org/10.1109/CBMS.2014.16

Onnasch, L., & Roesler, E. (2020). A Taxonomy to Structure and Analyze Human–Robot Interaction. *International Journal of Social Robotics*. https://doi.org/10.1007/s12369-020-00666-5

Pavolini, E., & Ranci, C. (2008). Restructuring the welfare state: Reforms in long-term care in Western European countries. *Journal of European Social Policy*, *18*(3), 246–259. https://doi.org/10.1177/0958928708091058

Pavolini, E., & Ranci, C. (2013). Reforms in Long-Term Care Policies in EuropeAn:Introduction. In C. Ranci & E. Pavolini (Eds.), *Reforms in Long-Term Care Policies in Europe* (pp. 3–22). Springer New York. https://doi.org/10.1007/978-1-4614-4502-9_1

Peine, A., & Neven, L. (2019). From Intervention to Co-constitution: New Directions in Theorizing about Aging and Technology. *The Gerontologist*, *59*(1), 15–21. https://doi.org/10.1093/geront/gny050

Pérez, P. J., Garcia-Zapirain, B., & Mendez-Zorrilla, A. (2015). Caregiver and social assistant robot for rehabilitation and coaching for the elderly. *Technology and Health Care*, *23*(3), 351–357. https://doi.org/10.3233/THC-150896

Peri, K., Kerse, N., Broadbent, E., Jayawardena, C., Kuo, T., Datta, C., Stafford, R., & MacDonald, B. (2016). Lounging with robots - social spaces of residents in care: A comparison trial: Lounging with robots. *Australasian Journal on Ageing*, *35*(1), E1–E6. https://doi.org/10.1111/ajag.12201

Perugia, G., Diaz Boladeras, M., Mallofre, A. C., Rauterberg, M., & Barakova, E. (2017a). Modelling engagement in dementia through behaviour. Contribution for socially interactive robotics. *2017 International Conference on Rehabilitation Robotics (ICORR)*, 1112–1117. https://doi.org/10.1109/ICORR.2017.8009398

Perugia, G., Rodriguez-Martin, D., Diaz Boladeras, M., Mallofre, A. C., Barakova, E., & Rauterberg, M. (2017b). Electrodermal activity: Explorations in the psychophysiology of engagement with social robots in dementia. *2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*, 1248–1254. https://doi.org/10.1109/ROMAN.2017.8172464

Pfadenhauer, M. (2014). On the sociality of social robots. A sociology-of-knowledge perspective. *Science, Technology & Innovation Studies*, *10*(1), 137-163.

Pfadenhauer, M., & Dukat, C. (2015). Robot Caregiver or Robot-Supported Caregiving?: The Performative Deployment of the Social Robot PARO in Dementia Care. *International Journal of Social Robotics*, *7*(3), 393–406. https://doi.org/10.1007/s12369-015-0284-0

Piasek, J., & Wieczorowska-Tobis, K. (2018). Acceptance and Long-Term Use of a Social Robot by Elderly Users in a Domestic Environment. *2018 11th International Conference on Human System Interaction (HSI)*, 478–482. https://doi.org/10.1109/HSI.2018.8431348

Piezzo, C., & Suzuki, K. (2017). Feasibility Study of a Socially Assistive Humanoid Robot for Guiding Elderly Individuals during Walking. *Future Internet*, *9*(3), 30. https://doi.org/10.3390/fi9030030

Pinch, T. J., & Bijker, W. E. (1984). The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology might Benefit Each Other. *Social Studies of Science*, *14*(3), 399–441. https://doi.org/10.1177/030631284014003004

Pino, M., Granata, C., Legouverneur, G., Boulay, M., & Rigaud, A.S. (2012). Assessing design features of a graphical user interface for a social assistive robot for older adults with cognitive impairment. *Gerontechnology*, *11*(2). https://doi.org/10.4017/gt.2012.11.02.490.734

Portugal, D., Santos, L., Alvito, P., Dias, J., Samaras, G., & Christodoulou, E. (2015). SocialRobot: An interactive mobile robot for elderly home care. *2015 IEEE/SICE International Symposium on System Integration (SII)*, 811–816. https://doi.org/10.1109/SII.2015.7405084

Pu, L., Moyle, W., Jones, C., & Todorovic, M. (2019). The Effectiveness of Social Robots for Older Adults: A Systematic Review and Meta-Analysis of Randomized Controlled Studies. *The Gerontologist*, *59*(1), e37–e51. https://doi.org/10.1093/geront/gny046

Prange, A., Sandrala, I. P., Weber, M., & Sonntag, D. (2015). Robot Companions and Smartpens for Improved Social Communication of Dementia Patients. *Proceedings of the 20th International Conference on Intelligent User Interfaces Companion*, 65–68. https://doi.org/10.1145/2732158.2732174

Pripfl, J., Kortner, T., Batko-Klein, D., Hebesberger, D., Weninger, M., Gisinger, C., Frennert, S., Eftring, H., Antona, M., Adami, I., Weiss, A., Bajones, M., & Vincze, M. (2016). Results of a real world trial with a mobile social service robot for older adults. *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 497–498. https://doi.org/10.1109/HRI.2016.7451824

Ranci, C., & Pavolini, E. (2013). Institutional Change in Long-Term Care: Actors, Mechanisms and Impacts. In C. Ranci & E. Pavolini (Eds.), *Reforms in Long-Term Care Policies in Europe* (pp. 269–314). Springer New York. https://doi.org/10.1007/978-1-4614-4502-9_13

Rehm, M., Krummheuer, A. L., Rodil, K., Nguyen, M., & Thorlacius, B. (2016). From Social Practices to Social Robots – User-Driven Robot Development in Elder Care. In A. Agah, J.-J. Cabibihan, A. M. Howard, M. A. Salichs, & H. He (Eds.), *Social Robotics* (Vol. 9979, pp. 692–701). Springer International Publishing. https://doi.org/10.1007/978-3-319-47437-3_68

Reppou, S. E., Tsardoulias, E. G., Kintsakis, A. M., Symeonidis, A. L., Mitkas, P. A., Psomopoulos, F. E., Karagiannis, G. T., Zielinski, C., Prunet, V., Merlet, J.-P., Iturburu, M., & Gkiokas, A. (2016). RAPP: A Robotic-Oriented Ecosystem for Delivering Smart User Empowering Applications for Older People. *International Journal of Social Robotics*, *8*(4), 539–552. https://doi.org/10.1007/s12369-016-0361-z

Robinson, H., MacDonald, B., & Broadbent, E. (2014). The Role of Healthcare Robots for Older People at Home: A Review. *International Journal of Social Robotics*, *6*(4), 575–591. https://doi.org/10.1007/s12369-014-0242-2

Rodić, A., Vujović, M., Stevanović, I., & Jovanović, M. (2016). Development of Human-Centered Social Robot with Embedded Personality for Elderly Care. In P. Wenger, C. Chevallereau, D. Pisla, H. Bleuler, & A. Rodić (Eds.), *New Trends in Medical* *and Service Robots* (Vol. 39, pp. 233–247). Springer International Publishing. https://doi.org/10.1007/978-3-319-30674-2_18

Roger, K., Guse, L., Mordoch, E., & Osterreicher, A. (2012). Social Commitment Robots and Dementia. *Canadian Journal on Aging / La Revue Canadienne Du Vieillissement*, *31*(1), 87–94. https://doi.org/10.1017/S0714980811000663

Rostgaard, T. (2012). Quality reforms in Danish home care - balancing between standardisation and individualisation: Balancing between standardisation and individualisation. *Health & Social Care in the Community*, *20*(3), 247–254. https://doi.org/10.1111/j.1365-2524.2012.01066.x

Rowe, J., & Kahn, R. (1987). Human aging: Usual and successful. *Science*, *237*(4811), 143–149. https://doi.org/10.1126/science.3299702

Russell, S. (n.d.). *Provably beneficial artificial intelligence.* https://people.eecs.berkeley.edu/~russell/papers/russell-bbvabook17-pbai.pdf

Sakamoto, K., Fern, S.-A. L. C., Han, L., & Tong, J. C. (2016). Psychographic Profiling for Use in Assistive Social Robots for the Elderly. In N. Kubota, K. Kiguchi, H. Liu, & T. Obo (Eds.), *Intelligent Robotics and Applications* (Vol. 9835, pp. 58–67). Springer International Publishing. https://doi.org/10.1007/978-3-319-43518-3_6

Salichs, M. A., Encinar, I. P., Salichs, E., Castro-González, Á., & Malfaz, M. (2016). Study of Scenarios and Technical Requirements of a Social Assistive Robot for Alzheimer's Disease Patients and Their Caregivers. *International Journal of Social Robotics*, *8*(1), 85–102. https://doi.org/10.1007/s12369-015-0319-6

Sasama, R., Yamaguchi, T., & Yamada, K. (2011). An Experiment for Motivating Elderly People with Robot Guided Interaction. In C. Stephanidis (Ed.), *Universal*

Access in Human-Computer Interaction. Users Diversity (Vol. 6766, pp. 214–223). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-21663-3_23

Sebastian, J., Hsu, Y.-L., & Lu, J.-M. (2014). Creation of a 'Caricature Robot' for social inclusion of older adults. *Gerontechnology*, *13*(2), 278. https://doi.org/10.4017/gt.2014.13.02.383.00

Seibt, J. (2017). Towards an Ontology of Simulated Social Interaction: Varieties of the "As If" for Robots and Humans. In R. Hakli & J. Seibt (Eds.), *Sociality and Normativity for Robots* (pp. 11–39). Springer International Publishing. https://doi.org/10.1007/978-3-319-53133-5_2

Serholt, S., Ljungblad, S., & Ni Bhroin, N. (2021). Introduction: Special issue—critical robotics research. *AI & SOCIETY*. https://doi.org/10.1007/s00146-021-01224-x

Shiomi, M., Iio, T., Kamei, K., Sharma, C., & Hagita, N. (2015). Effectiveness of Social Behaviors for Autonomous Wheelchair Robot to Support Elderly People in Japan. *PLOS ONE*, *10*(5), e0128031. https://doi.org/10.1371/journal.pone.0128031

Siciliano, B., & Khatib, O. (2008). *Springer Handbook of Robotics*. Springer

Smarr, C.-A., Mitzner, T. L., Beer, J. M., Prakash, A., Chen, T. L., Kemp, C. C., & Rogers, W. A. (2014). Domestic Robots for Older Adults: Attitudes, Preferences, and Potential. *International Journal of Social Robotics*, *6*(2), 229–247. https://doi.org/10.1007/s12369-013-0220-0

Stafford, R. Q., MacDonald, B. A., Jayawardena, C., Wegner, D. M., & Broadbent, E. (2014). Does the Robot Have a Mind? Mind Perception and Attitudes Towards Robots Predict Use of an Eldercare Robot. *International Journal of Social Robotics*, *6*(1), 17–32. https://doi.org/10.1007/s12369-013-0186-y

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research*. Sage publications.

Suchman, L. A. (2007). *Human-machine reconfigurations: Plans and situated actions*. Cambridge University Press.

Sung, H.-C., Chang, S.-M., Chin, M.-Y., & Lee, W.-L. (2015). Robot-assisted therapy for improving social interactions and activity participation among institutionalized older adults: A pilot study: Robot therapy for older adults. *Asia-Pacific Psychiatry*, *7*(1), 1–6. https://doi.org/10.1111/appy.12131

Tapus, A., & Mataric, M. J. (2008). Socially Assistive Robotic Music Therapist for Maintaining Attention of Older Adults with Cognitive Impairments. *AAAI Fall Symposium: AI in Eldercare: New Solutions to Old Problems*, 124-127. https://www.aaai.org/Papers/Symposia/Fall/2008/FS-08-02/FS08-02-019.pdf

Tapus, A., Wade, E., & Mataric, M. J. (2008). Using a Socially Assistive Robot in Gait Recovery and Training for Individuals with Cognitive Impairments. *AAAI Fall Symposium: AI in Eldercare: New Solutions to Old Problems*, 128-130. https://www.aaai.org/Papers/Symposia/Fall/2008/FS-08-02/FS08-02-020.pdf

Torta, E., Werner, F., Johnson, D. O., Juola, J. F., Cuijpers, R. H., Bazzani, M., Oberzaucher, J., Lemberger, J., Lewy, H., & Bregman, J. (2014). Evaluation of a Small Socially-Assistive Humanoid Robot in Intelligent Homes for the Care of the Elderly. *Journal of Intelligent & Robotic Systems*, *76*(1), 57–71. https://doi.org/10.1007/s10846-013-0019-0

Trenholm, S. (2011). *Thinking through communication: An introduction to the study of human communication*. Pearson Education.

Utt, J., & Padó, S. (2011). Ontology-Based Distinction between Polysemy and Homonymy. *Proceedings of the Ninth International Conference on Computational Semantics*, 265–274.

Valentí-Soler, M., Agüera-Ortiz, L., Olazarán Rodríguez, J., Mendoza Rebolledo, C., Pérez Muñoz, A., Rodríguez Pérez, I., Osa Ruiz, E., Barrios Sánchez, A., Herrero Cano, V., Carrasco Chillón, L., Felipe Ruiz, S., López Alvarez, J., León Salas, B., Cañas Plaza, J. M., Martín Rico, F., Abella Dago, G., & Martínez Martín, P. (2015). Social robots in advanced dementia. *Frontiers in Aging Neuroscience*, *7*. https://doi.org/10.3389/fnagi.2015.00133

Verbeek, P.-P. (2006). Materializing Morality: Design Ethics and Technological Mediation. *Science, Technology, & Human Values*, *31*(3), 361–380. https://doi.org/10.1177/0162243905285847

Verbeek, P.-P. (2014). Some Misunderstandings About the Moral Significance of Technology. In P. Kroes & P.-P. Verbeek (Eds.), *The Moral Status of Technical Artefacts* (Vol. 17, pp. 75–88). Springer Netherlands. https://doi.org/10.1007/978-94-007-7914-3_5

Wada, K., Shibata, T., Saito, T., & Tanie, K. (2003a). Psychological and social effects of robot assisted activity to elderly people who stay at a health service facility for the aged. *2003 IEEE International Conference on Robotics and Automation*, *3*, 3996–4001. https://doi.org/10.1109/ROBOT.2003.1242211

Wada, K., Shibata, T., Saito, T., & Tanie, K. (2003b). Psychological, physiological and social effects to elderly people by robot assisted activity at a health service facility for the aged. *Proceedings 2003 IEEE/ASME International Conference on Advanced*

Intelligent Mechatronics (AIM 2003), 272–277. https://doi.org/10.1109/AIM.2003.1225107

Werner, F., Krainer, D., Oberzaucher, J., & Werner, K. (2013). Evaluation of the acceptance of a social assistive robot for physical training support together with older users and domain experts. In P. Encarnação, L. Azevedo, & G.J. Gelderblom (Eds.), *Assistive Technology: From Research to Practice: AAATE* (pp. 137-142). IOS Press.

Werner, K., Oberzaucher, J., & Werner, F. (2012). Evaluation of Human Robot Interaction Factors of a Socially Assistive Robot Together with Older People. *2012 Sixth International Conference on Complex, Intelligent, and Software Intensive Systems*, 455–460. https://doi.org/10.1109/CISIS.2012.36

Woolgar, S. (1990). Configuring the User: The Case of Usability Trials. *The Sociological Review*, *38*(1_suppl), 58–99. https://doi.org/10.1111/j.1467-954X.1990.tb03349.x

Yamazaki, R., Nishio, S., Ishiguro, H., Nørskov, M., Ishiguro, N., & Balistreri, G. (2014). Acceptability of a Teleoperated Android by Senior Citizens in Danish Society: A Case Study on the Application of an Embodied Communication Medium to Home Care. *International Journal of Social Robotics*, *6*(3), 429–442. https://doi.org/10.1007/s12369-014-0247-x

Yu, R., Hui, E., Lee, J., Poon, D., Ng, A., Sit, K., Ip, K., Yeung, F., Wong, M., Shibata, T., & Woo, J. (2015). Use of a Therapeutic, Socially Assistive Pet Robot (PARO) in Improving Mood and Stimulating Social Interaction and Communication for People With Dementia: Study Protocol for a Randomized Controlled Trial. *JMIR Research Protocols*, *4*(2), e45. https://doi.org/10.2196/resprot.4189

Zlatintsi, A., Rodomagoulakis, I., Pitsikalis, V., Koutras, P., Kardaris, N., Papageorgiou, X., Tzafestas, C., & Maragos, P. (2017). Social Human-Robot Interaction for the Elderly: Two Real-life Use Cases. *Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction*, 335–336. https://doi.org/10.1145/3029798.3038400

9. Appendix A: Sampled academic publications

Agrigoroaie, R. M., & Tapus, A. (2016). Developing a healthcare robot with personalized behaviors and social skills for the elderly. *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 589–590. https://doi.org/10.1109/HRI.2016.7451870

Azkune, G., Orduña, P., Laiseca, X., López-de-Ipiña, D., & Loitxate, M. (2012, December). Semantic based self-configuration approach for social robots in health care environments. In J. Bravo, R. Hervás, & M. Rodríguez (Eds), *Ambient Assisted Living and Home Care* (Vol. 7657, pp. 354-361). Springer International Publishing. https://doi.org/10.1007/978-3-642-35395-6_48

Baisch, S., Kolling, T., Schall, A., Rühl, S., Selic, S., Kim, Z., Rossberg, H., Klein, B., Pantel, J., Oswald, F., & Knopf, M. (2017). Acceptance of Social Robots by Elder People: Does Psychosocial Functioning Matter? *International Journal of Social Robotics*, *9*(2), 293–307. https://doi.org/10.1007/s12369-016-0392-5

Bartl, A., Bosch, S., Brandt, M., Dittrich, M., & Lugrin, B. (2016). The Influence of a Social Robot's Persona on How it is Perceived and Accepted by Elderly Users. In A. Agah, J.-J. Cabibihan, A. M. Howard, M. A. Salichs, & H. He (Eds.), *Social Robotics* (Vol. 9979, pp. 681–691). Springer International Publishing. https://doi.org/10.1007/978-3-319-47437-3_67

Bechade, L., Duplessis, G. D., Pittaro, G., Garcia, M., & Devillers, L. (2017). Towards Metrics of Evaluation of Pepper Robot as a Social Companion for the Elderly. In M. Eskénazi, L. Devillers, & J. Mariani (Eds.), *Advanced Social Interaction with Agents—8th International Workshop on Spoken Dialog Systems, IWSDS 2017* (Vol.

510, pp. 89–101). Springer International Publishing. https://doi.org/10.1007/978-3-319-92108-2_11

Bedaf, S., Draper, H., Gelderblom, G.J., Sorell, T., & de Witte, L. (2016). Can a Service Robot Which Supports Independent Living of Older People Disobey a Command? The Views of Older People, Informal Carers and Professional Caregivers on the Acceptability of Robots. *International Journal of Social Robotics*, *8*(3), 409–420. https://doi.org/10.1007/s12369-016-0336-0

Bonaccorsi, M., Fiorini, L., Cavallo, F., Saffiotti, A., & Dario, P. (2016). A Cloud Robotics Solution to Improve Social Assistive Robots for Active and Healthy Aging. *International Journal of Social Robotics*, *8*(3), 393–408. https://doi.org/10.1007/s12369-016-0351-1

Boumans, R., van Meulen, F., Hindriks, K., Neerincx, M., & Olde Rikkert, M. (2018). Proof of Concept of a Social Robot for Patient Reported Outcome Measurements in Elderly Persons. *Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, 73–74. https://doi.org/10.1145/3173386.3177013

Bruno, B., Mastrogiovanni, F., & Sgorbissa, A. (2013). Functional requirements and design issues for a socially assistive robot for elderly people with mild cognitive impairments. *2013 IEEE RO-MAN*, 768–773. https://doi.org/10.1109/ROMAN.2013.6628406

Cesta, A., Cortellessa, G., Orlandini, A., & Tiberio, L. (2016). Long-Term Evaluation of a Telepresence Robot for the Elderly: Methodology and Ecological Case Study. *International Journal of Social Robotics*, *8*(3), 421–441. https://doi.org/10.1007/s12369-016-0337-z

Chang, R. C.-S., Lu, H.-P., & Yang, P. (2018). Stereotypes or golden rules? Exploring likable voice traits of social robots as active aging companions for tech-savvy baby boomers in Taiwan. *Computers in Human Behavior*, *84*, 194–210. https://doi.org/10.1016/j.chb.2018.02.025

Chu, M.T., Khosla, R., Khaksar, S. M. S., & Nguyen, K. (2017). Service innovation through social robot engagement to improve dementia care quality. *Assistive Technology*, *29*(1), 8–18. https://doi.org/10.1080/10400435.2016.1171807

Cortellessa, G., Fracasso, F., Sorrentino, A., Orlandini, A., Bernardi, G., Coraci, L., De Benedictis, R., & Cesta, A. (2018). ROBIN, a Telepresence Robot to Support Older Users Monitoring and Social Inclusion: Development and Evaluation. *Telemedicine and E-Health*, *24*(2), 145–154. https://doi.org/10.1089/tmj.2016.0258

Cruz-Sandoval, D., Favela, J., & Sandoval, E. B. (2018). Strategies to Facilitate the Acceptance of a Social Robot by People with Dementia. *Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, 95–96. https://doi.org/10.1145/3173386.3177081

Damholdt, M. F., Nørskov, M., Yamazaki, R., Hakli, R., Hansen, C. V., Vestergaard, C., & Seibt, J. (2015). Attitudinal Change in Elderly Citizens Toward Social Robots: The Role of Personality Traits and Beliefs About Robot Functionality. *Frontiers in Psychology*, *6,* 1-13. https://doi.org/10.3389/fpsyg.2015.01701

Draper, H., & Sorell, T. (2017). Ethical values and social care robots for older people: An international qualitative study. *Ethics and Information Technology*, *19*(1), 49–68. https://doi.org/10.1007/s10676-016-9413-1

Draper, H., Sorell, T., Bedaf, S., Lehmann, H., Ruiz, C.G., Hervé, M., Gelderblom, G.J., Dautenhahn, K., & Amirabdollahian, F. (2014, April 1-4). *What asking potential users about ethical values adds to our understanding of an ethical framework for social robots for older people* [Conference presentation]. 50th Annual Convention of the AISB , London , United Kingdom. http://doc.gold.ac.uk/aisb50/AISB50-S17/AISB50-S17-Draper-Paper.pdf

Eftring, H., & Frennert, S. (2016). Designing a social and assistive robot for seniors. *Zeitschrift Für Gerontologie Und Geriatrie*, *49*(4), 274–281. https://doi.org/10.1007/s00391-016-1064-7

Fasola, J., & Mataric, M. J. (2012). Using Socially Assistive Human–Robot Interaction to Motivate Physical Exercise for Older Adults. *Proceedings of the IEEE*, *100*(8), 2512–2526. https://doi.org/10.1109/JPROC.2012.2200539

Fasola, J., & Matarić, M. J. (2013). Socially Assistive Robot Exercise Coach: Motivating Older Adults to Engage in Physical Exercise. In J. P. Desai, G. Dudek, O. Khatib, & V. Kumar (Eds.), *Experimental Robotics* (Vol. 88, pp. 463–479). Springer International Publishing. https://doi.org/10.1007/978-3-319-00065-7_32

Fasola, J., & Mataric, M. J. (2010). Robot exercise instructor: A socially assistive robot system to monitor and encourage physical exercise for the elderly. *19th International Symposium in Robot and Human Interactive Communication*, 416–421. https://doi.org/10.1109/ROMAN.2010.5598658

Fernandes, F.E., Do, H. M., Muniraju, K., Sheng, W., & Bishop, A. J. (2017). Cognitive orientation assessment for older adults using social robots. *2017 IEEE International*

Conference on Robotics and Biomimetics (ROBIO), 196–201. https://doi.org/10.1109/ROBIO.2017.8324417

Frennert, S., Eftring, H., & Östlund, B. (2013). Older People's Involvement in the Development of a Social Assistive Robot. In G. Herrmann, M. J. Pearson, A. Lenz, P. Bremner, A. Spiers, & U. Leonards (Eds.), *Social Robotics* (Vol. 8239, pp. 8–18). Springer International Publishing. https://doi.org/10.1007/978-3-319-02675-6_2

Given-Wilson, T., Legay, A., & Sedwards, S. (2017). Information Security, Privacy, and Trust in Social Robotic Assistants for Older Adults. In T. Tryfonas (Ed.), *Human Aspects of Information Security, Privacy and Trust* (Vol. 10292, pp. 90–109). Springer International Publishing. https://doi.org/10.1007/978-3-319-58460-7_7

Glende, S., Conrad, I., Krezdorn, L., Klemcke, S., & Krätzel, C. (2016). Increasing the Acceptance of Assistive Robots for Older People Through Marketing Strategies Based on Stakeholder Needs. *International Journal of Social Robotics*, *8*(3), 355–369. https://doi.org/10.1007/s12369-015-0328-5

Gross, H.M., Schroeter, C., Mueller, S., Volkhardt, M., Einhorn, E., Bley, A., Martin, C., Langner, T., & Merten, M. (2011). Progress in developing a socially assistive mobile home robot companion for the elderly with mild cognitive impairment. *2011 IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2430–2437. https://doi.org/10.1109/IROS.2011.6094770

Hammer, S., Kirchner, K., André, E., & Lugrin, B. (2017). Touch or Talk?: Comparing Social Robots and Tablet PCs for an Elderly Assistant Recommender System. *Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction*, 129–130. https://doi.org/10.1145/3029798.3038419

Hebesberger, D., Koertner, T., Gisinger, C., & Pripfl, J. (2017). A Long-Term Autonomous Robot at a Care Hospital: A Mixed Methods Study on Social Acceptance and Experiences of Staff and Older Adults. *International Journal of Social Robotics*, *9*(3), 417–429. https://doi.org/10.1007/s12369-016-0391-6

Heerink, Marcel, Kröse, B., Evers, V., & Wielinga, B. (2006). The Influence of a Robot's Social Abilities on Acceptance by Elderly Users. *ROMAN 2006 - The 15th IEEE International Symposium on Robot and Human Interactive Communication*, 521–526. https://doi.org/10.1109/ROMAN.2006.314442

Heerink, M., Kröse, B., Evers, V., & Wielinga, B. (2008a). The influence of social presence on acceptance of a companion robot by older people. *Journal of Physical Agents (JoPha)*, *2*(2), 33–40. https://doi.org/10.14198/JoPha.2008.2.2.05

Heerink, Marcel, Kröse, B., Evers, V., & Wielinga, B. (2008b). The influence of social presence on enjoyment and intention to use of a robot and screen agent by elderly users. *RO-MAN 2008 - The 17th IEEE International Symposium on Robot and Human Interactive Communication*, 695–700. https://doi.org/10.1109/ROMAN.2008.4600748

Heerink, M., Kröse, B., Evers, V., & Wielinga, B. (2009). Influence of Social Presence on Acceptance of an Assistive Social Robot and Screen Agent by Elderly Users. *Advanced Robotics*, *23*(14), 1909–1923. https://doi.org/10.1163/016918609X12518783330289

Heerink, M., Kröse, B., Wielinga, B., & Evers, V. (2009). Measuring the Influence of Social Abilities on Acceptance of an Interface Robot and a Screen Agent by Elderly Users. *Proceedings of the 23rd British HCI Group Annual Conference on People* *and Computers: Celebrating People and Technology*, 430–439. https://dl.acm.org/citation.cfm?doid=1671011.1671067

Heerink, M., Kröse, B., Evers, V., & Wielinga, B. (2010). Assessing Acceptance of Assistive Social Agent Technology by Older Adults: The Almere Model. *International Journal of Social Robotics*, *2*(4), 361–375. https://doi.org/10.1007/s12369-010-0068-5

Jonell, P., Mendelson, J., Storskog, T., Hagman, G., Ostberg, P., Leite, I., Kucherenko, T., Mikheeva, O., Akenine, U., Jelic, V., Solomon, A., Beskow, J., Gustafson, J., Kivipelto, M., & Kjellstrom, H. (2017). Machine Learning and Social Robotics for Detecting Early Signs of Dementia. *ArXiv:1709.01613 [Cs]*. http://arxiv.org/abs/1709.01613

Kargar, B. A. H., & Mahoor, M. H. (2017). A pilot study on the eBear socially assistive robot: Implication for interacting with elderly people with moderate depression. *2017 IEEE-RAS 17th International Conference on Humanoid Robotics (Humanoids)*, 756–762. https://doi.org/10.1109/HUMANOIDS.2017.8246957

Khosla, R., Chu, M.T., Kachouie, R., Yamada, K., Yoshihiro, F., & Yamaguchi, T. (2012). Interactive multimodal social robot for improving quality of care of elderly in Australian nursing homes. *Proceedings of the 20th ACM International Conference on Multimedia - MM '12*, 1173. https://doi.org/10.1145/2393347.2396411

Khosla, R., Chu, M.-T., & Nguyen, K. (2013). Enhancing Emotional Well Being of Elderly Using Assistive Social Robots in Australia. *2013 International Conference* *on Biometrics and Kansei Engineering*, 41–46. https://doi.org/10.1109/ICBAKE.2013.9

Khosla, R., Nguyen, K., & Chu, M.T. (2016, August 24-26). *Socially Assistive Robot Enabled Personalised Care for People with Dementia in Australian Private Homes* [Conference Presentation]. The 25th International Conference on Information Systems Development (ISD 2016), Katowice, Poland. http://aisel.aisnet.org/isd2014/proceedings2016/CreativitySupport/8.

Kidd, C. D., Taggart, W., & Turkle, S. (2006). A sociable robot to encourage social interaction among the elderly. *Proceedings 2006 IEEE International Conference on Robotics and Automation, 2006. ICRA 2006.*, 3972–3976. https://doi.org/10.1109/ROBOT.2006.1642311

Klamer, T., & Allouch, S. B. (2010). Acceptance and use of a social robot by elderly users in a domestic environment. *Proceedings of the 4th International ICST Conference on Pervasive Computing Technologies for Healthcare*, 1-8. https://doi.org/10.4108/ICST.PERVASIVEHEALTH2010.8892

Kobayashi, T., Katsuragi, K., Miyazaki, T., & Arai, K. (2017). Social Media Intermediation Robot for Elderly People Using External Cloud-Based Services. *2017 5th IEEE International Conference on Mobile Cloud Computing, Services, and Engineering (MobileCloud)*, 31–38. https://doi.org/10.1109/MobileCloud.2017.18

Lane, G. W., Noronha, D., Rivera, A., Craig, K., Yee, C., Mills, B., & Villanueva, E. (2016). Effectiveness of a social robot, "Paro," in a VA long-term care setting. *Psychological Services*, *13*(3), 292–299. https://doi.org/10.1037/ser0000080

Looije, R., Neerincx, M. A., & Cnossen, F. (2010). Persuasive robotic assistant for health self-management of older adults: Design and evaluation of social behaviors. *International Journal of Human-Computer Studies*, *68*(6), 386–397. https://doi.org/10.1016/j.ijhcs.2009.08.007

Louie, W.Y.G., Li, J., Vaquero, T., & Nejat, G. (2014). A focus group study on the design considerations and impressions of a socially assistive robot for long-term care. *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*, 237–242. https://doi.org/10.1109/ROMAN.2014.6926259

Louie, W.Y.G., McColl, D., & Nejat, G. (2012). Playing a memory game with a socially assistive robot: A case study at a long-term care facility. *2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication*, 345–350. https://doi.org/10.1109/ROMAN.2012.6343777

Marin Mejia, A. L. (2014). Social networking sites photos and robots: A pilot research on facebook photo albums and robotics interfaces for older adults. *Proceedings of the Second International Conference on Human-Agent Interaction - HAI '14*, 287–291. https://doi.org/10.1145/2658861.2658944

McColl, D., Louie, W.-Y. G., & Nejat, G. (2013). Brian 2.1: A socially assistive robot for the elderly and cognitively impaired. *IEEE Robotics & Automation Magazine*, *20*(1), 74–83. https://doi.org/10.1109/MRA.2012.2229939

Merten, M., Bley, A., Schroeter, C., & Gross, H. (2012). A mobile robot platform for socially assistive home-care applications. *ROBOTIK 2012; 7th German Conference on Robotics*, 1–6. https://ieeexplore.ieee.org/document/6309513

Michaud, F., Boissy, P., Labonte, D., Corriveau, H., Grant, A., Lauria, M., Clouties, R., Roux, M.A., Iannuzzi, D., & Royer, M. P. (2007). Telepresence Robot for Home Care Assistance. *AAAI spring symposium: multidisciplinary collaboration for socially assistive robotics*, 50-55. https://www.aaai.org/Papers/Symposia/Spring/2007/SS-07-07/SS07-07-012.pdf

Moyle, W., Bramble, M., Jones, C., & Murfield, J. (2018). Care staff perceptions of a social robot called Paro and a look-alike Plush Toy: A descriptive qualitative approach. *Aging & Mental Health*, *22*(3), 330–335. https://doi.org/10.1080/13607863.2016.1262820

Moyle, W., Jones, C., Cooke, M., O'Dwyer, S., Sung, B., & Drummond, S. (2013). Social robots helping people with dementia: Assessing efficacy of social robots in the nursing home environment. *2013 6th International Conference on Human System Interactions (HSI)*, 608–613. https://doi.org/10.1109/HSI.2013.6577887

Moyle, W., Jones, C., Sung, B., Bramble, M., O'Dwyer, S., Blumenstein, M., & Estivill-Castro, V. (2016). What Effect Does an Animal Robot Called CuDDler Have on the Engagement and Emotional Response of Older People with Dementia? A Pilot Feasibility Study. *International Journal of Social Robotics*, *8*(1), 145–156. https://doi.org/10.1007/s12369-015-0326-7

Neven, L., & Leeson, C. A. P. (2015). Beyond determinism: understanding actual use of social robots by older people. In D. Prendergast, & C. Garattini (Eds.), *Aging and the digital life course* (pp. 84 – 102). Berghahn Books.

Pérez, P. J., Garcia-Zapirain, B., & Mendez-Zorrilla, A. (2015). Caregiver and social assistant robot for rehabilitation and coaching for the elderly. *Technology and Health Care*, *23*(3), 351–357. https://doi.org/10.3233/THC-150896

Peri, K., Kerse, N., Broadbent, E., Jayawardena, C., Kuo, T., Datta, C., Stafford, R., & MacDonald, B. (2016). Lounging with robots - social spaces of residents in care: A comparison trial: Lounging with robots. *Australasian Journal on Ageing*, *35*(1), E1–E6. https://doi.org/10.1111/ajag.12201

Perugia, G., Diaz Boladeras, M., Mallofre, A. C., Rauterberg, M., & Barakova, E. (2017a). Modelling engagement in dementia through behaviour. Contribution for socially interactive robotics. *2017 International Conference on Rehabilitation Robotics (ICORR)*, 1112–1117. https://doi.org/10.1109/ICORR.2017.8009398

Perugia, G., Rodriguez-Martin, D., Diaz Boladeras, M., Mallofre, A. C., Barakova, E., & Rauterberg, M. (2017b). Electrodermal activity: Explorations in the psychophysiology of engagement with social robots in dementia. *2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*, 1248–1254. https://doi.org/10.1109/ROMAN.2017.8172464

Pfadenhauer, M., & Dukat, C. (2015). Robot Caregiver or Robot-Supported Caregiving?: The Performative Deployment of the Social Robot PARO in Dementia Care. *International Journal of Social Robotics*, *7*(3), 393–406. https://doi.org/10.1007/s12369-015-0284-0

Piasek, J., & Wieczorowska-Tobis, K. (2018). Acceptance and Long-Term Use of a Social Robot by Elderly Users in a Domestic Environment. *2018 11th International*

Conference on Human System Interaction (HSI), 478–482. https://doi.org/10.1109/HSI.2018.8431348

Piezzo, C., & Suzuki, K. (2017). Feasibility Study of a Socially Assistive Humanoid Robot for Guiding Elderly Individuals during Walking. *Future Internet*, *9*(3), 30. https://doi.org/10.3390/fi9030030

Pino, M., Granata, C., Legouverneur, G., Boulay, M., & Rigaud, A.S. (2012). Assessing design features of a graphical user interface for a social assistive robot for older adults with cognitive impairment. *Gerontechnology*, *11*(2). https://doi.org/10.4017/gt.2012.11.02.490.734

Portugal, D., Santos, L., Alvito, P., Dias, J., Samaras, G., & Christodoulou, E. (2015). SocialRobot: An interactive mobile robot for elderly home care. *2015 IEEE/SICE International Symposium on System Integration (SII)*, 811–816. https://doi.org/10.1109/SII.2015.7405084

Prange, A., Sandrala, I. P., Weber, M., & Sonntag, D. (2015). Robot Companions and Smartpens for Improved Social Communication of Dementia Patients. *Proceedings of the 20th International Conference on Intelligent User Interfaces Companion - IUI Companion '15*, 65–68. https://doi.org/10.1145/2732158.2732174

Pripfl, J., Kortner, T., Batko-Klein, D., Hebesberger, D., Weninger, M., Gisinger, C., Frennert, S., Eftring, H., Antona, M., Adami, I., Weiss, A., Bajones, M., & Vincze, M. (2016). Results of a real world trial with a mobile social service robot for older adults. *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 497–498. https://doi.org/10.1109/HRI.2016.7451824

Rehm, M., Krummheuer, A. L., Rodil, K., Nguyen, M., & Thorlacius, B. (2016). From Social Practices to Social Robots – User-Driven Robot Development in Elder Care. In A. Agah, J.-J. Cabibihan, A. M. Howard, M. A. Salichs, & H. He (Eds.), *Social Robotics* (Vol. 9979, pp. 692–701). Springer International Publishing. https://doi.org/10.1007/978-3-319-47437-3_68

Reppou, S. E., Tsardoulias, E. G., Kintsakis, A. M., Symeonidis, A. L., Mitkas, P. A., Psomopoulos, F. E., Karagiannis, G. T., Zielinski, C., Prunet, V., Merlet, J.-P., Iturburu, M., & Gkiokas, A. (2016). RAPP: A Robotic-Oriented Ecosystem for Delivering Smart User Empowering Applications for Older People. *International Journal of Social Robotics*, *8*(4), 539–552. https://doi.org/10.1007/s12369-016-0361-z

Rodić, A., Vujović, M., Stevanović, I., & Jovanović, M. (2016). Development of Human-Centered Social Robot with Embedded Personality for Elderly Care. In P. Wenger, C. Chevallereau, D. Pisla, H. Bleuler, & A. Rodić (Eds.), *New Trends in Medical and Service Robots* (Vol. 39, pp. 233–247). Springer International Publishing. https://doi.org/10.1007/978-3-319-30674-2_18

Roger, K., Guse, L., Mordoch, E., & Osterreicher, A. (2012). Social Commitment Robots and Dementia. *Canadian Journal on Aging / La Revue Canadienne Du Vieillissement*, *31*(1), 87–94. https://doi.org/10.1017/S0714980811000663

Sakamoto, K., Fern, S.-A. L. C., Han, L., & Tong, J. C. (2016). Psychographic Profiling for Use in Assistive Social Robots for the Elderly. In N. Kubota, K. Kiguchi, H. Liu, & T. Obo (Eds.), *Intelligent Robotics and Applications* (Vol. 9835, pp. 58–67). Springer International Publishing. https://doi.org/10.1007/978-3-319-43518-3_6

Salichs, M. A., Encinar, I. P., Salichs, E., Castro-González, Á., & Malfaz, M. (2016). Study of Scenarios and Technical Requirements of a Social Assistive Robot for Alzheimer's Disease Patients and Their Caregivers. *International Journal of Social Robotics*, *8*(1), 85–102. https://doi.org/10.1007/s12369-015-0319-6

Sebastian, J., Hsu, Y.-L., & Lu, J.-M. (2014). Creation of a 'Caricature Robot' for social inclusion of older adults. *Gerontechnology*, *13*(2), 278. https://doi.org/10.4017/gt.2014.13.02.383.00

Shiomi, M., Iio, T., Kamei, K., Sharma, C., & Hagita, N. (2015). Effectiveness of Social Behaviors for Autonomous Wheelchair Robot to Support Elderly People in Japan. *PLOS ONE*, *10*(5), e0128031. https://doi.org/10.1371/journal.pone.0128031

Sidner, C., Rich, C., Shayganfar, M., Bickmore, T., Ring, L., & Zhang, Z. (2015). A Robotic Companion for Social Support of Isolated Older Adults. *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts - HRI'15 Extended Abstracts*, 289–289. https://doi.org/10.1145/2701973.2702103

Smarr, C.-A., Mitzner, T. L., Beer, J. M., Prakash, A., Chen, T. L., Kemp, C. C., & Rogers, W. A. (2014). Domestic Robots for Older Adults: Attitudes, Preferences, and Potential. *International Journal of Social Robotics*, *6*(2), 229–247. https://doi.org/10.1007/s12369-013-0220-0

Stafford, R. Q., MacDonald, B. A., Jayawardena, C., Wegner, D. M., & Broadbent, E. (2014a). Does the Robot Have a Mind? Mind Perception and Attitudes Towards Robots Predict Use of an Eldercare Robot. *International Journal of Social Robotics*, *6*(1), 17–32. https://doi.org/10.1007/s12369-013-0186-y

Stafford, R. Q., MacDonald, B. A., Li, X., & Broadbent, E. (2014b). Older People's Prior Robot Attitudes Influence Evaluations of a Conversational Robot. *International Journal of Social Robotics*, *6*(2), 281–297. https://doi.org/10.1007/s12369-013-0224-9

Sung, H.C., Chang, S.M., Chin, M.Y., & Lee, W.L. (2015). Robot-assisted therapy for improving social interactions and activity participation among institutionalized older adults: A pilot study: Robot therapy for older adults. *Asia-Pacific Psychiatry*, *7*(1), 1–6. https://doi.org/10.1111/appy.12131

Tapus, A., & Mataric, M. J. (2008). Socially Assistive Robotic Music Therapist for Maintaining Attention of Older Adults with Cognitive Impairments. *AAAI Fall Symposium: AI in Eldercare: New Solutions to Old Problems*, 124-127. https://www.aaai.org/Papers/Symposia/Fall/2008/FS-08-02/FS08-02-019.pdf

Tapus, A., Wade, E., & Mataric, M. J. (2008). Using a Socially Assistive Robot in Gait Recovery and Training for Individuals with Cognitive Impairments. *AAAI Fall Symposium: AI in Eldercare: New Solutions to Old Problems*, 128-130. https://www.aaai.org/Papers/Symposia/Fall/2008/FS-08-02/FS08-02-020.pdf

Torta, E., Werner, F., Johnson, D. O., Juola, J. F., Cuijpers, R. H., Bazzani, M., Oberzaucher, J., Lemberger, J., Lewy, H., & Bregman, J. (2014). Evaluation of a Small Socially-Assistive Humanoid Robot in Intelligent Homes for the Care of the Elderly. *Journal of Intelligent & Robotic Systems*, *76*(1), 57–71. https://doi.org/10.1007/s10846-013-0019-0

Valentí-Soler, M., Agüera-Ortiz, L., Olazarán Rodríguez, J., Mendoza Rebolledo, C., Pérez Muñoz, A., Rodríguez Pérez, I., Osa Ruiz, E., Barrios Sánchez, A., Herrero

Cano, V., Carrasco Chillón, L., Felipe Ruiz, S., López Alvarez, J., León Salas, B., Cañas Plaza, J. M., Martín Rico, F., Abella Dago, G., & Martínez Martín, P. (2015). Social robots in advanced dementia. *Frontiers in Aging Neuroscience*, *7*. https://doi.org/10.3389/fnagi.2015.00133

Varène, T., Hillereau, P., & Simonnet, T. (2010). Telecare and Social Link Solution for Ambient Assisted Living Using a Robot Companion with Visiophony. In T. Sobh & K. Elleithy (Eds.), *Innovations in Computing Sciences and Software Engineering* (pp. 235–239). Springer Netherlands. https://doi.org/10.1007/978-90-481-9112-3_39

Wada, K., & Shibata, T. (2006). Living with Seal Robots in a Care House—Evaluations of Social and Physiological Influences. *2006 IEEE/RSJ International Conference on Intelligent Robots and Systems*, 4940–4945. https://doi.org/10.1109/IROS.2006.282455

Wada, K., & Shibata, T. (2007). Social Effects of Robot Therapy in a Care House—Change of Social Network of the Residents for Two Months. *Proceedings 2007 IEEE International Conference on Robotics and Automation*, 1250–1255. https://doi.org/10.1109/ROBOT.2007.363156

Wada, K., & Shibata, T. (2009). Social effects of robot therapy in a care house–change of social network of the residents for one year. *Journal of Advanced Computational Intelligence and Intelligent Informatics*, *13*(4), 386-392. https://www.fujipress.jp/jaciii/jc/jacii001300040386/

Wada, K., Shibata, T., Saito, T., Sakamoto, K., & Tanie, K. (2005). Psychological and Social Effects of One Year Robot Assisted Activity on Elderly People at a Health Service Facility for the Aged. *Proceedings of the 2005 IEEE International*

Conference on Robotics and Automation, 2785–2790. https://doi.org/10.1109/ROBOT.2005.1570535

Wada, K., Shibata, T., Saito, T., & Tanie, K. (2003a). Psychological and social effects of robot assisted activity to elderly people who stay at a health service facility for the aged. *2003 IEEE International Conference on Robotics and Automation*, *3*, 3996–4001. https://doi.org/10.1109/ROBOT.2003.1242211

Wada, K., Shibata, T., Saito, T., & Tanie, K. (2003b). Psychological, physiological and social effects to elderly people by robot assisted activity at a health service facility for the aged. *Proceedings 2003 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM 2003)*, 272–277. https://doi.org/10.1109/AIM.2003.1225107

Wada, K., Shibata, T., Saito, T., & Tanie, K. (2004). Psychological and social effects in long-term experiment of robot assisted activity to elderly people at a health service facility for the aged. *2004 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, *3*, 3068–3073. https://doi.org/10.1109/IROS.2004.1389877

Werner, F., Krainer, D., Oberzaucher, J., & Werner, K. (2013). Evaluation of the acceptance of a social assistive robot for physical training support together with older users and domain experts. In P. Encarnação, L. Azevedo, G.J. Gelderblom (Eds.), *Assistive Technology: From Research to Practice: AAATE* (pp. 137-142). IOS Press.

Werner, K., Oberzaucher, J., & Werner, F. (2012). Evaluation of Human Robot Interaction Factors of a Socially Assistive Robot Together with Older People. *2012*

Sixth International Conference on Complex, Intelligent, and Software Intensive Systems, 455–460. https://doi.org/10.1109/CISIS.2012.36

Yamazaki, R., Nishio, S., Ishiguro, H., Nørskov, M., Ishiguro, N., & Balistreri, G. (2014). Acceptability of a Teleoperated Android by Senior Citizens in Danish Society: A Case Study on the Application of an Embodied Communication Medium to Home Care. *International Journal of Social Robotics*, *6*(3), 429–442. https://doi.org/10.1007/s12369-014-0247-x

Yu, R., Hui, E., Lee, J., Poon, D., Ng, A., Sit, K., Ip, K., Yeung, F., Wong, M., Shibata, T., & Woo, J. (2015). Use of a Therapeutic, Socially Assistive Pet Robot (PARO) in Improving Mood and Stimulating Social Interaction and Communication for People With Dementia: Study Protocol for a Randomized Controlled Trial. *JMIR Research Protocols*, *4*(2), e45. https://doi.org/10.2196/resprot.4189

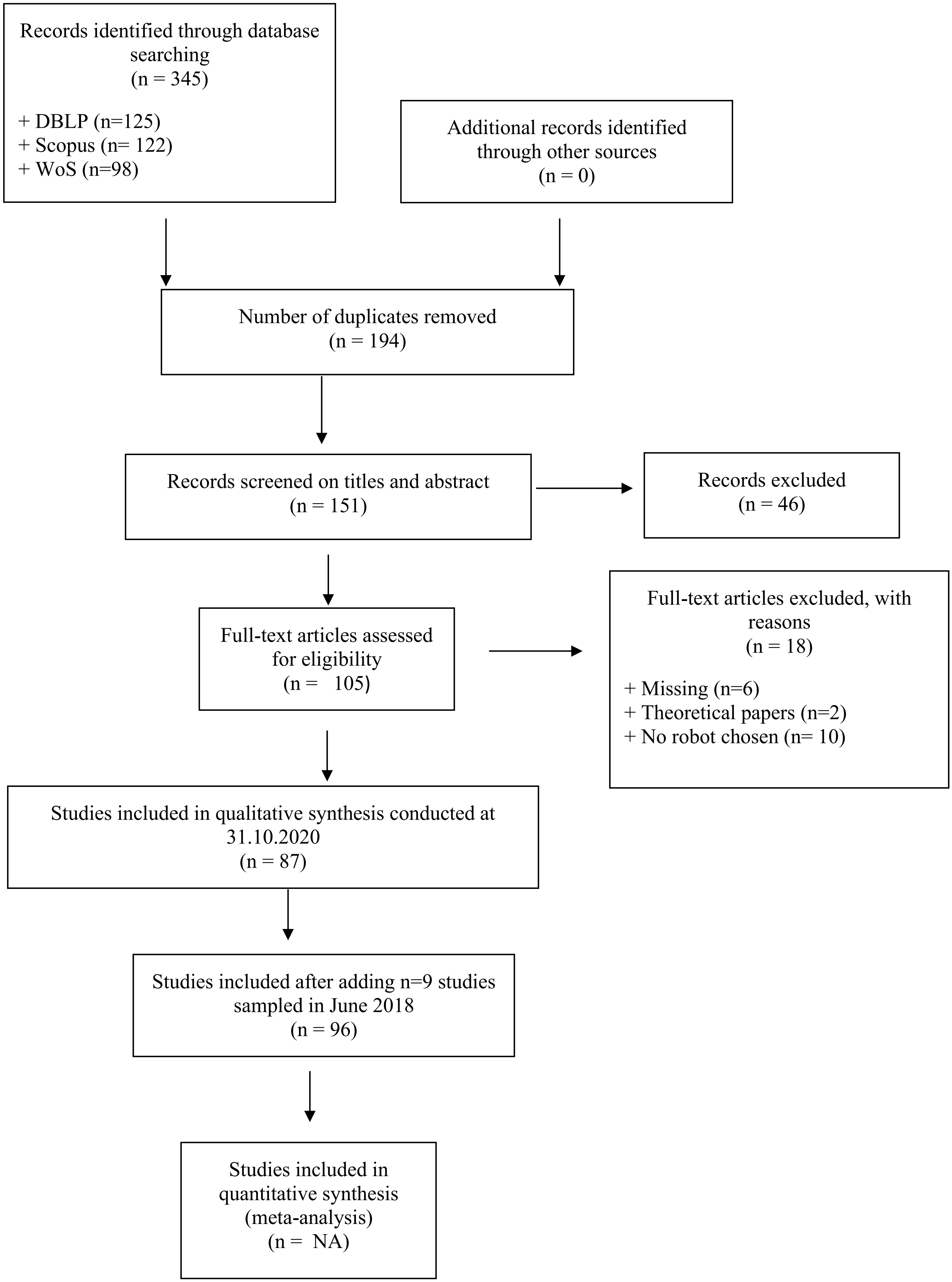
Yu, R., Woo, J., Hui, E., Lee, J., Poon, D., Ip, K., & Yeung, F. (2014). Feasibility and effect of a therapeutic robot PARO on moods and social interaction in older adults with declining cognitive function. *Gerontechnology*, *13*(2), 317. https://doi.org/10.4017/gt.2014.13.02.149.00

Zlatintsi, A., Rodomagoulakis, I., Pitsikalis, V., Koutras, P., Kardaris, N., Papageorgiou, X., Tzafestas, C., & Maragos, P. (2017). Social Human-Robot Interaction for the Elderly: Two Real-life Use Cases. *Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction*, 335–336. https://doi.org/10.1145/3029798.3038400

10. Appendix B: PRISMA flowchart

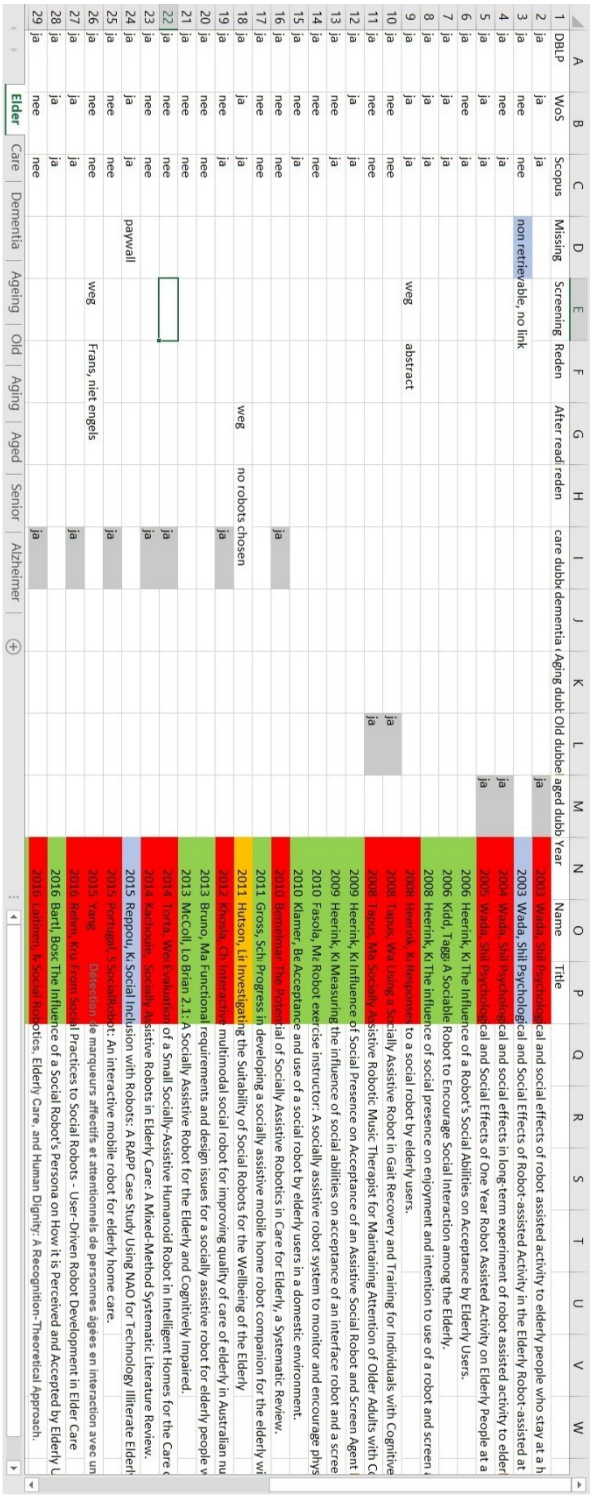
This flowchart shows the results of a search conducted on 31.10.2020. Though this flowchart represents the search flow conducted in June 2018 fairly well (e.g. all publications from after June 2018 were excluded, and it includes the publication analyzed for this dissertation), the database DBLP seems to have changed its search engine. In 2018, one could search for "social robot senior" and it would show publications that included those words in the title and/or in the journal name. For instance, the author retrieved the following publication in 2018: Yamazaki, R., Nishio, S., Ishiguro, H., Nørskov, M., Ishiguro, N., & Balistreri, G. (2014). Acceptability of a Teleoperated Android by Senior Citizens in Danish Society: A Case Study on the Application of an Embodied Communication Medium to Home Care. *International Journal of Social Robotics*, *6*(3), 429–442. https://doi.org/10.1007/s12369-014-0247-x

However currently, one cannot find that same publication with the search strategy adopted in 2018, as DBLP abbreviated the journal name to " Int. J. Soc. Robotics ". In other words, while the same search strategy was applied at 31.10.2020, a total of nine publications that were retrieved in 2018 and *are* included in the sample, but did not show on a recent DBLP search. This means that this flowchart might not give a complete representation of what was retrieved in 2018, but it does give an approximation of what happened then. Also, the following chart is slightly modified for that reason, compared with regular PRISMA flowcharts.


Records identified through database searching
(n = 345)
+ DBLP (n=125)
+ Scopus (n= 122)
+ WoS (n=98)
Additional records identified through other sources
(n = 0)
Number of duplicates removed
(n = 194)
Records screened on titles and abstract
(n = 151)
Records excluded
(n = 46)
Full-text articles assessed for eligibility
(n = 105)
Full-text articles excluded, with reasons
(n = 18)
+ Missing (n=6)
+ Theoretical papers (n=2)
+ No robot chosen (n= 10)
Studies included in qualitative synthesis conducted at 31.10.2020
(n = 87)
Studies included after adding n=9 studies sampled in June 2018
(n = 96)
Studies included in quantitative synthesis (meta-analysis)
(n = NA)

11. Appendix C: Inclusion/exclusion publications

To get a visual impression of how the data was managed, this appendix shows a screenshot (image 1) of the applied sampling criteria. As shown here, an Excel file was kept to keep track (partially in the author's native language for convenience) of all excluded and included papers with the additional information of: the title, authors, reason for exclusion, which databases it was shown, if they are duplicates according to which search term and database. Red, orange, or blue means exclusion whereas green means inclusion in columns N,O,P. Besides green, the different colors mean different types of exclusion. Red means exclusion after screening on titles and abstracts, orange means exclusion after reading, blue means missing (paywall or non-retrievable), the gray highlighted entries indicate duplicates.



	DBLP	WoS	Scopus	Missing	Screening	Reden	After readi	reden	care dubb	dementia (	Aging dubl	Old dubbe	aged dubb	Year	Name	Title
2	ja	ja	ja										ja	2003	Wada, Shil	Psychological and social effects of robot assisted activity to elderly people who stay at a h
3	ja	nee	nee	non retrievable, no link										2003	Wada, Shil	Psychological and Social Effects of Robot-assisted Activity in the Elderly Robot-assisted at
4	ja	nee	ja										ja	2004	Wada, Shil	Psychological and social effects in long-term experiment of robot assisted activity to elder
5	ja	ja	ja										ja	2005	Wada, Shil	Psychological and Social Effects of One Year Robot Assisted Activity on Elderly People at a
6	ja	nee	ja											2006	Heerink, K	The Influence of a Robot's Social Abilities on Acceptance by Elderly Users.
7	ja	ja	ja											2006	Kidd, Tagg	A Sociable Robot to Encourage Social Interaction among the Elderly.
8	ja	ja	ja											2008	Heerink, K	The influence of social presence on enjoyment and intention to use of a robot and screen
9	ja	ja	ja		weg	abstract								2008	Heerink, K	Responses to a social robot by elderly users.
10	ja	nee	nee									ja		2008	Tapus, Wa	Using a Socially Assistive Robot in Gait Recovery and Training for Individuals with Cognitive
11	ja	nee	nee									ja		2008	Tapus, Ma	Socially Assistive Robotic Music Therapist for Maintaining Attention of Older Adults with C
12	ja	ja	ja											2009	Heerink, K	Influence of Social Presence on Acceptance of an Assistive Social Robot and Screen Agent
13	ja	nee	ja											2009	Heerink, K	Measuring the influence of social abilities on acceptance of an interface robot and a scree
14	ja	nee	nee											2010	Fasola, Ma	Robot exercise instructor: A socially assistive robot system to monitor and encourage phys
15	ja	nee	ja											2010	Klamer, Be	Acceptance and use of a social robot by elderly users in a domestic environment.
16	ja	nee	nee						ja					2010	Bemelmar	The Potential of Socially Assistive Robotics in Care for Elderly, a Systematic Review.
17	ja	nee	nee											2011	Gross, Sch	Progress in developing a socially assistive mobile home robot companion for the elderly wi
18	ja	ja	ja				weg	no robots chosen						2011	Hutson, Lir	Investigating the Suitability of Social Robots for the Wellbeing of the Elderly
19	ja	nee	ja						ja					2012	Khosla, Ch	Interactive multimodal social robot for improving quality of care of elderly in Australian nu
20	ja	nee	nee											2013	Bruno, Ma	Functional requirements and design issues for a socially assistive robot for elderly people w
21	ja	nee	nee											2013	McColl, Lo	Brian 2.1: A Socially Assistive Robot for the Elderly and Cognitively Impaired.
22	ja	nee	nee						ja					2014	Torta, We	Evaluation of a Small Socially-Assistive Humanoid Robot in Intelligent Homes for the Care
23	ja	nee	nee						ja					2014	Kachouie,	Socially Assistive Robots in Elderly Care: A Mixed-Method Systematic Literature Review.
24	ja	ja	ja	paywall										2015	Reppou, K	Social Inclusion with Robots: A RAPP Case Study Using NAO for Technology Illiterate Elderl
25	ja	nee	nee						ja					2015	Portugal, S	SocialRobot: An interactive mobile robot for elderly home care.
26	ja	nee	nee		weg	Frans, niet engels								2015	Yang	Détection de marqueurs affectifs et attentionnels de personnes âgées en interaction avec un
27	ja	ja	ja						ja					2016	Rehm, Kru	From Social Practices to Social Robots - User-Driven Robot Development in Elder Care
28	ja	ja	ja											2016	Bartl, Bosc	The Influence of a Social Robot's Persona on How it is Perceived and Accepted by Elderly U
29	ja	nee	nee						ja					2016	Laitinen, N	Social Robotics, Elderly Care, and Human Dignity: A Recognition-Theoretical Approach.

Elder | Care | Dementia | Ageing | Old | Aging | Aged | Senior | Alzheimer

Image 1. Sample overview

12. Appendix D: Extra information methods study 1 [26]

This appendix is structured in four parts. The first part describes how grounded theory was applied, i.e. what worked and what did not in the process. The numbers refer to "steps" taken though it should be emphasized, in reality, grounded theory is by definition a circular/iterative activity instead of linear. As a result, the steps are not an indication for replicability. The second part gives examples of how raw data translates into axial codes. Then it is explained how those axial codes informed the selective codes. Finally, it is explained how theory was derived and refined by looking at ambiguous cases.

12.1. Coding procedure study 1

1. I read all sampled papers and while doing so, marked all pieces of text (physically printed the publications on paper and highlighted pieces of text with a marker) that might be relevant for the analysis (open coding). This is a highly iterative approach, since "relevant" is difficult to establish without a predefined theoretical understanding of the phenomenon. At first, it was believed that it would suffice to sample definitions/conceptualizations as presented in the sampled academic publications. This turned out to have no value whatsoever, since the conceptualizations were not informative/detailed enough. Two other ideas were explored: the relationship between anthropomorphic appearance and functionality, and a categorization of robots based on sensory experience.

Typically, determining "relevant" texts depends on the positionality of the researcher. For instance, I am not an engineer and mistook some variables as initially

[26] All references mentioned in appendix D, E, F are included in the reference list.

relevant that are inherent to the discipline of engineering: e.g. sampling the sensors used for each robot. After some rounds of revisiting the sampled academic publications, it became clear that some robots are more intervening than others in their offered activities. At this stage of coding, it was not entirely clear what that meant. In order to get more clarity, all publications were re-read, and labelled according to their activities. This labelling could be seen as the first attempt of axial coding.

2. What followed, was the creation of an excel file, where all the publications would have a short description of their offered activities (axial coding). Jonell et al. (2017) for instance, aim to develop a robot-as-a-clinician, whereas Yamazaki et al. (2014) tested for remote embodiment for their telepresence robot. At this stage, all robots were labelled in accordance with their general functionalities: e.g. tool for walking, everyday living and networking (Given-Wilson et al., 2017), Web 2.0/Social Networking Sites (Marin Mejia, 2014) etc.

3. These general descriptions lead to the tentative formation of the categorization of tools/agents – which was added to that excel file per publication. Also, it was noticed that for instance Yamazaki et al.'s (2014) case was about connecting people, whereas Jonell et al. (2017) was about carrying out neuropsychological tests. This lead to the understanding that some robots were more social in nature, whereas others were engaging in care activities. In other words, a second dimension in addition to tools/agents was established, which was also added to the excel file. At this stage, social tools, social agents, social telecommunication, care tools, care agents, care telecommunication was established as tentative selective codes (even though they proved not to be "actual" selective codes). At this point, these codes were nothing more than an educated guess –

i.e. this was an idea that arose after reading all the assigned axial codes, but needed to be put to the test.

4. In order to understand if all labels were assigned correctly, a new excel file was created where all the labelled social tools/social agents/social telecommunication, care tools/care agents/care telecommunication were treated as separate categories in separate excel sheets. For instance, one sheet labeled “ST”, translating to Social Tool, would list all publications that was deemed as a social tool. Then, in order to provide stronger “evidence” compared with descriptive labels only such as “smart housing interface” or “robot as clinician”, as to why one publication could be seen as e.g. a social tool, step 1 was repeated with the aim to sample *literal quotations* per publication (marking the iterative nature of grounded theory).

This step proved to be more difficult than anticipated, since having a closer look at the data revealed that a robot does not necessarily “have” x qualities, but rather, the qualities are also interpreted in specific contexts. In other words, Paro “is” not necessarily x or y, but rather, is interpreted by the authors of the sampled publications to expect to act a certain way. This lead to sampling different descriptions of robots for the data analysis: quotations that mention general descriptions and activities of the robot, and quotations that describe which activities of the robots were tested for (i.e. situational information in order to understand the contextual relevance of the robot). It is important to note that there was not a structural comparison made between the two types of data. Rather, they serve as complementary information, i.e. a means for data triangulation. It is not the aim of this PhD to understand how the two sources of data reveal certain types of information. Rather, the aim is to understand how to define social robots in elder care, which coincidentally shows that robots are both contextual things as well as things with certain features.

5. Once all quotations were put into the excel sheet, it was time to sort out whether the axial codes were correct. This is a step, of looking at how the sampled literal quotations relate to one another: is there overlap found, and if so, how to label this overlap? This step basically, is conducting axial coding for the second time. This step is explained in-detail in paragraph 12.2, i.e. how raw data (literal quotations, i.e. open codes) translate into axial codes. This was a process of constantly shuffling and reshuffling quotations to particular axial codes, but also in relation to the tentative selective codes. For instance, it was here, that robots that enable long distance communication were not treated anymore as a selective code. Rather, robots enabling long distance calls could be seen as robot tools, since tools typically enable older user to enhance their pre-existing qualities (e.g. maintain already existing social network) and aid with mundane activities.

The axial codes here ended up being relevant for the rest of the analysis, and also relevant *an sich*. These axial codes are the basis of the robot typology as presented in this dissertation: care/entertainment assistants, robot therapists, robots running medical tests, social networking robots, therapeutic robot-toys, conversational robots. As explained in chapter four, these axial codes could be seen as ideal types, as sometimes the boundaries between, for instance, a care or entertainment assistant would not be too obvious. Whenever this happened, a note was taken in the excel sheet. This latter statement is further discussed in paragraph 12.4 onwards.

6. It was now time to establish the relationality of such axial codes, and start with selective coding. The question is now, what does this say? How do these axial codes overlap? When comparing the axial codes, one could see how robot therapists and robots running medical tests are synonymous for robot health care practitioners. These robots were envisioned to help with intensive caregiving, mimicking human caregiving. They are given the term care agents (selective code). Care tools as a selective code, on the contrary, refer to care assistance, and give additional aid for the care receiver for mundane activities. The selective code “social agents” refers to robots that typically serve as companions by functioning as a conversational machine, or a toy that induces some para-social interactions/emotional relief. It is not about merely enhancing older adult’s existing social networks in everyday interactions, rather, it is about creating companionship. Finally, entertainment assistants are social tools (selective code) that enable older adults to enjoy particular activities such as listening to music, or view photo albums. Also social tools enable older adults to connect with their social network. This therefore lead to the establishment of the following selective codes: social tool, social agent, care tool, care agent. Paragraph 12.3 explains this step, i.e. going from axial codes to selective codes, in more detail.

7. The final step entails testing this categorization, i.e. social tool, social agent, care tool, care agent. It required re-reading all publications again, with the aim to understand if there are any anomalies, or if the categorization itself needed to be revised. Besides an occasional miscategorization (i.e. negative cases), the developed categorization generally fit. However, all the ambiguous cases were subject to further analysis, as also discussed in paragraph 12.4. To give an example of a publication that is difficult to categorize: Heerink et al. (2006) mention the following:

> "After a short introduction by one of the researchers the robot told them what its possibilities were: an interface to domestic applications, monitoring, companionship, information providing, agenda-keeping and memorizing medication times and dates. They were told that for today's experiment, the robot was only programmed to perform three tasks: setting an alarm, give directions to the nearest supermarket and giving the weather forecast for tomorrow" [Heerink, 2006, p. 523].

This was initially labeled as social tool, but then relabeled as care tool. After all, it does not give the impression of being a very entertaining device, if it is able to e.g. set an alarm. However, in their later study, they mention that in addition their robot is able to make jokes, indicating a more social device:

> "It could be used for information and for fun: the participants could ask for weather forecast, a television program overview or a joke by pressing the appropriate choices from a menu on the screen" [Heerink et al., 2008, p. 36].

This means that the categorizations are ideal types and interpretively flexible, as also explained in paragraph 12.4.

8. In the last step, I was confident to make theoretical statements about how to use the conceptual framework and typologies. The theory developed about communicative dominance is derived from the idea of agents/tools: tools imply different user/machine roles, compared with agents. The social/care distinction exemplifies how robots cannot "do it all". In other words, the these conclusions are based on a reflection of the empirical results. However, the ambiguous cases also show issues that prevent these conclusions from being a solid theory. Therefore, the relationship between the empirically derived categorization (i.e. social/care and tool/agent) and the ambiguous cases needed to be revisited. This is done, by analyzing what all ambiguous cases have in common. These steps are explained in paragraph 12.4.

12.2. Examples of open codes and axial codes

In order to understand how raw data (i.e. open codes), which are in this case are literal quotations, translate into axial codes, all axial codes are listed with examples. What follows are lists of open codes. Each paragraph ends with an explanation of how they fit the axial code.

12.2.1. Care assistant

> "In the following paragraphs, we will refer to the following scenario: the gyroscope and the accelerometer data suggest that the user, Emma, is walking; the GPS receiver specifies that she is in Italia Road, Genova; the image acquired by the camera shows a line of suburban houses, the side-walk and the left side of the street; the microphone has just acquired the sentence 'It's 6 p.m., I have to go home.' (...) The robot acquires from sensors data useful information about user requests, status and preferences and about the context. In our scenario, an analysis of the sensor data gives the robot context awareness (Emma is walking toward home) and allow for learning of her habits and preferences (Emma is usually at home before 7 p.m.; Emma likes to walk). On-line information allows for the update of the knowledge bases containing, respectively, the knowledge representation system (task "walking home" is characterized by an initial time in

the late afternoon, the user walking for a number of minutes in between 5 and 20 and the final location of the user to be 7 Saracco Street, Genova) and the user habits and preferences, defined in accordance with knowledge representation principles (when at the park of Italia Road, Emma usually leaves around 6 p.m. and likes to walk toward home). On the basis of the context and the knowledge bases, the robot determines the assistive task to be executed (make sure that Emma gets home by providing her with the proper sequence of directions) and subsequently plans the list of suggestions to be provided in output, as spoken messages in the user natural language" [Bruno et al., 2013, pp. 770-771].

"After a short introduction by one of the researchers the robot told them what its possibilities were: an interface to domestic applications, monitoring, companionship, information providing, agenda-keeping and memorizing medication times and dates. They were told that for today's experiment, the robot was only programmed to perform three tasks: setting an alarm, give directions to the nearest supermarket and giving the weather forecast for tomorrow" [Heerink, 2006, p. 523].

"This paper presents first results of a long-term field trial in real private homes with prototype 2 (PT2) of an autonomous mobile social service robot called HOBBIT (see Fig. 1). Its main goal was to provide a feeling of safety (e.g. by fall detection) and to support the users in some tasks of daily living (e.g. pick-up objects from the floor/fall detection). (…) It provided entertainment (radio, music, audio- books, games, preinstalled web services, fitness function), reminders, phone service, control of a manipulator, access to an Ambient

Assisted Living (AAL) environment (e.g. call buttons), and emergency call features. The robot's functionalities included automatic emergency detection (e.g. patrolling and detecting persons lying on the floor), handling emergencies (communication with relatives), and supportive fall prevention measures (transporting small items, picking up objects from the floor, searching for objects the robot had been taught by the user)" [Pripfl et al., 2016, pp 497-498].

"Advanced approach to support daily life activities of elderly people consists of creating a living environment supported by different technologies including wireless sensor networks and service robot(s). The elderly and people with disabilities tend to have difficulty in performing basic daily activities. Adjusting the physical environment (ambient) to make space more comfortable and ergonomic is not enough. It is necessary to set up an informational structured environment to enhance benefits of different technologies to be applied. Such systems represent adaptive systems, where the context is customizable, and adjustment is done by integrating circuitry in an intelligent system. In other words, living or working space for people turns into an intelligent environment - the smart house [8]. The robot is actually just part of the system (Fig. 5), which includes a kind of smart home aspect to it, with environmental sensors around the house feeding back information about the inhabitant's movements, movement objects, and physiological sensors to track their health. Motion sensors track if someone is in a certain room, while pressure sensors under beds and sofas can tell if someone is sitting down. There are also sensors that are activated when certain appliances are plugged in, and sensors that monitor when doors and windows are

> open or closed, temperature and humidity trackers, etc. Also, there are wearable body devices (Fig. 5) that measure blood pressure, heart pulse, motion acceleration and so on. All of the data from the sensors is stored in the database. Based on this information we can extract some activities, like if the person is sleeping or the person got up during the night, the person is watching television or cooking, the person is anxious or calm, etc. The care robot, which is not autonomous, complements these tasks by allowing virtual visits from friends, family, and healthcare professionals. It's basically the equivalent of Skype on wheels. The user calls the robot and is able to direct it around the home to check in on the inhabitant. It's intended to make visits easier for those who aren't immediately at hand. Care robot on command is able to find and bring own objects required by patient(s), bring medicaments, meal or drinks. Based on RGB-D camera robot observes elderly gestures (body gestures as well face mime) and deliver information acquired to the cloud system [9, 10] (Fig. 6). The robot, devices and sensors put and used together create a 24 hours monitoring system that demonstrates quite how machines can outperform us in roles that are traditionally considered inherently human, like looking after loved ones" [Rodić et al., 2016, p. 239-240].

What can be observed here, is that there are robots that help with basic daily activities (e.g. medication reminders, weather prediction, vital sign measurements, remote communication) sometimes incorporated with smart housing. They basically function as assistants for everyday living.

12.2.2. Running medical tests

> "PROMs are regularly acquired by healthcare professionals through administering questionnaires to patients. (...) We used relevant values for supporting patients in the hospital context (i.e., helpfulness, cheerfulness, politeness, responsibility, intellect and logic) to derive the interaction design requirements. Next we selected 15 questions on wellbeing, malnutrition, pain, sleep, and ability to perform certain activities of daily living from existing PROMs. The question types included dichotomous and polytomous items, linear scales, visual analogue scales, and asking for texts, numbers or dates. Robot arm motions were used that support a question and answering (Q&A) interaction, such as spreading your arms low with hands palms up" [Boumans et al., 2018, p. 73].

One can see that this is about robots running medical tests. But before permanently assigning this as a code to the text, other quotations need to be read in order to make sense of this:

> "This paper presents the EACare project, an ambitious multidisciplinary collaboration with the aim to develop an embodied system, capable of carrying out neuropsychological tests to detect early signs of dementia, e.g., due to Alzheimer's disease (…) a user- and caregiver-friendly embodied agent that carries out established neuropsychological tests. This includes the development of an adaptive and sustainable dialogue system, with elements of gamification that encourages the subject to carry out the tests as effectively as possible (Section 5) (...) We will in this project implement clinical neuropsychological assessments

> with the Furhat system (Section 3). The Furhat agent will take the clinician's role, supervising and driving the test procedure. The assessments with Furhat will take place in the user's home and complement the regular assessments at the memory clinic. (…) We employ the Furhat system to implement the Montreal Cognitive Assessment test (MoCA). The intent is replicate the typical interaction between patient and clinician during the administration of the test, with the robot acting as the clinician. In order to rapidly get feedback from participants, a Wizard of Oz [7] prototype has been developed where participants can interact with the embodied agent" [Jonell et al., 2017, pp. 1-2,5].

When seeing this repeatedly, one could say that some robots are developed to become a health administrator in order to run medical tests. To give another example:

> "This paper aims to develop a robotic platform which conducts cognitive orientation assessments for the elderly people. The robot asks questions based on time, space and memory recall, and analyzes the voice response from the user. (…) The proposed system is capable of automatically evaluating answers given by the patient during cognitive assessment sessions, generating a score and saving it for further analysis by a physician or caregiver. (...) For this work, in order to assess the orientation to time, place, recall and attention in our cognitive assessment, the following 9 questions were devised: 1) What month is this? 2) What is the capital of your state? 3) What year is this? 4) What is the time now? 5) What is the current season? 6) What day of the week is this? 7) Which state are you living in? 8) Which city are you living in? 9) Count back from 10 to 1" [Fernandes et al., 2017, abstract; introduction, para. 4; results, para. 1].

12.2.3. Robot therapist

> “Given the reasons specified in the previous section, the final aim of the current study involves designing a robot that works as a walking trainer for elderly individuals. Training refers to the double task of motivating a user to walk more and to assisting him/her. (…) During the preparation phase, the robot and the experimental environment were introduced to the participants. The participants were clearly told that they could walk once without the robot and once with the robot (Figure 3). In the second case, they could choose the preferred position either side-by-side by keeping the robot at their right (1) or their left (5), or behind Pepper by keeping the robot at their front-right (2), at their front (3) or at their front-left (4). Figure 4 shows the relative position of the user with respect to the robot. In all five cases, Pepper looked at an individual’s eyes. The case of the robot following the user from behind was discarded because it was considered that elderly individuals must always look in front of them while walking due to safety reason. All the subjects signed the informed consent form and agreed to the video recording prior to participating in the experiment. A Wizard of Oz approach was preferred due to the hardware limitations of the current robot i.e., its inability to keep tracking the human user’s position and measuring the gait data in real time. In the study, the robot moves and speaks based on the actions of elderly individuals” [Piezzo & Suzuki, 2017, p. 3, 8].

Piezzo and Suzuki (2017) include a table in their publication, which unfortunately cannot be reproduced in this study due to copyright issues, which show examples of conversational dialogues between users and robots.

"The main, general objective of this project is to design and develop a complete robotic agent, using a LEGO NXT Mindstorms kit and an iPod Touch as its interface, so that it performs physical and mental rehabilitation activities for elder people to maintain their healthy life habits and, as a final result, improve their quality of life and prevent major risks such as falls, physical weaknesses or mental disorders. (...) ALECSA is prepared to deliver basic coaching for physical rehabilitation as proposed by the client, the staff of La Misericordia" [Pérez et al., 2015, pp. 351-352, 356].

"The main goal of this work is to improve and maintain gait through the use of the Rhythmic Auditory Stimulation (RAS) methodology combined with the robot's social behavior. Based on our previous work and pilot studies, we expect the appearance and behavior of the robot to serve as an additional motivating factor to keep users interested and invested in the rehabilitation activity (Tapus et al. 2008).(...) Based on the FIM responses and evaluation by health professionals, we will determine the chief deficiencies in the user's gait, and in turn, the characteristics we will seek to improve during the remaining sessions. (...) In order to verify the improvement level, a baseline for the gait will be calculated in the first of the twelve sessions. In this baseline session, the participant will be asked to walk on a path of 18 meters, with no robot present. The first 3 meters will be considered as warm-up, and the final 15 will be used for analysis. The parameters that are recorded during the baseline session are the following: cadence, velocity, and stride length. These parameters are measured by using the motion capture device worn by the participant on the lower legs. (...) The

> participants in the RLT group will interact with the human-like robot (see Figure 1). During the experiment the robot will ask the participant to walk for a distance of 18 meters in a straight line. A line will be drawn on the floor. The robot will modify and adapt its behavior so as to maximize the user's cadence and velocity. Three parameters will be used to define the robot's behavior and will be adapted by using the Policy Gradient Reinforcement Learning (PGRL) algorithm (Tapus et al. 2008). These parameters are: personality style (encouraging ('I'm not doing much to help! Great job!') vs. nurturing ('You are doing better today.')), speed and amount of movement, and music played. The music played parameter has three sub-conditions, consisting of: (1) rhythmic cues (based on user's cadence and velocity) embedded in the music, (2) rhythmic cues (based on the user's cadence and velocity) provided by an electronic metronome, and (3) no auditory stimuli. Music selection will be based on the participant's musical preference. Two recordings will be created for each participant, based on his/her cadence – these recordings will be: (1) with music and audible rhythmic beats; and (2) with metronome beats alone. The volume of the music and the robot's voice will be set at a high, yet comfortable level as determined by the nurses. The robot will be facing the participant and will move backwards (away from the user), at 1.5 meters" [Tapus et al., 2008, Experimental Design, para. 1-3].

What all the open codes exemplify is how the robot therapist instructs the older user what to do in terms of for instance physical training. There is overlap found between the open codes in terms of robots instructing the user what to do albeit with encouragement. The aim is to improve the physical/cognitive wellbeing of the older adult. In the data, there were also examples found of the robot requesting the user to tell the robot what physical exercises to do, which was taken note of in the excel sheet, since this means that not always do robots instruct users in a uni-directional manner.

12.2.4. Entertainment assistant

> "The robot focuses on assisting residents with two activities: 1) the group recreational activity of Bingo, and 2) the one-on-one telepresence activity between the residents and their family and friends. Tangy is capable of autonomously: 1) planning and scheduling these activities based on the schedules of the residents, and 2) facilitating and promoting engagement in these activities" [Louie et al., 2014, p. 238].

> "Two applications related to social engagement and healthy living are described. (…) A large majority of elderly wanted Matilda to participate in group activities and play games like Hoy (see Figure 3). Matilda's ability to mix calling of numbers with gestures (nod), expressions, music and dance brought in more variety, enthusiasm and wider range of social interaction among the elderly. (…) The diet improvement dialog system is based on trans-theoretical model of behavior change suggested by [8] and adopted by health practitioners" [Khosla et al., 2012, p. 1174].

> "It could be used for information and for fun: the participants could ask for weather forecast, a television program overview or a joke by pressing the appropriate choices from a menu on the screen" [Heerink et al., 2008, p. 36].

> "The RAPP project aims to offer RApps that will assist older adults in their daily life activities such as communicating with friends and family, being informed and up to date with regional and international news, getting updates on the weather conditions and weather forecasts, ensuring their safety with hazard detection, practicing their cognitive skills with games that exercise attention and memory and supporting their rehabilitation after hip fracture with physical exercises" [Reppou et al., 2016, p. 549].

Similar to care assistants, these robots have an amalgamation of features, but in this case focus also especially on entertainment: telling jokes, playing music and games, telling the news etc. instead of for instance measuring vital signs or detecting falls, thereby forming the axial code entertainment assistant, rather than care assistant. However, it should be noted that robots are able to mix types as the example of Khosla et al. (2012) shows with the diet improvement system, which could be seen as a more "care" related domain than "social".

12.2.5. Social networking robots

> "Therefore, we propose a Social Media Intermediation Robot which can be used for the interactive communication between elderly people and younger generation via existing social media like Twitter or Google Calendar [5][6]. We implemented this proposed system on a single board computer embedded in a human-type robot, which is equipped with a microphone, camera, speaker, sensors and network access function. Elderly people can retrieve and transmit information by voice via social media only by simple finger operation like touching a part of the

> robot body. At the younger generation side, they can communicate with elderly people at any time through their accustomed social media using smart phones without special manner. (…) We used Twitter and YouTube, and Google Calendar as social media of external cloud-based services" [Kobayashi et al., 2017, p. 31].

> "Using a case study design [13] to allow individuals, practices and the *Giraff* experience to be described over time, this study aimed to gather initial pilot data to explore the feasibility of using the *Giraff* in nursing home care to encourage communication between family living in the community and the person with dementia. (...) The experiences of the *Giraff* were explored through video observation of the family-resident communication and semi-structured interviews with individual members of each dementia triad" [Moyle et al., 2013, p. 611].

> "This paper presents the development of WOBOT, which is a hybrid telepresence and companionship robot that offers interactive communication through video conferencing and tele-operated facial expressions, body motions, and built-in autonomous reactions. (...) The remote user manipulates WOBOT through the user interface on a smart phone/tablet/PC to show cartoon-like facial expressions and body motions while video conferencing with the local user, the older adult staying with the robot in their home environment" [Sebastian et al., 2014, p. 278].

What all these codes have in common, is that the main purpose of these robots is to connect older adults with geographically distant others. They allow the older adults to maintain their social network. This could be done via existing social networking sites, as the code of Kobayashi et al. (2017) illustrates, but it could also be done via videocalling.

12.2.6. Therapeutic robot toys

> "As CuDDler is a companion robot designed to interact and respond to touch, participants were asked to freely interact with CuDDler. (…) The facilitator ensured each participant was directly in front of CuDDler and asked them to touch and speak with CuDDler so that they could see CuDDler's response. 1. *Introduction* Each session involved an introduction to CuDDler and a discovery element including a review of CuDDler's emotions, social interaction, and closure. During the introduction CuDDler was introduced to each participant with a statement of 'Hello participant. This is CuDDler. CuDDLer is a robotic bear. Would you like to get to know CuDDler?' 2. *Discovery* This was followed by the opportunity for discovery, whereby the participant was encouraged to touch and interact with CuDDler and to explore CuDDler's emotions. Where a participant seemed unsure or unable to touch or speak to CuDDler the facilitator assisted CuDDler's reaction by helping the participant to touch CuDDler. Participants were encouraged to follow CuDDler's movements and to watch CuDDler's eyes when they spoke to CuDDler. 3. *Engagement* The facilitator then further engaged each participant with CuDDler through the use of the following questions: What does CuDDler remind you of? What would you like to do with CuDDler? Would you like the facility to have a CuDDler? Do you like the feel of CuDDler's fur? What is good about CuDDler? What is not so good about CuDDler? 4. *Closure* At the end of the session the facilitator thanked the participant for their participation

and informed them that CuDDler would be back later in the week" [Moyle et al., 2016, pp. 147-148].

"The robot-assisted therapy lasted for 30 minutes and was led by a trained nurse, who acted as a facilitator to assist in the interaction. The participants interacted with the Paro in a group setting in an activity room of the facility in the afternoon. (…) The participants took turn and were encouraged to interact with the Paro by talking, touching, and stroking. The facilitator provided some cues and questions to encourage the participant to talk to the Paro if the participant was not active to talk to the Paro. At the end of each session, the participants were also asked to take turn to clean the Paro with towels" [Sung et al., 2015, pp. 2-3].

"The PARO therapy will be delivered in a structured, small-group approach, in which a group of three to four subjects will be arranged to sit around a table with PARO in the centre. (…) The PARO therapy is based upon a standardised framework, and involves activities around the concepts of engaging, social interaction, and communication. There are six stages/themes, including (1) introducing PARO, (2) baby-sitting PARO, (3) grooming PARO, (4) feeding PARO, (5) making over PARO, and (6) wardrobe PARO. During each session, the facilitator will show PARO to each subject and demonstrate how PARO responds. Subjects will be encouraged to touch and hold PARO, describe the features and appearance of PARO, and help take care of PARO" [Yu et al., 2015, Intervention group, Para. 2-3].

> "The study was conducted in nursing homes and followed a repeated measurement design with two playful activities as experimental conditions: a game-based cognitive stimulation, and a robot-based free play (…) For what regards the robot play, we left participants free to interact with the robot, Pleo (Figure 2), and gave facilitators a script with a list of activities to be introduced in case the interaction faded (*call Pleo, make Pleo sleep, feed Pleo, dress Pleo, stroke Pleo, heal Pleo*)" [Perugia et al., 2017b, pp. 1249-1250].

What all these codes have in common is play, much like toys although in a therapeutic context.

12.2.7. Conversational robots

> "To build a coherent and engaging conversational agent, social dialogue is essential. An autonomous robot with clever perceptual analysis is more engaging for the user. Furthermore, it may lead to personalize relationship with the user. Empathy may help a lot in the analysis and decision of answer tasks. The purpose of JOKER (JOKe and Empathy of a Robot) project is to give a robot such a capability, as well as humor. (...) They carried out three experimental sessions within the same context. In the first session, the Humor system was a Wizard of Oz (totally operated by a human experimenter) with Nao. The experimenter provided a part of the inputs manually (emotion detection). In the second and third ones, all the system was autonomous. The authors used pepper. (...) The tested scenarios relate to possible daily life interactions between the robot companion and an elderly person. Emotions: A first scenario consists in asking

the user to mimic chosen emotions while speaking. Pepper asked the user to imitate the four emotions it can detect: Joy, Sadness, Anger, Neutral. (...) Jokes/Riddles: Pepper can make several riddles and puns. For instance: - Question: ‘What is a cow making while closing its eyes?’ Answer: ‘Concentrated milk!’ – Question: ‘How do we call a dog without legs?’ Answer: ‘We do not call it, we pick it up.’ (...) Persuasion/Negotiation: The robot as a companion has to take care of the user showing initiative. In this experiment, Pepper tried to convince old people to drink a glass of water. (...) Cultural Quiz: The robot makes the user listen to extract of music or movies, and asks the user to recognize the singer or actor, or the name of the song or the movie” [Bechade et al., 2017, pp. 89-90, 92, 94]

“This paper presents the results of a pilot study on using eBear, a perceptive and expressive animal-like robot equipped with artificial intelligence in assisting the elderly people with depression. The main motivation behind this study was to investigate how social robots can become companions of elderly individuals with depression and improve their mood and increase their happiness and well-being. eBear can show facial expressions and head gestures, can understand a user’s emotion using audio-video sensory inputs and machine learning, can speak and show relatively accurate visual speech, and make dialog with users. It also responds to the user’s questions by querying the Internet and even encourage them to physically be more active and even perform simple physical exercises. (…) Each session, the eBear started with greetings followed by the face scale quiz. The face scale quiz was performed at the end of each session as well. After the face scale quiz, he/she would continue an open conversation with the eBear on whatever subject he/she prefer. The conversations were mostly about their daily lives at the facility and their plans for the rest of the day. In middle of the conversation, the eBear prompted the subject to start one of the programs that were integrated into the eBear including performing a physical activity, watching a short video, playing games, and the open conversation. The subject could refuse to perform any of the programs at any time during the sessions. The eBear would prompt one or two of the programs randomly during each session to decrease the chance of being perceived as boring. The operator could also choose any of the programs at any time. Each resident was told to ask for help at anytime during each session if they needed it" [Kargar & Mahoor. 2017, pp. 757, 759].

"The robot offered a greeting task on a certain spot in the lobby twice a day. It addressed by-passers asking if they liked to interact with it via voice output. Due to the robot not having a speech-recognition system, interested persons could click through some information about the robot and the research project on the screen. Additionally, the robot read out aloud the visible text" [Hebesberger et al., 2017, p. 419].

"We illustrate actual profiling cases using the proposed dialog-based user modeling frameworks" [Sakamoto et al., 2016, p.65].

The latter quote by Sakamoto et al. (2016) is illustrated in their figures in their publication, which unfortunately cannot be reproduced in this study due to copyright issues. Those figures show examples of conversational dialogues between users and robots.

Nonetheless, what still can be observed with the mentioned citations, is that all robots were imagined to be conversational partners. It was not just speech to achieve some type of activity, e.g. a robot saying verbally that a user should take his/her medication, rather, the aim is to provide conversation for the sake of having a conversation. The open codes also show that some conversational agents are more or less intense in their conversational aims, this is clear when for instance comparing the greeting robot in a care facility of Hebersberger et al. (2017), while other robots are envisioned to alleviate depression (Kargar & Mahoor, 2017). Again, one can see overlap between some codes, as Kargar and Mahoor (2017) e.g. also envision the robot doing physical exercises with their users, much like a robot therapist.

12.3. Axial codes and selective codes

When looking at the summaries provided under each axial code, one can see relational overlap between some axial codes. In essence, the step of axial codes to selective codes is another way to reduce complexity/data. For instance the care assistants, entertainment assistants, and social networking robots are focused on mundane activities. While these codes might be slightly different in their focus, e.g. the care assistants are occupied with pragmatic features, while the entertainment assistants provide elements of fun and play, while the social networking robots enable older adults to connect with their social network, they all are additional aids in chores or social activities. They are therefore labelled as tools. Their difference in connectivity/pragmatic features leads to the distinction social/care.

Furthermore, one can see that the therapists, robots running medical tests, toys and conversational robots do more than merely aiding in mundane activities. These activities are more intervening in nature. These robots function as replacements for physicians, therapists, or social companions and enable activities such as physical therapy, health related tests, and play based therapy or conversations. They are not merely mediators or tools in a toolbox, rather, they are supposed to act as biologically inspired entities. These types of robots are therefore called agents. Bearing all this in mind, the selective codes empirically derived in this dissertation are: social tools, social agents, care tools, care agents.

12.4. Theory

When reflecting on the two social dimensions, one can observe that the tools require different roles from the users than the agents. Some robots are more intervening and others are more mundane, meaning, their presence in relation to the users are different. One could interpret this along the lines of agency and dominance, as the input of the machines/users are different depending on the robot category: tool or agent. Secondly, the mere difference in terms of social and pragmatic activities indicates that robots cannot "do it all". This could say something about standardization processes of care work: it allocates certain tasks still to human caregiving, since holistic care is seemingly not possible based on the findings of the current literature.

However, before confirming this idea, all ambiguous cases need to be looked at, to understand nuance in the theory. This has to do with differences within and across cases in the dataset. This within and across case variance lead to the establishment of two further concepts: robot versatility and interpretative flexibility (although the latter concept is not a new one, as in the literature it already has been established by Pinch and Bijker, 1984). Taken the two together, flexible essentialism as a theory is established. The steps taken towards these concepts and the main theory are explained next.

12.4.1. Differences within cases

Within case variance refers to the same case of a robot as described by one publication, which has more than one meaning in the care/social or tool/agent dichotomy. This within-case variance was found in two ways. First, the general description of *activities* were found to be applicable across social agent, social tool, care agent, care tool categorizations. Second, the description of the *agency* of the robot was challenged when in-use (i.e. situational deviations). Both types are explained with examples.

Concerning within-case variance that mixed activities, an example can be found in the study Peri et al. (2016). They mention that their two robots (they did not mention the name of the robots) were able to perform multiple activities:

> “Two types of robot, one chest height and one head height, were stationed in resident lounges for a period of 12 weeks. The functionalities of the robots were the same regardless of size of robot and included: entertainment – music videos, old-time photos, quotes, jokes; brain fitness – questions; communication – Skype calls to preprogrammed contacts; vital signs – blood pressure, pulse and pulse oxymetry” [Peri et al., 2016, p. E2].

This illustrates that the robots in their activities were sometimes crossing the line between social/care: the same robot is able to help with checking vital signs, but is also able to provide entertainment. The same mechanism was also found for the tool/agent analogy, as the example of Khosla et al. (2013) indicates. The robot is supposed to sing and dance, tell jokes, reading books, reading the news, skype, reminders etc. much like a tool, but the authors also incorporate another type of activity:

> “We had four residents (two females and two males) who volunteered to be a part of diet suggestion interaction with Matilda for healthy eating and living” [Khosla et al., 2013, p. 46].

A robot as a dietary coach was typically classified as an agent in this dissertation, since it requires a more interventionist approach coming from the robot (i.e. changing a diet), rather than helping with mundane activities such as medication reminders, or reading the news.

The other type of within-case variance found, refers to how agency derived from the tool/agent analogy gets challenged in context. The tool/agent and care/social analogy are derived from quotations that describe robot activities – i.e. mundane vs intervention, and pragmatic vs pleasure. However, the tool/agent dichotomy also invokes understandings of agency: a tool is mute and an agent is dominant. Although interrelated, a tool/agent analogy based on activities does not always correspond with assumed agency. As the codebook was constructed with quotations, axial codes, and selective codes, in relation to activities, notes were taken about where the assumed agency of tools/agents were challenged.

For instance, in the case of Paro, this robot is described in the literature as a technology that is able to give play based therapy and is able to act as a companion, i.e. an agent. However, in its interpretation, the literature sometimes treated Paro as a stimulus for human-to-human communication. To give an example:

> "Thus we wanted to explore the Paro as an impetus to conversation and interaction in a group. (…) We created a placebo versus interactive robot comparison in order to measure whether robotic interactions generated more social activity" [Kidd et al., 2006, p. 3973].

Therefore, the "agent" is reduced to a trigger of some sort, instead of being the sole provider of companionship. Paro's agency might therefore be differently interpreted than the terminology "agent" might invoke when looking "objectively" at the activities this robot is supposed to provide.

All within-case differences of machine agency were tracked in the codebook. To visually illustrate how they were tracked: column K in the screenshot images 2-5 relate to all cases that refer to within-case variance about agency. If it is noted "Ja", it means that while the activities of the robot might be "objectively" interpreted as a tool or an agent based on activity, the agent/tool behavior is interpreted differently by the authors of the sampled publications. If a "Ja" appears in column N or Q in images 2-5, it refers to within-case differences as based on activity.

These findings in column K show interpretative flexibility: just because a robot is envisioned to have certain tool or agent like functions, it does not mean that its agency is interpreted as such. If it is noted "Ja", it means that while the activities of the robot might be "objectively" interpreted as a tool or an agent based on its performed activities, the agential behavior is interpreted differently by the authors of the sampled publications. Since the "Ja" appeared to be distributed evenly across the categorizations social agent, social tool, care agent, care tool (as one can visually see in the screenshots) in column K, it appears that interpretative flexibility could occur irrespective of categorization of robot.

In other words, all robots are prone to interpretative flexibility. Furthermore, this means that communicative dominance can be challenged, and is situational. Inferring communicative dominance from a robot's main functionalities/activities suffices in most cases, but not always as interpretative flexibility shows.

If a "Ja" appears in column N or Q, it refers to differences within-cases in terms of activities. Here is where robot versatility comes in, as is explained next.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Year of Pu	Authors	Title	DOI/URL	robot	Waarom e	Experimer	Waarom e	Terminolc	Agency	Mix agenc	Bewijs	Note	Mix activi	bewijs	note	Mix activi	bewijs	note				
2006	Wada, Shi	Living wit	10.1109/I	Paro	Caregivers	ja	we propo:	free play														
2005	Wada, Shi	Psycholog	10.1109/I	Paro	We have a	ja	We have	free play														
2004	Wada, Shi	Psychological and sc		Paro	We have a	ja	We have	free play														
2006	Kidd, Tagg	A Sociabl	10.1109/I	Paro	If the parc	ja		free play	entitiy as	ja	We wante	robot stimulus										
2003	Wada, Shi	Psycholo	10.1109/I	Paro	We applie	ja	seal robot	free play														
2015	Sung, Cha	Robot-ass	https://dc	Paro	The robot	ja	paro can r	moderated/structured play														
2014	Yu, Woo, I	Feasibility	10.4017/	Paro	The interv	ja		free play														
2015	Neven, Le	Beyond determinism		Paro			In contrac	play (ethographic fieldwork)														
2016	Moyle, Jo	What Effe	10.1007/	CuDDler	As cuddle	ja	Cuddler m	moderated/structured play														
2012	Roger, Gu	Social con	10.1017/	Paro	The reside	ja	Paro resp	play interaction														
2013	Moyle, Jo	Social rob	10.1109/I	Paro + Gir	The interv	ja		moderated/structured play														
2015	Pfadenhau	Robot Car	10.1007/	Paro			page 394	companionship robot/ethnographic fieldwork														
2015	Yu, Hui, Le	Use of a T	10.2196/	Paro	The paro t	ja	Paro is a t	moderated/structured play														
2017	Perugia, R	Electrode	10.1109/I	Pleo	They stud	ja	Pleo is an	free play, analogy children														
2017	Perugia, D	Modelling	10.1109/I	Pleo	The study	ja	Pleo is an	free play, analogy children														
2012	Louie, Mc	Playing a	10.1109/I	Brian2.1	For robot	ja	In this pap	play (memory game/cognition)														
2016	Lane, Nor	Effectiven	10.1037/	Paro	For the pu	ja	The paro i	play														
2018	Moyle, Br	Care staff	https://dc	Paro	This quali	ja	Whilst a r	toy/play comparison														
2017	Kargar, M	A pilot stu	10.1109/I	eBear	Each sessi	ja	This pape	conversational					ja	IN the mic	social too	ja	IN the mic	social tool/care entity (WoZ (not automated)				
2017	Hebesber	A Long-Te	10.1007/	Scitos	The robot	ja	The objkie	greeting robot/conversational														
2017	Baisch, Kc	Acceptanc	10.1007/	Paro/Gira	The introc	ja	Mimicking	free play	entitiy as	ja	In additic	robot stimulus										
2014	Stafford, I	Older Peo	10.1007/	peoplebot	Potential	ja	During the	conversational														
2003	Wada. Shi	Psycholog	10.1109/	paro	We have a	ja	Paro has a	free play														
2007	Wada, Shi	Social Effe	10.1109/I	paro	Robot the	ja	Ubiquitou	free play	entity as s	ja	In this pap	robot stimulus										
2016	Sakamoto	Psychogr	10.1007/	software	We illustr	ja (hypoth	Another s	conversational														
2017	Bechade, I	Towards	10.1007%	nao + pep	To build a	ja		conversational														
2015	Soler, Agü	Social rob	https://dc	Paro + NA	In the pre	ja	Paro - a sc	robot the	therapy tc	ja	In the pre	robot stimulus therapy										
2013	McColl, Lc	Brian 2.1	10.1109/I	Brian 2.1	The goal c	ja	Brian 2.1 (	robot game master (eating coach and memory game)/ instructor								ja	The goal c	care agen	robot dietary coach			

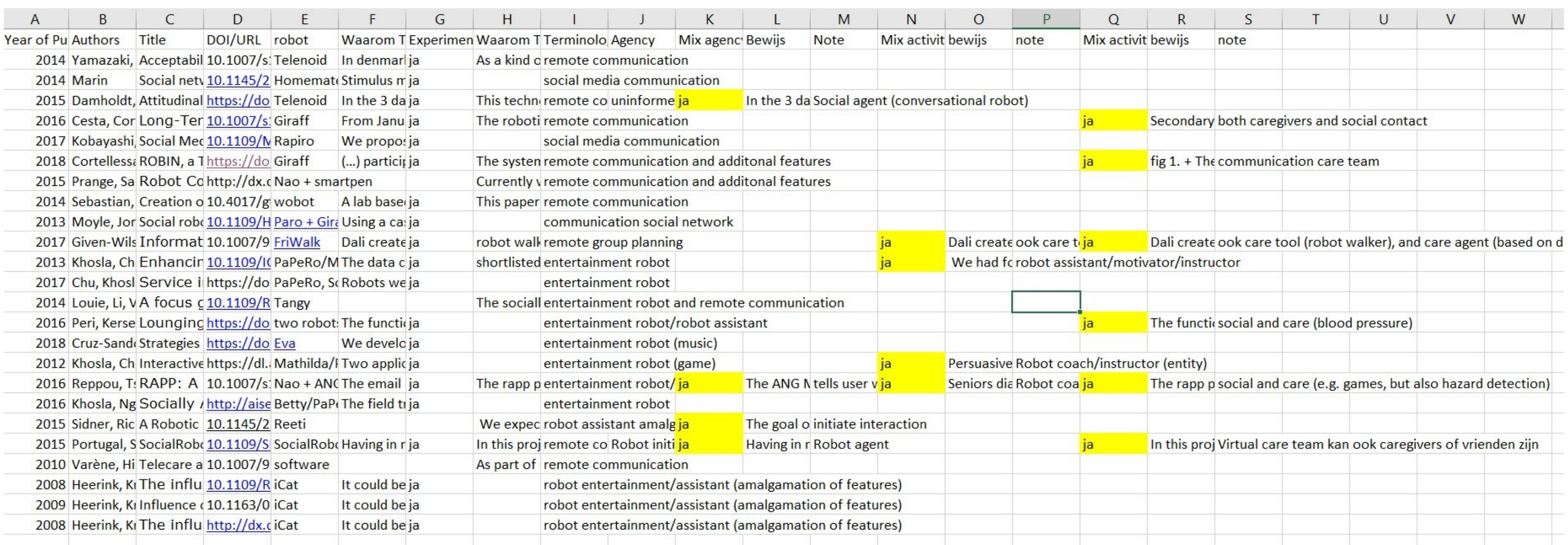
Image 2. Social agent

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Year of Pu	Authors	Title	DOI/URL	robot	Waarom e	Experimen	Waarom e	Terminolo	Agency	Mix agenc	Bewijs	Note	Mix activit	bewijs	note		
2012	Fasola, Ma	Using Soci	10.1109/JI	Bandit	The exerci	ja	To adress	robot instr	robot follc	ja	imitation g	roles reverse					
2012	Fasola, Ma	Socially /	10.1007/9	Bandit	The robot	ja	Our SAr SY	robot instr	robot follc	ja	IN the imit	roles reverse					
2017	Piezzo, Suz	Feasibility	https://do	Pepper	during the	ja	The final a	robot instructor/motivator (gait)									
2018	Boumans,	Proof of (	https://do	Pepper	PROMS are	ja	We progra	robot health administration									
2010	Looije, Ne	Persuasive	https://do	iCat	We aim at	ja	We use th	robot coach/instructor/motivator/persuasive (health guide/diabetes)									
2013	Werner, Kr	Evaluation	10.3233/9	NAO	It was sho	ja	The physic	robot instructor/coach/motivator (exercise)									
2008	Tapus, Wa	Using a S	http://ww	bandit	The main g	ja	The roboti	robot instructor/motivator (gait)									
2008	Tapus, Ma	Socially /	http://ww	bandit	The robot	ja	Tto addess	robot instructor/therapeutic intervention (music therapy)									
2010	Fasola, M	Robot ex	10.1109/R	bandit	Three exer	ja	Tto addess	robot instructor (exer		ja	imitation	roles reversed					
2015	Pérez, Gar	Caregive	10.3233/T	Lego	The main,	ja maar nie	The body i	robot instructor (exercise)									
2017	Fernandes	Cognitive	10.1109/R	ASCC com	This paper	ja	The cognit	robot health administration									
2017	Jonell,Mer	Machine	https://arx	Furrhat	This paper	ja maar nie	The projec	robot health administration									
2012	Azkune, Or	Semantic	https://linl	ACROSS/R	The scenar	ja maar vo	As part of	robot health administration									
2017	Hammer, K	Touch or	http://dx.c	Reeti	After an in	ja		robot coach/ instructor/motivator (excersize, diet, social)									
2010	Klamer, Be	Acceptar	10.4108/I(	Nabaztag	The goal o	ja		robot coach/ instructor/motivator (health and fitness)					ja	Additional	kan ook weerbericht geven		

Image 3. Care agent

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
Year of Pu	Authors	Title	DOI/URL	robot	Waarom T	Experimer	Waarom T	Terminolc	Agency	Mix agenc	Bewijs	Note	Mix activi	bewijs	note	Mix activi	bewijs	note			
2007	Michaud,	Teleprese	http://wv	Telerobot	Potential	ED hebbe	Using the	Robot assistant/ remote monitoring/surveillance													
2017	Baisch, Kc	Acceptanc	10.1007/	Paro/Gira	The introc	ja	The mobil	Robot assistance/remote communication													
2014	Torta, We	Evaluatior	10.1007/	Nao	we impler	ja	The need	robot assi	proactive	ja	Scenario	robot initiates call if needed, robot nurse (agent)									
2014	Stafford,	Does the I	10.1007/	Charlie H	residents	ja	Seven pro	robot assistant (amalgamation of functions)/entertainment/tele robot								ja	Seven pro	both social tool (remote communication,			
2015	Shiomi, Ii	Effectiven	https://d	NEO-PR4	Simple co	ja maar in	We used a	robot assistant (wheelchair)													
2018	Piasek, W	Acceptanc	https://ie	Tiago	The HMI (	ja	ENRICHM	robot assistant (amalgamation of functions)/entert					ja	The HMI (	care agen	ja	The HMI (	social tool (video calling) entertainment (			
2014	Smarr, Mi	Domestic	10.1007/	PR2 (Pers	Participan	ja	The mobil	robot assistant (amalgamation of features)													
2016	Glende, C	Increasing	10.1007/	robot-era			Exemplary	robot assistant (amalgamation of features)													
2017	Draper, Sc	Ethical val	10.1007/	car-o-bot	In the firs	ja		robot assi	proactive	ja	In the firs	dominance van communicatie anders dan functies (agent)									
2016	Bedaf, Dra	Can a Serv	10.1007/	car-o-bot	Marie, wh	ja		robot assi	proactive	ja	Marie, wh	dominance van communicatie anders dan functies (agent)									
2016	Pripfl, Kör	Results of	10.1109/I	HOBBIT	This pape	ja	This pape	Robot assistant and entertainment robot (amalgamation of features)								ja	This pape	social entertainment (books, songs etc)			
2014	Draper, Sc	What aski	10.1.1.67	car-o-bot			ACCOMpa	robot assi	proactive	ja	Scenarios	dominance van communicatie anders dan functies (agent)									
2012	Werner, C	Evaluatior	10.1109/	NAO	Three test	ja	The Ksera	robot assi	proactive	ja	Medical r	robots initiates communication									
2011	Gross, Sch	Progress i	10.1109/I	Compani	Of particu	ja	With a he	robot assistant (fall detection, medication reminders etc)													
2016	Bonaccors	A Cloud R	https://lir	Scitos	In order t	ja	The servic	robot assistant (amalgamation, smart home)													
2013	Bruno, Ma	Functiona	10.1109/I	zelf ontw	In the foll	ja (scenari	Figure 2 s	robot assistant (GPS)													
2016	Rodić, Vuj	Developm	https://lir	no name			The body	robot assistant (amalgamation, smart home)													
2016	Rehm, Kru	From Soci	https://lir	no name	At the sar	ja	For the in	robot assistant (meal reminders)													
2016	Agrigoroa	Developin	10.1109/I	Kompai	The syste	ja	The robot	robot assi	proactive	ja	This use c	robot initiates call if needed (agent)				ja	This use c	social interaction remote			
2017	Zlatintsi, I	Social Hur	http://dx.	Mobot & iSupport			This refer	robot assistant (shower and movement)													
2016	Eftring, Fr	Designing	10.1007/	Hobbit	The aim o	ja	In the fina	robot assistant (fall detection, safety monitor)													
2012	Pino, Grar	Assessing	https://w	Kompai	Participan	ja	Kompai (F	robot assistant (amalgamation of features, online communication, medication rem								ja	Kompai (F	entertainment assistant			
2013	Frennert,	Older Peo	https://lir	hobbit	As a comp	ja		robot assistant (amalgamation - unclear what features are, still in design phase)													
2012	Merten, B	A mobile	https://p	check naam robot			With a he	robot assistant (amalgamation of features, online communication, safety detection/monitoring, medication reminders, games)													
2016	Salichs, E	Study of S	10.1007/	Maggie/zelf ontwer		ED further	The size o	robot assistant (amalgamation of features, remote communication)								ja	taking thi	social/entertainment assistant			
2006	Heerink, K	Th e Influ	10.1109/I	iCat	After a sh	ja		robot assistant (amalgamation of features)													
2009	Heerink, K	Measuring	https://dl	iCat	After a sh	ja		robot assistant (amalgamation of features)													
2016	Bartl, Bos	The Influe	https://lir	Reeti	A potentia	ja		robot assistant (reminder, amalgamation of features)													
2010	Heerink, K	Assessing	10.1007/	iCat	They were	ja		robot assistant (amalgamation of features)													

Image 4. Care tool



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Year of Pu	Authors	Title	DOI/URL	robot	Waarom T	Experimen	Waarom T	Terminolo	Agency	Mix agenc	Bewijs	Note	Mix activit	bewijs	note	Mix activit	bewijs	note				
2014	Yamazaki,	Acceptabil	10.1007/s:	Telenoid	In denmarl	ja	As a kind c	remote communication														
2014	Marin	Social netv	10.1145/2	Homemat	Stimulus m	ja		social media communication														
2015	Damholdt,	Attitudinal	https://do	Telenoid	In the 3 da	ja	This techn	remote co	uninforme	ja	In the 3 da	Social agent (conversational robot)										
2016	Cesta, Cor	Long-Ter	10.1007/s:	Giraff	From Janu	ja	The roboti	remote communication								ja	Secondary	both caregivers and social contact				
2017	Kobayashi,	Social Mec	10.1109/N	Rapiro	We propo:	ja		social media communication														
2018	Cortelless:	ROBIN, a T	https://do	Giraff	(...) partici	ja	The systen	remote communication and additonal features								ja	fig 1. + The	communication care team				
2015	Prange, Sa	Robot Co	http://dx.c	Nao + smartpen			Currently v	remote communication and additonal features														
2014	Sebastian,	Creation o	10.4017/g	wobot	A lab base	ja	This paper	remote communication														
2013	Moyle, Jor	Social robc	10.1109/H	Paro + Gira	Using a ca:	ja		communication social network														
2017	Given-Wils	Informat	10.1007/9	FriWalk	Dali create	ja	robot walk	remote group planning					ja	Dali create	ook care t	ja	Dali create	ook care tool (robot walker), and care agent (based on d				
2013	Khosla, Ch	Enhancir	10.1109/I(	PaPeRo/M	The data c	ja	shortlisted	entertainment robot					ja	We had fc	robot assistant/motivator/instructor							
2017	Chu, Khosl	Service i	https://do	PaPeRo, S	Robots we	ja		entertainment robot														
2014	Louie, Li, V	A focus c	10.1109/R	Tangy			The sociall	entertainment robot and remote communication														
2016	Peri, Kerse	Lounging	https://do	two robot:	The functi	ja		entertainment robot/robot assistant								ja	The functi	social and care (blood pressure)				
2018	Cruz-Sand	Strategies	https://do	Eva	We develc	ja		entertainment robot (music)														
2012	Khosla, Ch	Interactive	https://dl.	Mathilda/I	Two applic	ja		entertainment robot (game)					ja	Persuasive	Robot coach/instructor (entity)							
2016	Reppou, T:	RAPP: A	10.1007/s:	Nao + ANC	The email	ja	The rapp p	entertainment robot/		ja	The ANG N	tells user v	ja	Seniors dia	Robot coa	ja	The rapp p	social and care (e.g. games, but also hazard detection)				
2016	Khosla, Ng	Socially /	http://aise	Betty/PaP	The field t	ja		entertainment robot														
2015	Sidner, Ric	A Robotic	10.1145/2	Reeti			We expec	robot assistant amalg		ja	The goal o	initiate interaction										
2015	Portugal, S	SocialRob	10.1109/S	SocialRob	Having in r	ja	In this proj	remote co	Robot initi	ja	Having in r	Robot agent				ja	In this proj	Virtual care team kan ook caregivers of vrienden zijn				
2010	Varène, Hi	Telecare a	10.1007/9	software			As part of	remote communication														
2008	Heerink, K	The influ	10.1109/R	iCat	It could be	ja		robot entertainment/assistant (amalgamation of features)														
2009	Heerink, K	Influence	10.1163/0	iCat	It could be	ja		robot entertainment/assistant (amalgamation of features)														
2008	Heerink, K	The influ	http://dx.c	iCat	It could be	ja		robot entertainment/assistant (amalgamation of features)														

Image 5. Social tool

When isolating specifically column N and Q in relation to specific robots, one can see the following pattern emerge.

SE	Versatile	Versatile	CE	Versatile	Versatile	ST	Versatile	Versatile	CT	Versatile	Versatile social/care
Paro			Bandit			Telenoid			Telerobot		
Paro			Bandit			Homemate Robot			Giraff		
Paro			Pepper			Telenoid			Nao		
Paro			Pepper			Giraff			Charlie HealthBot		ja
Paro			iCat			Rapiro			NEO-PR45		
Paro			NAO			Giraff			Tiago	ja	ja
Paro			bandit			Nao + smartpen			PR2 (Personal Robot 2)		
Paro			bandit			wobot			robot-era		
CuDDler			bandit			Giraff			car-o-bot		
Paro			Brian 2.1			FriWalk	ja	ja	car-o-bot		
Paro			Lego			PaPeRo/N	ja		HOBBIT		ja
Paro			ASCC companion robot			PaPeRo, Sophie and Jack			car-o-bot		
Paro			Furrhat			Tangy			NAO		
Pleo			ACROSS/Roinbot			two robots, name n		ja	Companiable		
Pleo			Reeti			Eva			Scitos		
Brian2.1		ja	Nabaztag			Mathilda/	ja		zelf ontworpen geen naam		
Paro						Nao + AN(	ja	ja	no name		
Paro						Betty/PaPeRo			no name, zelf ontworpen		
eBear	ja	ja				Reeti			Kompai		ja
Scitos						SocialRobot (SoCoN		ja	Mobot & iSupport		
Paro						software			Hobbit		
peoplebot						iCat			Kompai		ja
paro						iCat			hobbit		
paro						iCat			check naam robot		
no name									Maggie/zelf ontwer		ja
nao + pepper									iCat		
Paro + NAO									iCat		
									Reeti		
									iCat		

Image 6. Differences within cases robot versatility

The yellow cells in image 6 refer to tool and agent activities, whereas the blue cells refer to social and care activities. SE means social entity (agent), CE means care entity (agent), ST is social tool, CT is care tool. This means that if a case is assigned to e.g. social tool but has a blue and/or yellow mark, it could also be ascribed to another category (based on performed activities). In other words, these are ambiguous cases. It therefore does not make sense to try to fit them into a mold, but rather mark them as ambiguous, as this codebook does. The reason why they are still assigned to one of the 4 categories first, and then marked yellow or blue is because of an intuitive categorization, then later was double checked in retrospect.

What is noticeable is that all the robots that are listed here that are ambiguous are multi-purpose robots: they do more than one thing, as compared with single purpose robots perform particular activities such as Paro, Pleo, Mobot, Wobot, iSupport, or NEO-PR45. The reason why they are overrepresented in the tool section, is because tools are typically assistants with an amalgamation of functions. They can measure your vital signs but they can also read books and play games, thereby already crossing the social/care category. This hints towards robot versatility: multi-purpose robots are ambiguous in their meaning compared with single-purpose robots. This latter statement is confirmed after an analysis on cross-case variance.

12.4.2. Differences across cases

There are also differences found across cases. Cross-case differences are interpretations of the same robot across the four different types, social tool, social agent, care tool, care agent, *across different publications*. For instance, iCat was used as a robot to set an alarm or give weather predictions (care tool) in Heerink et al. (2006), whereas Looije et al. (2010) used iCat as a dietary coach (care agent). In order to understand whether the concept of robot versatility has explanatory potential, all robots need to be listed and checked which one's appear in different categorizations (i.e. social tool, social agent, care tool, care agent). When listing all the robots per category, and comparing which robot appears where, the following overview appears (image 7).

SE	CE	ST	CT
nao	nao	Nao	Nao
Pepper	Pepper	Telenoid	care-o-bot
CuDDler	iCat	iCat	iCat
scitos	Bandit	FriWalk	scitos
peoplebot	Lego	Rapiro	mobot
eBear	Furrhat	Homemat	isupport
Brian2.1	ACROSS/R	wobot	NEOPR45
no name	ASCC com	Tangy	Telerobot
Paro	Reeti	Reeti	Reeti
Pleo	Nabaztag	Giraff	Giraff
		2x no nam	Kompai
		PaPeRo	Hobbit
		no name	Maggie
		SocialRob	Robot-era
		eva	no name4x
		ANG	PR2
			Tiago
			Charlie
			Companiable

Image 7. Differences across cases robot versatility

Interestingly, the robots that overlap across cases are all multi-purpose robots as opposed to single purpose robots, except for Giraff. This is because Giraff is a telepresence robot that allows its users to interact with others, irrespective if the secondary users are caregivers or people from their social circles – i.e. the social/care distinction is able to be blurred. This means that some robots travel well across categorizations, while others do not, which most likely has in part to do with the nature of the robot's activities. The more purposes a robot has, the more versatile it is, the more ambiguous it is. This leads to the concept of robot versatility. The concept of interpretative flexibility however also shows, that even for single purpose robots, interpretations of agency inferred might be different than assumed when looking at the mere categorization of agent/tool.

Flexible essentialism is in essence the integration of these two findings: the meaning of a robot is in part related to its essences as robot versatility shows how multi-purpose robots have ambiguous meanings compared with single purpose robots, however this meaning in terms of machine agency is simultaneously situational as the scholars made some very creative interpretations for even single-purpose robots (interpretative flexibility) in terms of agency in HRI.

13. Appendix E: Extra information methods study 2

This appendix is structured in three parts. First, the coding procedure is explained. Then, examples are given of codes and quotations. Then, it is discussed how codes were grouped into themes. It should be noted that study two and study three, although having a starting point in grounded theory, in their analysis are more comparable to thematic analysis than grounded theory. Though also here, the method is highly iterative and circular, and should not be read as a step-by-step linear guideline.

13.1. Coding procedure study 2

1. After conducting grounded theory in study one, it became clear that several rationales were communicated in the literature, as to why social robots in elder care are necessary: costs, care, Quality of Life (QoL). Now, the task is to understand rather deductively understand whether these themes hold true by sampling literal quotations. A new Excel file was created that related quotations of rationales to publications.

2. The quotations were then read and placed in a new Excel sheet with a tab for: staff, money and system, QoL. The same quotation could entail multiple codes, so the same publication could have different arguments for the relevance of social robots in elder care.

3. During this process, i.e. placing quotations in terms of three categories, it appeared that the initial classification needed some more in-depth refinement, as not every quote could have been placed neatly in one of these codes. For “staff and caregiving” and “money and system” quotations this was a rather straightforward procedure. It should be noted, that when placing quotations in “staff and caregiving”, two dimensions were noticed: burdened nurses and shortage of staff. For QoL turned out to be more of a challenge to put quotations into this category. A "rest" category was created in order to have a closer look what those quotations had in common that could not be placed in the pre-formulated themes of QoL, care, and costs.

4. The "rest" category showed two things: 1) sometimes no rationales are given (consisting of publications rooted in solutionism and publications in STS) 2) QoL has several dimensions to it, and is too narrow of a code to include all facets related to it. To illustrate: 1) statements were made about how the increasing number of older adults in a populations in relation to QoL/subjective wellbeing 2) statements were made about aging inherently being problematic to QoL/subjective wellbeing 3) statements were made in relation to wellbeing in general (i.e. not only subjective wellbeing, but also physical, cognitive, mental health etc.). The quotations therefore relate to 1) collective QoL 2) inherent QoL, and 3) health (general). Taking all these three dimension together, "wellbeing" was seen as a theme that could capture the width of these codes.

5. All codes, though most established deductively, needed to be compared to see if they overlapped. This was the case with the three QoL codes as mentioned before, but in addition two of the "no rationale" codes could be merged into one theme "no rationale". The theme "care work" comprises of codes on burdened staff and shortage of staff. Cost containment is both a theme and a code on its own. Paragraph 13.3 elaborates on this process.

6. It was already mentioned that for wellbeing, some publications relate the relevance of social robots in elder care to aging populations. This was found repeatedly across cases, but as is illustrated with the QoL discussion earlier not *all* cases. This means, that it should be mentioned in the main text that aging populations is seen as the heart of many argumentations, but not all.

7. The final task is to put all themes into perspective with additional information about societal developments. Indeed, the purpose of this chapter was to illustrate how technologies do not appear out of thin air. So all these themes were related to e.g. policy reforms, change in care work, and perceptions of older adults and aging. This was done with a non-systematic, yet purposeful literature search in the context of a critical analysis.

13.2. Examples of codes study 2

What follows is an overview of how the quotations turn into codes. It should be noted, that some examples here show multiple rationales, and therefore were then sampled in accordance with *all* their respective codes in the database (although they are not repeated here for the sake of avoiding repetitiveness, and introducing new examples). All emphases are inserted by the author of this dissertation in order to highlight which pieces of text relate to the code.

13.2.1. Cost containment

> "Older people generally prefer to remain in their own homes for as long as possible, and may be reluctant to move to care institutions. *At the same time, at societal level, keeping older people in their homes for as long as possible is desirable: institutionalized care is expensive, and providing good care can be labor-intensive. Promoting independence, then, may reduce calls on services*

provided by the welfare state. Being able to stay in one's own home depends upon one's ability to wash, go to the toilet, prepare and consume food and drinks—in short, to meet one's own needs [1]. The practical problems older people face are person-specific due to variation in age-related loss of abilities and the diversity of their home environments and personal preferences. Self-care, mobility, and interpersonal interaction & relationships are most important for independent living of older people [1]. As older people become frail or disabled their ability to function in these domains diminishes, opening up a space where care must be provided. We will describe this as the 'care-gap', the gap between the abilities one still has to care for oneself, and the abilities that are required for independent living. Traditionally, this gap has been bridged with human care, either informally—by friends and family—or by care professionals. Changing social structures, however, have resulted in family members being less inclined or available to provide care. These changes and the increasing shortage of care staff [2] has led to technology—and more specifically robotics—being given increasing attention. Robots, particularly service robots, have the potential to support care and independence in many ways [3]" [Bedaf et al., 2016, pp. 409-410]

"*The increasing number of elderly people with cognitive disabilities creates higher efforts and costs for care providers and family members. Assistive robot systems could accompany elderly people and help keeping the elderly longer at home to increase their quality of life and to save costs.* However, current robot systems fail to deliver an adequate support of elderly people at acceptable costs.

This paper presents a mobile robot platform for socially assistive care applications that was developed under consideration of functionalities, user acceptance, and costs. (…) The increasing life expectancy leads to an increasing number of elderly people with cognitive disabilities. *At the same time, the costs for the care systems increase, which results in an overall assistance restricted to people with advanced disabilities.* Further, the changed structure of nowadays families and personal living conditions complicate a comprehensive private care by family members. To compensate this leak of personal care, assistive robots could be used to support elderly or mildly disabled persons in their homely environments" [Merten et al., 2012, p. 233].

"As the world's elderly population continues to grow, so does the number of individuals diagnosed with cognitive impairments. It is estimated that 115 million people will have age-related memory loss by 2050 [1]. The number of older adults who have difficulties performing self-care and independent-living activities increases significantly with the prevalence of cognitive impairment. This is especially true for the population over 70 years of age [2]. Cognitive impairment, as a result of dementia, severely affects a person's ability to independently initiate and perform daily activities, as cognitive abilities can be diminished [3]. If a person is incapable of performing these activities, continuous assistance from others is necessary. *In 2010, the total worldwide cost of dementia (including medical, social, and informal care costs) was estimated to be US$604 billion* [1] (…) . There exists an urgent need to further investigate the potential use of cognitive training interventions as a tool to aid the elderly. The goal of our

> research is to advance knowledge in cognitive/social interventions for elderly individuals suffering from cognitive impairments via the development of robotic technology [6], [7]. We aim to design humanlike, socially assistive robots capable of providing cognitive assistance and social interaction in self-maintenance (i.e., eating, dressing, and grooming) and activities of daily living (i.e., cognitively and socially stimulating leisure activities)" [McColl et al., 2013, pp. 74-75].

What all these quotations have in common, is mentioning how expensive elder care is with the rise of aging populations, and the suggestion that robots could enable older people to take care of themselves.

13.2.2. Burdened staff

> "Due to improvement of our living environment, dietary life and progress of medical, we have obtained the longest life in our history [1]. However, in most advanced countries, the number of elderly people who need nursing because of dementia, bedridden, and so on, has been increasing. Then, there are many people who stay in an elderly institution for long time, until the end of their life. *Moreover, nursing staffs body and mental poverty by manpower shortage and increasing of load is becoming a big problem. Especially, mental stress of nursing causes Burnout syndrome [2]. It makes nursing staff into irritation and losing sympathy to patients. Therefore, it is important to improve 'quality of life (QOL)' of elderly people because this helps them to spend their life healthily and independently.* It also saves social cost for elderly people. (…) In this research,

animal type robots that give mental value to human beings are referred to as 'mental commit robot.' We have developed cat robot and seal robot as the mental commit robot" [Wada et al., 2003a, p. 3996].

"*Mental health problems of older adults have been an important issue and care burden for nursing staff and family caregivers*. As older adults age, they may face and experience difficult situations and losses, such as loss of their health and functions, family, friends, and social roles. These situations may force older adults to become depressed and suffer from mental health problems, such as depression and social isolation. Depression is prevalent among older adults and could lead to severe health problems with detrimental impact on their functional status, quality of life, and a poor prognosis (Licht-Strunk *et al*., 2007*). Mental problems of older adults, if left untreated, may have a negative impact on the health and quality of life of both the older adults and the caregivers* (Shibata and Wada, 2011). (...) Animal-assisted therapy (AAT) or robot therapy or robot-assisted therapy, as one approach to CAM, has been suggested as one of non-pharmacological interventions to improve mental and social health for older adults (Colombo *et al*., 2006; Banks *et al*., 2008; Shibata and Wada, 2011)" [Sung et al., 2015, pp. 1-2].

"Due to the steep increase in the number of elderly people in countries as Japan, Italy, and Germany, assisting them has become one of the essential purposes of robotics. (…) *We believe that physical support situations should be aided by such systems because the physical loads are difficult; actually supporting caregivers is another important issue in super-aging societies*" [Shiomi et al., 2015, pp. 1,12].

What all these examples have in common is mentioning that the nature of the job, i.e. caregiving, is discussed as inherently tiring, difficult etc., thereby burdening the staff.

13.2.3. Shortage of staff

> "*An ageing population paired with a shortage of care personnel make alternatives for the everyday support of dependent people increasingly important*. In 2050 there will be 164 million people above 65 in the EU. 31.8 million people over 65 will live alone [3]. Already in 2008, almost 50% of people older than 85 years relied on outside help to live. *With more people getting older, the demand for care is expected to rise to levels, where traditional care cannot cope*. (…) The goal is the development of an assistive-robotic systems and intelligent environments for domestic, condominium and outdoor environments" [Glende et al., 2016, p. 355].

> "*The aging population is increasing the demand for healthcare services worldwide. By the year 2050, the number of people over the age of 85 will increase fivefold, according to recent estimates [1], and the shortfall of nurses is already becoming an issue* [2]–[4]. (…) Among the many healthcare services that will need to be provided, physical exercise therapy, social interaction, and companionship can be addressed by socially assistive robotics technology" [Fasola & Mataric, 2012, p. 2512].

> "The population of the world is aging rapidly. By 2050, it is projected that 2 billion people will be aged 60 and over, more than double what the population is today at 784 million [1]. *This increase in the elderly population is putting a strain*

> *on healthcare systems as elder adults use a disproportionately large portion of the available healthcare services [2]. While the demand for healthcare is increasing, large numbers of healthcare workers who are a part of this aging population are also retiring. The drastic increase in the number of older adults that need care and the decline in the number of healthcare workers could result in the diminishing of the quality of elder care*. This is particularly true for long-term care facilities, where frail older adults that have more complex cognitive and/or physical needs usually live. For these individuals, it is important to provide quality care while also delivering programs that can enhance their independent abilities, increase their social engagement and provide cognitive stimulation" [Louie et al., 2012, p. 345].

All these quotations describe how there will be a shortage of caregivers due to aging demographics.

13.2.4. QoL collective

> "*In 2010, approximately 500,000 Canadians suffered from a dementia-related illness. The number of sufferers is estimated to double in about 25 years. Due to this growing demographic, dementia (most frequently caused by Alzheimer's disease) will increasingly have a significant impact on our aging community and their caregivers. Dementia is associated with challenging behaviours such as agitation, wandering, and aggression. Care providers must find innovative strategies that facilitate the quality of life for this population; moreover, such strategies must value the individual person.* Social commitment robots – designed specifically with

communication and therapeutic purposes – provide one means towards attaining this goal. (…) *Due to a growing senior demographic, dementia – and AD specifically – will become one of the most significant conditions to impact our aging community and their caregivers. Dementia is associated with challenging behaviours such as agitation, wandering, and aggression; consequently, care providers must find innovative strategies to facilitate the quality of life for this population while continuing to value the person*" [Roger et al., 2012, pp. 87-88].

"*With an increasing number of elderly in the population, dementia is expected to increase. Dementia disorders and related illnesses such as depression in the aging population are devastating for the quality of life of the afflicted individuals, their families, and caregivers.* Moreover, the increase in such disorders imply enormous costs for the health sectors of all developed countries" [Jonell et al., 2017, p. 1].

"*Like most of the developed countries, Australia's population is ageing. According to Australia Bureau of statistics, in 1970 there were nearly 1.1 million people (8.3 percent) in Australia over 65. It increased to 3.01 million (13.5 percent) people in 2010. It is estimated that by a steady increase in 2050 around 8.1 million (22.7 percent) of Australian population to be 65 and over [1]. Thus the human element and engagement will be a major problem as number of elderly out-number the number of younger people*. (…) *In order to enhance the emotional well being of the elderly and to contribute to addressing the looming ageing problem*, the authors, in this paper, report on research conducted in three residential care facilities in Australia with low care and high care elderly residents using an effective communication robot called Matilda" [Khosla et al., 2013, p. 41].

> "*Current state and trends on the elderly and their environment in Japan is really serious. According to Annual Report on the Aging Society (2014) issued by Cabinet Office [1], the number of households with elderly people aged 65 and over is increasing. As of 2012, the number was 20.93 million, making up 43.4% of all households (48.17 million). The number of elderly people living alone is on the rise. The increase in elderly people living alone is remarkable among both males and females. The percentage of elderly people living alone against the total population of elderly people was 4.3% for males and 11.2% for females in 1980. However, in 2010, these numbers were 11.1% for males and 20.3% for females. According to this current situation, elderly people watching system has become important.* However, most of the existing elderly people watching services are belonging to the service category of a confirmation of elderly people's safety based on one-way communication from elderly people [2][3][4]. *Therefore, current services are not enough for elderly people who want to have more tight connection with society*. On the other hand, social media like Twitter has already become popular. However, people need to use smart devices like smart phones efficiently to access social media. This matter might be obstacles for elderly people to use social media" [Kobayashi et al., 2017, p. 31].

What these examples have in common, is that they first describe the development of aging populations, and then argue that it is important for older adults to enhance activities that could help them in their quality of life (e.g. social connectivity, valuing personhood etc.).

13.2.5. QoL inherent

"*Both cases shall assist towards independent living for the elderly to improve their life quality*" [Zlatintsi et al., 2017, p. 355].

"Interest in animal assisted interventions (AAI) has grown over the years, but acceptance of AAI by the clinical and research community has been hampered by safety, hygiene, and logistical concerns. Advances in the field of social robotics have provided a promising route to deliver AAI while avoiding these aforementioned obstacles (...) To summarize, there is documented evidence supporting the claim that AAI and, to a lesser degree, *exposure to social robots will tend to increase the incidence of observed positive mood states and behavioral indicators (smiling, verbal engagement, etc.) and will tend to decrease negative mood states and behavioral indicators (sadness, wandering, yelling).* For the purposes of the present study, Paro is conceptualized as a therapeutic tool designed to elicit the same positive physiological, psychological, and social variables that so-called 'pet therapy' is believed to elicit (Wada, Shibata, Musha, & Kimura, 2008) and—for the purposes of the present study—is considered to yield benefits to the user that are borne of its unique characteristics as a simulacrum of a real animal (e.g., Kruger & Serpell, 2006). *To that end, we will therefore be reporting on a test of the proposition that exposure to Paro increases the incidence of positive behavioral and mood states and reduces the observed incidence of negative ones*" [Lane et al., 2016, pp. 292, 294].

> "Dementia is a mental disorder that is associated with a progressive decline in mental functions and abilities. Memory, thinking, language, understanding, and judgement are affected. *While many older adults will remain healthy and productive, overall this segment of the population is subject to cognitive impairment at higher rates than younger people [8]. Robot companions and digital pens (smartpens) when used as intelligent cognitive assistance technologies may enable older adults to live independently for longer periods of time*" [Prange et al., 2015, p. 65].

All these quotations show that aging inherently dampens the quality of life of older adults. Robots are seen as a solution to help increase the quality of life of older adults.

13.2.6. Health general

> "*In the year 2000, one in ten individuals in the world was 60 years or older and one in fourteen was at least 65. It is expected that these numbers will increase to one in every five persons being 60 or older and nearly one in six people 65 or older in 2050 (United Nations, 2002). On top of that, the prevalence of chronic diseases is rising amongst older people because of urbanization and an unhealthy lifestyle (Wild et al., 2004) (e.g., diabetes, COPD, obesities). A major problem is that only 50% of the chronically ill adheres to their treatment advice (WHO, 2003). For older adults, this problem is particularly hard because of their health illiteracy and deep-rooted daily routines—or lifestyles*. (…) In our view, psychological techniques for behavioral change, such as motivational interviewing, should be accommodated by this type of ICT support (e.g., Rogers,

1951; Looije et al., 2006; Miller and Rollnick, 1991). However, a concise and coherent set of behaviors – worked-out in specific user-interface behaviors – for such an accommodation is lacking. Derived from relevant literature of psychology, persuasive technology and affective computing, this paper presents a first set of behaviors (e.g., compassion) that map support objectives (motivating, educating, and supporting) on specific – social – user-interface behaviors for the intended ICT support" [Looije et al., 2010, pp. 386-387].

"*Dementia, including Alzheimer's disease, is expected to affect to 75.62 million people by 2030 and 135.46 million by 2050*. (…) *Research focused on finding a cure for dementia is key, but in the meantime, we must bear in mind that patients with dementia need the most appropriate treatment. New drugs and non-pharmacological treatments are currently being researched. Animal-assisted therapy (AAT), the use of animals in therapy sessions, is one such non-pharmacological tool currently under investigation.* (…) In the present study, animals and robots were added into the therapy sessions at a center for dementia patients" [Valentí-Soler et al., 2015, p.2].

"*In many parts of the world, the older adult population is growing at an unprecedented rate. In fact, it is estimated that almost 20 % of the U.S. population will be over age 65 in 2030 [1]. Normal aging is associated with cognitive, motor, and perceptual changes that impact one's ability to perform daily activities. Thus, of the millions of adults over 65 years of age worldwide, even the most healthy and independent may still benefit from some types of assistance as a result of limitations associated with normal aging. Moreover, nearly 40 % of Americans*

> *over 65 report having a severe disability (e.g., hearing, vision, cognition, ambulation, self-care) and this percentage rises to 56 % for Americans over 80 years* [1]. (…) Technology, such as robots, may be able to provide support for older adults with the difficulties and challenges associated with aging. Robots, particularly, human-sized mobile manipulators, have great potential for providing assistance to older adults in their own homes" [Smarr et al., 2014, pp. 299-231].

What all these quotations have in common is that they relate the need for robots to an overall decline in general health, as opposed to QoL specifically, without technological intervention.

13.2.7. No rationale: STS studies

> "Much has been written—not least in this journal —about the potential, the benefits, and the risks of social robotics. *Our paper is based on the social constructivist perspective that what a technology actually is can be decided only when it is applied*" [Pfadenhauer & Dukat, 2015, p.393].

Similar to the aforementioned statement, Neven and Leeson (2015) state that robots are only relevant when situated in context:

> "*This chapter also contests these deterministic ideas and instead approaches technology not as being detached from, but embedded in and formed by its social context.* Thus, understanding technology as a social phenomenon (Pfaffenberger 1988) inscribed with meaning and having the ability to change social relations, this chapter focuses on how two different robots make the transition out of the laboratory to meet groups of older people among whom they are supposed to be

> used. If technology is not a pregiven independent entity, any study of technology's impact must be the study of a complex, intercausal relationship between one form of social behaviour and another (Pfaffenberger 1988: 244). Thus this relationship evokes the following questions: how do people respond to a robot? What does a robot actually do among older people in a nursing home, and what do people do to the robot? How do they change each other and what are the social effects of the robot in its social context?" [Neven & Leeson, 2015, p. 86].

Both publications do not mention how robots are useful for certain (hypothesized or implied) reasons, but rather study the robots in applied settings. They do not make specific statements as to why social robots in elder care are needed or necessary, i.e. they do not mention a specific rationale, as according to the authors, the robots are only relevant when in context.

13.2.8. No rationale: Solutionism

> "Attitudes toward robots influence the tendency to accept or reject robotic devices. *Thus* it is important to investigate whether and how attitudes toward robots can change. (…) Roboticists envisage that by 2020 robotics technology will "influence every aspect of work and home."[1] According to official projections, by 2025 the market value of robotics will expand to several trillion US$ per year, mainly due to social robotics, which will be outperforming industrial robotics by a large margin.[2] Despite these advances the vast majority of residents in the European Community (87% of 26.751 respondents; Public Attitudes Towards Robots, 2012; Special Eurobarometer 382) has of yet no

personal experience with robots (e.g., robotic vacuum cleaners or industrial robots) but report positive attitudes toward robot technologies (70%). However, this positive attitude is relative to the specific context in which the robot is applied, as 60% believe robots should be banned from being used as caretakers for children, elderly and disabled people, and 69% would feel uncomfortable having their dog being walked by a robot. In line with this only 3% believe robots should be used for education or caretaking of children, elderly or disabled people. This illustrates the challenges that may arise when robots are introduced into the social sphere and assigned assistive functions in direct interaction with humans" [Damholdt et al., 2015, pp. 1-2].

"*Exploring the possibilities for using robots and screen agents in eldercare [1], we face not only technological issues, but also challenging questions concerning the way elderly people are coping or not coping with this new technology* [2-5]. In our research, we address some of those questions by exploring the factors that may influence acceptance of a conversational robot by elderly users [6]" [Heerink et al., 2009, p. 1909].

"*For the design of socially acceptable robots, field studies in Human-Robot Interaction are necessary*. (...) This paper describes a study aiming at finding an objective evaluation procedure of the dialogue with a social robot. The goal is to build an empathetic robot (JOKER project) and it focuses on elderly people, the end-users expected by ROMEO2 project. (...) Currently, several research teams work on projects for the elderly self-sufficiency [4, 11, 12], particularly on

> conversational agents design [1, 15]. To build a coherent and engaging conversational agent, social dialogue is essential" [Bechade et al., 2017, p. 89].

What all these publications have in common, that it they focus on making users more accepting of such technologies, yet do not mention why social robots in elder care are necessary. The code was labelled as solutionism, because the publications do not reflect a deeper logic on why these technologies should be used and rather mirrors the German word "*Selbstzweck*".

13.3. Codes and themes

All codes were compared and contrasted in order to group themes. Since this study has a rather deductive approach, some codes did not have to be reshuffled or renamed. This especially holds true for cost containment, since there is no theoretical overlap between this code and any other, thereby establishing a theme of its own.

The codes that bear no rationales can be merged since they both do not discuss reasons for why social robots in elder care are necessary, leading to the theme "no rationales". The two codes on staff could also be merged into the theme "care work" since they both reflect issues on care work, albeit from a different perspective (one is more focused on the job itself, while the other one has a societal/macro perspective). Finally, all the codes on QoL and health are merged into "wellbeing", since they all describe how older adults (as an individual or collective) need to look after their wellbeing and technologies could aid with that. As a result, the following themes were established: Cost containment, care work, wellbeing, no rationales.

14. Appendix F: Extra information methods study 3

Similar to the other appendices, this appendix first starts with explaining the procedure with steps. Then, it shows how literal quotations translate into codes, and ends with a description of how the codes translate into themes. As mentioned before, study 2 and 3 are more similar to a thematic analysis than grounded theory, even though the ideas were derived from a study that conducted grounded theory. Also, (as also with the other appendices) the steps are merely a representation of the workflow, since this was not a linear procedure but rather a highly iterative and circular one.

14.1. Coding procedure study 3

1. When conducting grounded theory in study one, it appeared that the publications describe particular ideas about older adults. This study therefore particular tried to understand how older adults are represented in the field. During the first phase of coding, all quotations were sampled that related to ideas of what older adults “are”, especially in relation to the sensitizing concepts of activity/inactivity.

2. Trying to classify these quotations in terms of activity and inactivity was not deemed relevant, since older adults were not only described in terms of activity or inactivity, but more general traits such as being digitally illiterate. The sensitizing concepts “inactivity/activity” were therefore too restrictive. It was then decided to take the sensitizing concepts one step higher in abstraction, and so “third and fourth age” were used instead to guide the analysis.

3. All the quotations were assigned codes. This is in essence the same step as with the other studies: Trying to understand patterns in the data by clustering quotations, and comparing and contrasting them. The codes developed are: frail, activity, burdensome, silent users, e-illiteracy. Furthermore, a counternarrative was found in which the sampled publications did not to categorize older adults in one way or another. Paragraph 14.2 shows examples of how the quotations relate to the codes.

Additionally, the quotations of study two (appendix E) were also analyzed in the context of this study, since rationales/objectives for developing robots in elder care also make assumptions about prospective users. In other words, this also brought an additional layer of information to this study, relating more to *societal* issues of aging. Indeed, making claims about how the populations age and how that would negative consequences on 1) expenses 2) caregiving, and 3) wellbeing, says something about how older adults are seen as a collective. Though these three themes were already discussed in study two, the quotations behind these three themes were re-analyzed for the purpose of robustness and being thorough. Also these quotations are revisited in paragraph 14.2.

4. In the final step, it was looked at how these codes relate to one another. Frailty and activity were two sides of the same coin, and both relate to the general functioning of older adults on an individual level. Older adults being burdensome relates to how older adults function in relation to others. Silenced users and digitally illiterate users, relates to older adults as users of new technologies. Finally, all the codes related to older adults as a societal threat, relate to older adults as a collective. The counternarrative is the odd one out, as this code refers to publications that do not describe older adults in terms of general and essentialist characteristics.

14.2. Examples of codes study 3

It should be noted that some examples are able to be situated in more than one code. The fragments of texts therefore were during coding not exclusively placed under one code, but rather multiple codes. All emphases are inserted by the author of this dissertation in order to highlight which pieces of text relate to the code.

14.2.1. Frail

> "*It is a general truth that increase of age is associated with a level of mental and physical decline but unfortunately the former are often accompanied by social exclusion leading to marginalization and eventually further acceleration of the aging process.* A new approach in alleviating the social exclusion of older people involves the use of assistive robots. (…) RAPP aspires to foster the development of robots and RApps *to encourage social, emotional, and cognitive empowerment of people at risk of exclusion, and in particular older people, including those with social or cognitive deficits*. (…) RAPP will offer solutions that *help older people remain socially active, increasing their independence and autonomy*, while relieving helpers from tedious tasks and providing tools for the medical community for a better assessment of the functional and cognitive status of the subject" [Reppou et al., 2016, pp. 539-540].

> "To date, limited research has been conducted on the use and benefits of social robots as therapeutic aids or assistants for the elderly. However, such robots have the potential to bring a new interaction tool *to a vulnerable population that would otherwise lack resources* (…) *Research has found that individuals with cognitive*

> *impairments who reside in nursing homes have low activity levels and are at a higher risk for understimulation because they lack the initiative to begin or sustain activities of daily living* [14]" [McColl et al., 2013, pp. 75-76].

> "It is hypothesized that such artificial companions will *help the elderly live in their homes independently for longer and make them feel less lonely* (Broadbent, Stafford, & MacDonald, 2009). In order to realize those positive outcomes of social robots' use, it is valuable to study what could help the elderly accept social robots into their daily lives (Graaf, Allouch, & Klamer, 2015). (…) It's to the benefits of baby boomers and societies that we employ ICT to help boomers *stay active in order to prevent their physical, social, and mental functions from deteriorating while transitioning smoothly into retirement* (Chang, Lu, Luor, & Yang, 2015)" [Chang et al., 2018, p. 195].

All these quotes refer to issues of vulnerability, decline, deterioration etc. in relation to several issues (e.g. social, physical, mental etc.). Frailty therefore refers to publications that represent older adults in terms of frailty and the need to fix themselves.

14.2.2. Activation (enhance, stimulate, or prevent deterioration)

> "This work promotes the idea of continuously using a telepresence robot to *support and foster the social participation of elderly people*. Specifically, the study is focused on the analysis of attitude and acceptance of people who share the environments in which the telepresence robot operates over long periods of time with the aim to achieve a deeper understanding of the environmental, technical and psychological factors that can influence the adoption and effective

use of a telepresence robot in a real context of daily life. (…) Overall, even though its functionalities are rather simple, the robot offers an augmented communication channel between the primary and secondary users *that can be exploited to foster socialization, facilitate contacts as well as increase the opportunities of interaction*" [Cesta et al., 2016, pp. 421, 423].

"This article describes an enhanced telepresence robot named ROBIN, part of a telecare system derived from the GIRAFFPLUS project for supporting and monitoring older adults at home. ROBIN is integrated in a sensor-rich environment that aims to continuously monitor physical and psychological wellbeing of older persons living alone. The caregivers (formal/informal) can communicate through it with their assisted persons. (…) This works describes an enabling technology for remote assistance and social communication. It highlights the importance of being compliant with users' needs to develop solutions easy to use *and able to foster their social connections*. (…) Despite the fact that maintaining social relationships is widely recognized as an important factor of well-being in old age,[4-7] social inclusion is still an under-investigated topic.[3] (…) Telepresence robots represent a promising emerging technology that could serve the social participation of older adults.[9-11] This work describes ROBIN, a telepresence robot enhanced to better reflect the older user needs and *foster social inclusion.* This robot is integrated in a telecare system named GIRAFFPLUS[12] aiming at both monitoring health status *and improving social connections of older people*" [Cortellessa et al., 2018, pp. 145-146].

> "The main objective is to design and develop a complete robotic agent, so that it performs physical and mental activities for elderly *people to maintain their healthy life habits and, as a final result, improve their quality of life*. (…) this project will aim to exploit the unique characteristics of a LEGO Mindstorms NXT robot in terms of adaptability and engagement to develop rehabilitation and coaching activities and assistive functionalities for the elderly. Such activities will *aim to enhance their healthy habits, train them physically and mentally and assist them in highly remarked fields such as fall prevention and active ageing*. The main, general objective of this project is to design and develop a complete robotic agent, using a LEGO NXT Mindstorms kit and an iPod Touch as its interface, so that it performs physical and mental rehabilitation activities for elder people *to maintain their healthy life habits and, as a final result, improve their quality of life and prevent major risks such as falls, physical weaknesses or mental disorders*" [Pérez et al., 2015, pp. 351-352].

Instead of blatantly representing older adults as weak or frail, these examples all refer to concepts such as "fostering" "enhancing" or "maintaining" certain positive traits such as their existing social network or "preventing" older adults from decline. In other words, it refers to the third age and its focus on activity or activation. All quotations referring to such narratives are coded in terms of activity/activation.

14.2.3. Burden

> "*Many of the BPSD can lead to staff stress and burnout, and can result in negative staff attitudes towards the person with dementia* (Spenceley, Witcher,

Hagen, Hall, & Kardolus-Wilson, 2015). Further research is needed to develop and evaluate non-pharmacological interventions that specifically focus on opportunities *to enhance engagement and mood, and reduce agitated behaviours that subsequently may impact positively on staff stress*" [Moyle et al., 2018, p. 330].

"*Since Alzheimer's gradually renders patients incapable of tending for their own needs, caregiving becomes essential*. Besides, the majority of the affected people age 65 years or older and they mostly prefer to stay at home instead of being at nursery homes [4]. *This implies that the role of the main caregiver is often taken by the spouse or a close relative and, in most cases, this is a very stressing task for them, both physically and emotionally*" [Salichs et al., 2016, pp. 85-86].

"RAPP will offer solutions that help older people remain socially active, increasing their independence and autonomy, *while relieving helpers from tedious tasks* and providing tools for the medical community for a better assessment of the functional and cognitive status of the subject" [Reppou et al., 2016, p. 540].

"Medical staff uses Patient Reported Outcome Measurement (PROM) questionnaires as a means of collecting information on the effectiveness of care delivered to patients as perceived by the patients themselves. *Especially for the older patient group, the PROM questioning poses an undesirable workload on the staff*" [Boumans et al., 2018, p. 73].

All these quotations illustrate how older adults are represented as burdensome, especially in relation to caregivers (both formal and informal). Therefore the code “burden” was developed to refer to such representations of older adults.

14.2.4. Silent

> “In a manner similar to any commercial product, the success of a robot mainly depends on the level of acceptability perceived by the users. In the case in the present study, target users correspond to elderly individuals who may be more vulnerable and definitely possess individual necessities that should be addressed. An individual accepts and uses a certain tool if the following requirements are met: the individual possesses a motivation to use it, he/she considers it easy to use, and he/she feels physically and psychologically comfortable using the same. *Therefore,* it is important to initially understand the motivations of elderly individuals to accept or reject a new technology” [Piezzo & Suzuki, 2017, pp. 2-3].

> “Due to demographic changes, the population is aging rapidly in most parts of the world. At the same time, a decline of employees in the care sector can be noticed that will probably lead to a shortage of health-care provision in future years. To overcome the gap between the increasing numbers of senior adults in need of care and the decrease in caregivers, many authors suggest that the deployment of robotic aids could be of help [1–8]. *To ensure the adoption of robots in their specific field of use*, acceptance of such devices by end-users is crucial” [Hebesberger et al., 2017, p. 417].

> "Imagine the year 2019. Mr. Smith, 90 years old, is still able to live autonomously thanks to his social robot Suzy. Suzy cleans his house, monitors his health and plays card games with him. Mr. Smith states: 'She is my best friend and I can not live without her anymore.' Will this be reality ten years from now? *It is assumed that in the near future, social robots will be able to aid the elderly to live longer autonomously at their own homes. Robots will be able to, for example, do household tasks for them, monitor their health and be a social companion. Therefore, it is important to study the acceptance and use of social robots, so that future social robots can be adapted to the wishes and demands of the elderly, which is important for the future diffusion and adoption of robotic technology*" [Klamer & Ben Allouch, 2010, introduction, para. 1-2].

These quotations refer to studies of acceptance. Older adults are represented as silent: the objective is to increase acceptance and thereby understanding how to increase acceptance, not to understand *if* older adults want to use it in the first place. The very premise of acceptance is not questioned.

14.2.5. E-illiterate

> "A major problem is that only 50% of the chronically ill adheres to their treatment advice (WHO, 2003). For older adults, this problem is particularly hard because of their health illiteracy and deep-rooted daily routines—or lifestyles. Information and Communication Technology (ICT) might provide the required support to better cope with the personal health constraints, such as doing exercises (Kidd and Breazeal, 2006; Ruttkay et al., 2006; Bickmore et al., 2004; Goetz et al., 2003;

Gockley and Mataric, 2006), giving social support (Kidd et al., 2006; Kriglstein and Wallner, 2005), and helping with lifestyle change (Bigelow et al., 2000; Looije et al., 2006). (…) In an experiment, we tested how far these social behaviors help to make the interface more empathetic and trust-worthy, which are preconditions for long-term use. *It should be noted that older adults experience specific hindrances to actually make use of ICT support, due to relatively limited computer skills (partly due to limited sensory, physical and cognitive abilities), and motivation to use a standard Windows, Icons, Menu and Pointing (WIMP) device (Czaja and Lee, 2007). (…) A speech interface may be more natural to use than a text interface for people who are not experienced with computer technology* (Neerincx et al., 2008)" [Looije et al., 2010, pp. 386-387].

"Forgetting is a common obstacle people have to face when they become older which can be moderated by social robots by reminding on tasks. Since most elderly people are not used to robots a challenge in HRI is to identify aspects of a robot's design to promote its acceptance. (…) While conventional calendars miss an active reminder function, *technical alternatives such as smartphones require technical skills and the handling of small touch displays which can be barriers for older people [4]. A potential solution lies in using social robots: while combining the functionality of a calendar with its humanlike interaction the robot can serve as a social reminder for medication, family meetings and other appointments* [5]" [Bartl et al., 2016, p. 681].

"Over the next several decades, the need for aged care services is expected to grow at the rate of 68 percent and supply of health care workers is expected to

> grow at the rate of 14.8 percent, housing and demand for skilled labor [2*]. On the other hand, a number of researches point out that in general elderly have difficulty in learning to use and operate new technologies. Thus, an important task in the field of gerontology is to develop tools that can be used easily by elderly. One solution is using multimedia and multimodal systems, which can be perceived as social entities.* (…) *In designing assistive technologies for elderly, particularly mentally or physically impaired, since they have limited expert knowledge of the technology, it should be able to interact in a natural manner. Because of that, they still prefer embodiment of care in physical form*" [Khosla et al., 2012, p. 1173].

These examples represent older adults in terms of having difficulties operating new technologies. Robots are seen as more intuitive forms of interaction that even could promote more acceptance. The code is labelled digital illiteracy or e-illiteracy to indicate how older users are represented as not capable of handling new technologies.

14.2.6. Collective costs

> "*Welfare states aim to ensure that vulnerable citizens have a reasonable quality of life by providing care and support.* This includes those who are elderly and frail. *The population of older people is increasing*. Between 2015 and 2020, the number of people in the UK general population aged over 65 is expected to increase by 12% (1.1 million); those over 85 by 18% (300,000); and the number of centenarians by 40% (7000). The general population is expected to rise by 3%. (House of Commons Library 2015) Across the world those aged 65 and over are

predicted to outnumber children under 5 years old by 2020. (Suzman et al. 2015) Population ageing is a long-term trend that began several decades ago in Europe. The proportion of the population aged 65 years and over is increasing in every EU Member State, European Free Trade Area country and candidate country. The increase within the last decade ranges from 5.2 percentage points in Malta and 4.0 percentage points in Finland, to less than 1.0 percentage points in Luxembourg and Belgium. Eurostat explains the trend by reference to increased longevity and consistently low levels of fertility. (Eurostat 2015) At the time of the 2011 UK census 9.2 million residents were aged 65 and over, an increase of almost 1 million from 2001. Results show that just 50% of those aged over 65 reported their health to be ‘‘very good’’ or ‘‘good’’, compared with 88% of the rest of the population. In 2011, 56% (5.2 million) of those aged 65 and over were living as a couple, an increase from 52% (4.3 million) in 2001. Those living as married couples increased from 51 to 54% and the proportion living as cohabiting couples almost doubled from 1.6 to 2.8%. Around a third (31%) of those aged 65 and over were living alone in 2011; this was a decrease from 34% in 2001. *Accordingly, welfare states face increasing costs for the care and social support for older people who are unable to live independently*” [Draper & Sorell, 2017, p. 49-50].

“*Estimates from the United Nations suggest the population over 65 worldwide will increase 181 % between 2010 and 2050, compared to a 33 % increase in people aged 15–65.* That shift will create a large incentive to automate at least some assistive work. Because over the next 20 years the ratio of people over the age of 65 to the number of people under 65 is going to change rather dramatically.

> As robots become safer, smarter, and more capable, robotics companies are eyeing elder care as a huge potential market. A rapidly expanding elderly population could also necessitate other new forms of home-assistance i.e. assistive-living technology. (…) *The growing of elderly population enlarges need for larger number of caregivers, cost of medical and social care and life insurance*" [Rodić et al., 2016, p. 234].

> "*With an increasing number of elderly in the population, dementia is expected to increase.* Dementia disorders and related illnesses such as depression in the aging population are devastating for the quality of life of the afflicted individuals, their families, and caregivers. *Moreover, the increase in such disorders imply enormous costs for the health sectors of all developed countries*" [Jonell et al., 2017, p. 1].

All these representations refer to aging populations, i.e. older adults as a collective. The aforementioned consequences of aging populations are related to, amongst others, an increase of costs. Though it should be noted, and as mentioned before, multiple representations and rationales co-exist in these text fragments. For instance, in the example of Jonell et al. (2017), also quality of life and caregivers are mentioned as factors that get affected with aging populations (as elaborated on in the following paragraphs). One publication therefore can be listed in multiple codes and themes.

14.2.7. Collective staff

> "*By 2050 37% of the EU population will be over 60 years of age and it is expected that there will be fewer than two persons of working age per senior of 65*

or older. This will lead to both an increasing demand for care and a shortage of care givers. Intelligent home environments are one of the key facets to counterbalance the reduced number of caretakers and increase the QoL (Quality of Life) of older persons" [Werner et al., 2012, p. 455].

"*Due to a combination of declining fertility rates and decreased mortality, countries all across the world are facing the headwinds of a rapidly ageing population*. According to the UN's 'World Population Ageing 2013' report, not only is the global population of elderly aged above 60 expected to almost triple by 2050, the already low old-age support ratios in many countries will likely continue to plummet, adding fiscal and social pressures on society. In keeping with the extended life expectancies, incidence of non-communicable diseases, disabilities and cognitive declines will increase, especially given the projected global trends of obesity, diabetes, and neurodegenerative diseases such as Alzheimer's disease. To overcome this massive challenge, the healthcare sector has to boost the number of trained healthcare workers, increase development of therapeutic programmes extensively, and raise accessibility and quality of healthcare services. *It is already apparent that countries need even more trained healthcare workers than previously projected [1]. A promising solution to the problem of trained manpower shortages is emerging*: assistive technology, in the form of socially assistive robots (SAR) that provide assistances to people through social interaction" [Sakamoto et al., 2016, p. 58].

"*The upward trend of intense ageing in European societies has been observed for several years now. While the number of elderly individuals is constantly growing*

> *up, the number of professional caregivers does not. This situation presents a challenge for developing and implementing of new solutions, aimed at reducing the burden on caregivers working in the system*. One of the possible solutions may be based on the technology, especially on use of robots to assist the older people living in the community" [Piasek and Wieczorowska-Tobis, 2018, p. 478].

> "The impact of the world-wide ageing population has commenced with respect to society in developed countries. Several researchers focused on exploring new methods to improve the quality of life of elderly individuals by allowing them to remain independent and healthy to the maximum possible extent. For example, new walking aids are designed to allow elderly individuals to remain mobile in a safe manner because the importance of walking is well-known. (…) *There is a constant increase in the number of individuals over the age of 65. Projections indicate this will approximately correspond to 1.5 billion in 2050 [1]. Consequently, pressure on national pension plans and long-term health care is increasing. Simultaneously, the number of working-age adults available to support elderly individuals is decreasing due to declining birth rates and increased longevity* [1]. Health systems of individual governments should be prepared to address the fore-mentioned issues at the earliest" [Piezzo & Suzuki, 2017, p. 1].

What these quotations have in common is that they state how older adults as a collective that is growing in numbers puts pressure on caregiving, albeit sometimes with a mixed narrative (i.e. referring to wellbeing and/or expenses), as Sakamoto et al. (2016) and Piezzo and Suzuki (2016) illustrate.

14.2.8. Collective wellbeing

> "*SocialRobot is a collaborative European project, which focuses on providing a practical and interactive robotic solution to improve the quality of life of elderly people. (...) Several demographic studies report that Europe's population is aging, as the average life expectancy over the years increase* [1]. As a consequence, the elderly care market is growing, revealing a huge unexplored potential. *In order to address these challenges, there is growing attention for assistive technologies to support seniors to stay independent and active for as long as possible in their preferred home environment*. Robotic systems are among those initiatives offering functionality related to the support of independent living, *monitoring and maintaining safety or enhancement of health and psychological well-being of elders by providing companionship. The SocialRobot Project[1] aims to provide an answer to this demographic change challenge*" [Portugal et al., 2015, p. 811].

> "*As stated in recent studies, the number of people in the United States with AD will increase dramatically in the next 40 years [3]. A similar evolution may be expected for the rest of the world*. (…) Since Alzheimer's gradually renders patients incapable of tending for their own needs, caregiving becomes essential (…) Although Alzheimer's disease develops different for each individual, there exist some general treatments such as the adherence to simplified routines or the

> realization of stimulation exercises. *These treatments cannot stop the disease from progressing, but they can temporarily slow the worsening of dementia symptoms and improve quality of life for patients and caregivers*. Several robotic research projects have tried to help patients and also caregivers" [Salichs et al., 2016, pp. 85-86].

> "*The increasing number of elderly people with cognitive disabilities creates higher efforts and costs for care providers and family members. Assistive robot systems could accompany elderly people and help keeping the elderly longer at home to increase their quality of life and to save costs.* However, current robot systems fail to deliver an adequate support of elderly people at acceptable costs. This paper presents a mobile robot platform for socially assistive care applications that was developed under consideration of functionalities, user acceptance, and costs. (…) The increasing life expectancy leads to an increasing number of elderly people with cognitive disabilities. At the same time, the costs for the care systems increase, which results in an overall assistance restricted to people with advanced disabilities. Further, the changed structure of nowadays families and personal living conditions complicate a comprehensive private care by family members. To compensate this leak of personal care, assistive robots could be used to support elderly or mildly disabled persons in their homely environments" [Merten et al., 2012, p. 233].

While the latter example also mentions older adults in relation to the rise of care expenses as demographics age, what all the aforementioned quotations have in common is that they mention how the aging demographics lead to more people having lower levels of wellbeing.

14.2.9. No essentialist representations

> "It is important to realize that there is a great diversity of social robots and this diversity of designs of robots is more than matched by the diversity of older people. This makes it impossible for 'robots' to have one clear and unequivocal effect on 'older people' *as both categories are grossly oversimplified in such reasoning*" [Neven & Leeson, 2015, pp. 99-100].

> "In what follows, *we shall not be commenting on the potential therapeutic effectiveness of PARO*, which numerous studies have endeavored to prove by means of physiological and psychological testing. (…) Rather, we endeavor to understand the social order into which humans are integrated and which is, at the same time, a product of human activity. In so doing, we do not look at society through a wide-angle lens. *Instead, we zoom in on the institutional framework and the organizational constellations under specific socio-historical conditions and focus on situative encounters between the individuals who make up the universe of interest to us as sociologists—namely, the social world*" [Pfadenhauer & Dukat, 2015, p. 397][27].

These two examples show that they do not wish to say how humans or robots "are" or "behave" and thereby the authors do not engage in essentialist representations.

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[27] Two footnotes from quotation removed.

14.3. Codes and themes

In order to cluster codes into themes, it needs to be looked at how the codes do or do not overlap, i.e. their relational meaning. One could see that although frailty and activity are codes with seemingly opposing meaning, they are still relational. They both describe older adults in terms of their general characteristics, whereas for instance, in terms of the code "burden" it describes older adults in relationship with other people. In other words, frailty and activity relates to their general functioning (theme). The burden code relates to the theme of older adults and others. Silent and e-illiteracy both describe older *users* specifically, i.e. how users should accept the usage of robots regardless of their own opinion and how new technologies could help with their e-illiteracy since robots are relatively easy to interact with. So the theme "older users" is established. Since three codes relate to older adults as a collective that is growing in numbers, older adults in society is established as a theme. Finally, since all the aforementioned themes relate to essentialist representations, the code that does not embed essentialist perspectives is labelled "counternarratives".