Research Topics

Towards HRI of everyday life

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Towards HRI of everyday life

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Editorial: Towards HRI of everyday life

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Editorial on the Research Topic
Towards HRI of everyday life

Nowadays, it is often assumed that, at least in principle, robots in general, and social robots in particular, have the potential to increase human wellbeing across a wide range of sectors and application areas. At the same time, efforts to introduce such systems into our everyday environments have had only limited success and it is yet to be seen whether the impact of social robots on our daily lives, professional and private, will actually be beneficial. Therefore, there is a need to systematically address and study the long-term use and presence of social robots in everyday environments, where humans not only interact with robots, but also have them integrated into the totality of their lived experiences in everyday life.

One of the main ways to investigate human engagement with social robots in everyday environments is through HRI studies conducted “in-the-wild”. While such an approach has certainly been instrumental and increasingly used in HRI research, in this Research Topic we have proposed to further expand the underlying theoretical and methodological frameworks to address the notion of “everyday life.” Such a notion is viewed here as an important sociological concept and an umbrella term that allows us to address, not only specific application domains for robots, but also the continuity and totality of human lived experiences that emerge through long-term engagement with social robots in everyday life contexts. This is in a situation where placing social robots in everyday settings has often been an explicit goal for robot development but the very notion of “everyday life” has not been systematically analysed. Therefore, this Research Topic has brought together a number of contributions to further develop the HRI domain. While the main audience of this Research Topic is the HRI community, we have welcomed contributions from any disciplinary, interdisciplinary, theoretical, or methodological perspective.

As a result, we have published eight articles centered on the themes of integration, acceptance and people’s attitudes towards robots in everyday life.

Kühne et al. investigates the use of dialects in social robots and its impact on the perceived trustworthiness and competence of robots. This is part of a broader inquiry into design and contextual factors that affect people’s acceptance of robots as social interaction partners. In particular, the study involved playing a short online video featuring NAO the robot speaking either in the Berlin dialect or standard German and asking one hundred twenty native German speakers to evaluate robots through a survey. While the study resulted in observing a slight trend of higher trust and competence evaluation for the standard German-speaking robot compared to the robot that spoke the Berlin dialect, the difference was not statistically significant and the two robots received largely comparable ratings in terms of both competence and trustworthiness. Also, on the one hand, the study found a positive correlation between certain variables, e.g., between participants' self-reported Berlin dialect proficiency and trustworthiness, and on the other hand, it also depicted a complex picture of people's perceptions of robots being affected by a number of factors that go far beyond robot features such as demographic characteristics, or a type of device used to watch the video.

Zafrani et al. focuses on the acceptance and assimilation of socially assistive robots (SARs) in everyday life of the elderly persons. It presents the study that examined the uses, constraints and outcomes of engaging with 'Gymmy' the robot in real-life conditions and over a long period of time, and their effect on the older adults Quality Evaluations of SARs. The study involved nineteen community-dwelling adults aged 75–97 who interacted with a personal training robot installed at their homes for a period of 6 weeks. The main findings of the study involved identifying two assimilation patterns among the participants who could be categorized either as "Fans" or "Skeptics" based on the type of experience they reported regarding the robot. These two groups differed in terms of the positive vs. negative experience as well as participants' personal background, attitudes towards robots before and after using the robot in question, and actual user experience. Thus, the study has shown that assimilation and acceptance of SARs is far from being a homogenous process and requires and requires careful consideration of the older adults' needs and concerns.

Zawieska and Hannibal poses the basis for this Research Topic as it discusses the existing and possible conceptual frameworks for the study of 'everyday life' in the HRI research. The paper first provides an overview of the ways everyday life is typically addressed in the HRI studies, namely, in terms of settings, activity, population and/or methodology. Subsequently, the paper proposes further conceptual developments towards a systematic study of everyday life in HRI as a Research Topic in its own right. In the process, it follows Social Sciences and Humanities (SSH) and sociological perspectives that have a long tradition of studying the everyday. In search of possible synergies between the HRI and SSH approaches, the paper builds upon the notion of 'lived experiences', and depicts the everyday as an open-ended process. It also engages with a critique of the contemporary everyday life as it calls for challenging the underlying understanding of the everyday and the real-world as "natural" and by doing do, widening the scope of HRI research to include ethico-political stances oriented towards the pursuit of a "good life."

Komatsu et al. conducted participatory design workshops with middle-to-older adults in Japan—once during the COVID-19 pandemic and again post-pandemic—to explore how their needs and attitudes toward robot technologies evolved due to changing social circumstances. Drawing on Nowland et al.'s "stimulation vs. disengagement" framework, the study found a marked shift over time: during the pandemic, participants prioritized robot tools that enabled distanced communication and social sharing with family, aligning with the stimulation hypothesis. After pandemic restrictions lifted, their focus shifted inward—toward personal wellbeing, ease of use, and technologies that alleviate digital exclusion, reflecting the disengagement hypothesis. Throughout, the participants consistently emphasized the importance of user-friendly, multifunctional robotic solutions—citing familiarity, simplicity, and seamless integration into their daily routines (e.g., combining guidance with communication tools). The authors highlight that Japan's super-aged context and rapid digitization during COVID-19 exacerbated older adults' digital exclusion, particularly disadvantaging those less tech-savvy. They conclude with a strong call for inclusive co-design approaches that address evolving social needs, from enabling connection during isolation to supporting personal wellbeing in the post-pandemic era—ensuring robot technologies remain relevant and accessible across life stages and contexts.

Hägglund et al. explore young adults' trust considerations when interacting with a socially assistive robot in a high-stakes pharmacy scenario—specifically, medication counseling on emergency contraceptive pills. Utilizing a co-creation methodology, they worked with participants to design a prototype application using the Furhat social robot platform. Through in-lab testing and subsequent interviews (six participants), they conducted an inductive, reflexive thematic analysis. The study produced five distinct "tales of trust", each represented as a persona embodying varying expectations and willingness to trust a robot in this sensitive domain. The research identifies six key factors that drive initial trust formation: physical position (spatial relation to the robot), perceived autonomy, interaction boundaries, feelings of shame, eye gaze, and conversational alignment. These factors shaped whether participants were open to consulting a robot about intimate health matters. By mapping a continuum from low to high trust expectations, the authors illuminate the nuanced interplay of affective, contextual, and design elements influencing user trust in socially assistive robots. The insights significantly inform the understanding of trust formation in HRI, especially in sensitive healthcare contexts, offering important design considerations for socially assistive robotics in the healthcare sector.

Ostrowski et al. present a year-long co-design study involving 28 older adults, aimed at developing HRI guidelines that reflect seniors' real-world needs. Participants engaged in a series of interviews, design sessions, and reflections to articulate the types of interactions they would want in daily life. These older co-designers expressed growing confidence over time, increasingly favoring transactional robot capabilities—like reminders and scheduling—while maintaining reservations about surveillance-related functions such as personal data tracking and monitoring. Beyond practical assistance, the study found measured enthusiasm for robots facilitating social connection, monitoring bodily signals, and supporting emotional well-being—all tempered by concerns over autonomy, privacy, and the "naturalness" of robotic interactions. Employing ethnographic decision-tree modeling, the authors demonstrated that simpler, non-intrusive features gained acceptance, whereas more invasive ones triggered sustained skepticism. They conclude by offering clear, user-driven guidelines for HRI design with older adults, and highlight several areas—such as ethical data practices, enhancing agency, and improving emotional realism—that warrant deeper investigation before broader deployment.

Vetter et al. conducted a study that explores integrating robotic technologies in the care sector, where such innovations are seen as solutions to labor shortages and aging populations. Their research applied an integrated approach combining value sensitive design and speculative design to explore the complexities of care environments, focusing on the diverse needs, goals, and socio-material arrangements that shape this space. Drawing on six interviews and six card workshops with Austrian care workers and residents, five key themes emerged: trust-building routines, stakeholder negotiations, reciprocal and affective care, caregiver self-care, and material mediation. To provoke reflection and discussion, six speculative vignettes were created, highlighting tensions that arise when technologies disrupt established care practices. The study offers valuable insights for robotic designers to understand care values and dynamics prior to developing interventions.

Irfan et al. conducted a participatory design study with 28 older adults to explore their expectations of conversational companion robots powered by models, such as large language models (LLMs). The study introduced a functioning robot prototype using LLMs in everyday life scenarios to prompt discussion. Through a thematic analysis process of the data, the findings revealed that older adults prefer robots that actively engage in conversations during isolation and passively accompany them in social settings. Key expectations included memory and personalization, privacy and control over data, useful reminders and information, support for social connections, and the expression of empathy and emotion. Based on the findings outlined, the study offers design recommendations for incorporating models (such as LLMs) into companion robots. The outcomes of the articles provide insights that extend beyond robotic agents and contribute broadly to the development of socially responsive conversational agents for older adults.

We hope that with these contributions we have shed light on the importance of the notion of everyday life with robots, and the need for multifaceted HRI approaches that would consider a whole range of factors that together contribute to human lived experiences with robots. The next step is to further develop more nuanced and HRI-specific methods and approaches that would allow us to study a unique phenomenon of life with robots at is unfolds.

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Towards a conceptualisation and critique of everyday life in HRI

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This paper focuses on the topic of "everyday life" as it is addressed in Human-Robot Interaction (HRI) research. It starts from the argument that while human daily life with social robots has been increasingly discussed and studied in HRI, the concept of everyday life lacks clarity or systematic analysis, and it plays only a secondary role in supporting the study of the key HRI topics. In order to help conceptualise everyday life as a research theme in HRI in its own right, we provide an overview of the Social Science and Humanities (SSH) perspectives on everyday life and lived experiences, particularly in sociology, and identify the key elements that may serve to further develop and empirically study such a concept in HRI. We propose new angles of analysis that may help better explore unique aspects of human engagement with social robots. We look at the everyday not just as a reality as we know it (i.e., the realm of the "ordinary") but also as the future that we need to envision and strive to materialise (i.e., the transformation that will take place through the "extraordinary" that comes with social robots). Finally, we argue that HRI research would benefit not only from engaging with a systematic conceptualisation but also critique of the contemporary everyday life with social robots. This is how HRI studies could play an important role in challenging the current ways of understanding of what makes different aspects of the human world "natural" and ultimately help bringing a social change towards what we consider a "good life."

KEYWORDS

human-robot interaction, social robots, everyday life, lived experiences, conceptualisation, critique

1 Introduction

Whether in reality or only in the realm of expectations, social robots are thought to be increasingly entering our daily life. To achieve a widespread use and acceptance of robots in society, a large part of Human-Robot Interaction (HRI) research seeks to provide scientific and technological solutions for making robotic systems appear and behave socially (Dautenhahn, 2007). Different types of so-called 'social robots' have been increasingly envisioned and explicitly promoted as part of our daily life with the goal to assist people with their everyday tasks and activities. The underlying assumption is that the acceptance and use of robotic systems will have a profound impact on our socio-cultural spaces [(Hakli and Seibt, 2017): v], and that robotic technologies will transform "not only how we work but also *how we live*" [(Elliott, 2019): 60] [italics original]. In other words, social robots are considered part of an ongoing fourth industrial evolution that is changing our daily lives (Gonzalez-Aguirre et al., 2021), and the field of social robotics is expected to undergo "explosive growth" [(Dumouchel and Damiano, 2017): 105] in the coming years (whether there is enough empirical evidence to support such claims is a whole different discussion).

An important part of such transformation, and the very focus of this article is the impact of robotic systems on our contemporary everyday life.

The goal of this paper is to set the basis for a distinctive research theme and a conceptual framework in the HRI field dedicated to the "HRI of Everyday Life." We will start by providing an overview of the HRI research dedicated to the subject of everyday life, as well as identify and analyse the key concepts, methods and approaches used in HRI to address different aspects of what is understood as human daily life with social robots. In order to help advance such research, we will follow by proposing to incorporate Social Sciences and Humanities (SSH) perspectives that have long addressed everyday life across different theories and scholar traditions. Given the immense scope of the subject, our goal is to introduce everyday life as a distinctive research theme rather than provide a nuanced disciplinary discussion (it might also be relevant to ask to what extent disciplinary distinctions are possible or even necessary in a situation of increasing interdisciplinarity of SSH research [see, e.g., (Katz and Csordas, 2003; Pedersen, 2016)]). When discussing the key concepts (see Section 4) we rely mainly on the sociological perspectives that are widely established in SSH without prioritising any specific school of thought (e.g., a phenomenological, interactionist, constructivist, or structuralist approach). In other words, our analysis of SSH perspectives is deliberately generic with the goal to leave the doors open for various interdisciplinary explorations that are possible within HRI research and among sociologists themselves.

In SSH research, on the one hand, everyday life has often been perceived as an ordinary or trivial topic (Gardiner, 2000; Sztompka, 2008; Zimmerman et al., 2017); and on the other hand, it has also been seen as a highly complex phenomenon and a human "paramount reality" (Schutz and Luckmann, 1973) that is constitutive of all human thoughts and activities [(Gardiner, 2000): 2]. Not surprisingly, technological transformations have been seen as the key new phenomena in society that constitute an important intellectual challenge for the future sociology and related disciplines [(Tomasi, 2020): 33, after Abbott]. In HRI, a development and implementation of robots into our daily life has been sometimes defined as "the primary incentive" for social robotics [(Weiss and Hannibal, 2018): 399], with the process of widespread roboticisation often being perceived as only a matter of time (despite the general public often hesitates to accept social robots for everyday use [(Bartneck et al., 2020): 201]). In other words, in line with technological determinism or optimism, or both, it has often been assumed that as social robotics and AI technologies advance, "Clearly… they will likely play an increasingly larger role in our everyday lives and society" [(Bartneck et al., 2020): 203]. Thus, for different reasons but in both the HRI and SSH field, human everyday life is often viewed as a crucial element and the ultimate focus of a respective research agenda. In search for a common denominator for HRI and SSH research, we focus on the concept of 'lived experience', that has a potential to build upon the User Experience (UX) approaches that have been widely used in HRI. The key assumption is that social robots and the ways humans engage with such artefacts may constitute an important "extraordinary" element in the otherwise ordinary or taken-for-granted everyday life [(Gardiner, 2000): 6)], and ultimately help transform our social world by unveiling the new possibilities hidden within the everyday.

In particular, in order to help conceptualise the everyday as a distinctive research theme in HRI, we start by providing an overview of how the notion of the everyday has been addressed in HRI research to date, which we identify as related to four different areas (Section 2). We continue by addressing various perspectives the SSH research has to offer on everyday life, particularly in sociology (Section 3), and the elements of everyday lived experienced that we believe will remain largely unaltered in our daily life with social robots (shall it ever materialise) (Section 4). Afterwards, we propose a new conceptual framework that combines both SSH and HRI perspectives and can be used to further explore new aspects of human daily life with social robots, where the everyday is a matter of future and not of today (Section 5). Finally, we discuss potential new developments and roles for HRI research that require engagement with a critical analysis of the contemporary everyday life (Section 6).

2 Conceptualisations of the everyday in HRI

While HRI research started from predominantly technical investigations into "understanding, designing, and evaluating robotic systems for use by or with humans" [(Goodrich and Schultz, 2008): 1], its focus has gradually shifted towards more interdisciplinary perspectives with 'the social' component at its core (Bartneck et al., 2020). Part of such a shift includes an increasing use of methods and approaches that involve conducting HRI studies "in-the-wild," i.e., in the expected contexts of use (real-life environments). While still limited, such a trend can be expected to continue: It has been argued that "[t]he fundamental issues for human-robot interaction are in the real world" [(Kanda and Ishiguro, 2017): 8], and studying robotic systems "in-the-wild" is essential for HRI research (Syrdal et al., 2020) (as discussed below, while HRI researchers refer to the "real world," sociologists would rather use the term "life-worlds" - an important difference that is more than just a nuance). Further potential developments in HRI research include not only focusing on the social but also becoming more "socially-engaged" (Lee et al., 2022). At the same time, the idea of introducing social robots into people's daily life often remains more in the realm of motivation for social robotics rather than the actual conceptualisation and empirical study, or is only vaguely addressed, e.g., in terms of the "presence" of robots in our everyday life (Fortunati et al., 2015; de Graaf et al., 2016; Rossi et al., 2020). In other words, as already pointed out elsewhere (Hannibal, 2016; Weiss and Hannibal, 2018), the idea of placing robots in the everyday life contexts lacks a clear understanding of the everyday and is often taken-for-granted in both research and public debates. To the best of our knowledge, in addition to generic calls for an interdisciplinary reflection on the impact of robots on people's everyday lives (Ray et al., 2008), so far there has been only one attempt made to address everyday life as a distinct research theme in HRI, namely the Everyday-life centred approach (ELCA) (Weiss and Hannibal, 2018). While much more research has been done in this regard within Human-Computer Interaction (HCI) research (Bødker, 2006; Bardzell et al., 2012), the analogies between HRI and HCI are limited. This is because while computer technologies have truly become parts of people's lives and can be studied as such, social robots are still to a large extent in a research and development phase, and they involve embodied interactions with physical robotic systems (Herath et al., 2020). HCI in turn has been long facing developments towards "ubiquitous computing" where "computation is embedded into the fabric of the world around us. In this world, our primary experience of computation is not with a traditional desktop computer, but rather a range of computationally-enhanced devices—pieces of paper, pens, walls, books, hammers, etc." [(Dourish, 2004): 19]. Also, although research in HCI and HRI largely overlap in their methods and topics, it has also been recognised that people's interaction and experience with social robots pose new and distinct challenges (Huang, 2016) which is important to consider when demarcating the everyday life theme in HRI. Therefore, we propose to address the everyday as a distinctive analytical concept and research theme, and to explore its potential to lead to new ways to problematise and engage current HRI research. In order to illustrate why that is the case, the following sections provide an overview of how the everyday has been conceptualised in HRI to date, both explicitly and only in terms of tacit assumptions.

2.1 The everyday as settings

In line with thinking of the real world mostly in terms of socio-physical environments, a common way to conceptualise the everyday in HRI research is to refer to *domestic settings* (including in the case of the above-mentioned ELCA (Weiss and Hannibal, 2018)). In general, service robots have often been classified as robots for either professional or personal uses, where the term "personal" has sometimes been used as synonymous with "domestic" (Gonzalez-Aguirre et al., 2021). Social robots are often designed to move around in unstructured and constantly changing environments that are characteristics of people's homes. The latter are typically viewed as places where private life unfolds. HRI research offers a number of studies conducted in domestic settings where people shared households with robots to a varying degree, whether in real or simulated homes (Forlizzi and DiSalvo, 2006; Koay et al., 2009; Syrdal et al., 2009; Walters et al., 2011; Lee et al., 2022). This is also where one can observe the most frequent use of explicit references to the notion of everyday life, as it is taken-for-granted that daily life takes place at home (see, e.g., (Auger, 2014; de Graaf et al., 2016; Weiss and Hannibal, 2018)). In line with such thinking, social robots have also been studied in *institutional residential settings* where specific groups of people stay and live on a regular basis. For example, people in need of long-term residential care spend much time in nursing homes or rehabilitation centers, where social robots are introduced and used to assist both residents and care givers with daily tasks. Studies that stress the importance of carrying out HRI research in those specific settings (Mannion et al., 2020) are guided by the attention for everyday environments and related robot applications, which can be understood in terms of human daily life with robots. Yet another way of addressing real-life settings in HRI is to conduct HRI studies in *public settings*. This includes, for example, shopping malls (Kanda et al., 2009; Sabelli and Kanda, 2016), airports (Triebel et al., 2016; Joosse and Evers, 2017) or city spaces (Weiss et al., 2008; Weiss et al., 2010) among others, where people engage with robots, and other persons, as part of their daily life. Such an approach opens a discussion into what makes a given task or action "daily," or what is a relationship and distinction between the private and public domain in people's everyday life, particularly if we also include virtual spaces. For example, a recent study in digital anthropology has described smartphones as 'transportal homes', i.e., new places within which we live (Miller et al., 2021). Also, it has been argued that the actions we pursue in a public and private sphere are equally "everyday" [(Sztompka, 2008): 31]. An alternative approach includes addressing everyday settings in terms of "contexts" for people's daily experiences (e.g., aging) and related engagement with robotic technologies (Lee et al., 2016). In any case, regardless of their specific features and distinctions we make, it is important to note that addressing everyday settings is often instrumental to investigation of other subjects relevant for HRI research and a daily use of robots, e.g., human trust or acceptance of robots in daily life (Ray et al., 2008; de Graaf et al., 2016; Kuhnert et al., 2017) rather than a research theme in its own right. At the same time, domestic/residential and public settings together make everyday environments that constitute a solid basis for further conceptualisation of everyday life in HRI in terms of a 'living space' (see Section 5.1).

2.2 The everyday as activity

Another way to conceptualise the everyday in HRI research is in terms of the tasks or activities that social robots are intended to be used for, i.e., specific application domains (Weiss and Hannibal, 2018). While robotic systems used in the contexts of, e.g., healthcare, warfare, manufacturing, rescue, or space exploration are required to carry out very specialised tasks, social robots are typically designed to assist people with general activities in their daily life, e.g., helping people with exercising, cleaning, eating, learning, cooking, socialising, or shopping (Lum et al., 2020; Huang and Huang, 2021). This is how, while supporting everyday tasks, robots may become "everyday objects" (Kaplan, 2005). From this perspective, the everyday refers to those parts of life that occur on a regular basis and that most people are familiar with. A successful application of social robots in this context is also dependent on how well such robots can be integrated into or adapt to people's habits or routines of actions or behaviour (the goal that can be difficult for technology to achieve, especially with regards to everyday household routines (de Graaf et al., 2016)), and on the degree the interaction with robots can be perceived as 'natural'. Since this kind of activities is to a large extent considered habitual or mundane, social robots are often required to meet the needs of people through some form of personalisation or basic awareness about which social norms or scripts can be used for the various daily activities (Lee et al., 2012). All in all, a focus on robot applications and related human activities offers a potential for a more holistic conceptualisation of everyday life in HRI, as it covers a variety of domains from domestic assistance, through education or transportation, to healthcare.

2.3 The everyday as population

Yet another way to address the everyday in HRI research is to look at the target population intended to use social robots. In general, HRI studies in the real-life settings may involve various types of participants, from randomly selected individuals, through robot users to the actual robot owners (Lee et al., 2022). Those HRI studies that explicitly address the subject of everyday life often refer to people involved in the studies as "lay" or "naïve" users (Takayama et al., 2008; Theofilis et al., 2015; Suguitan and Hoffman, 2019; Rossi et al., 2020). The term "naïve" however is problematic as it does not accurately describe a lack of only a specific type of (technical) knowledge about robotics systems it points to (rather than a quality of being generally naïve), and it undermines people's active role in shaping technology by their "everyday living with it" [(Bakardjieva, 2005): 38]. An alternative term that we also view as more suitable for HRI research is that of 'non-expert' users, or 'lay experts' (Weiss and Spiel, 2022) (of course, we are not implying that people are not experts in other areas and everyday activities, including in those that roboticists may have a little understanding of). Such a term is useful not only in referring to people's limited knowledge or experience regarding robots but also in explicitly situating HRI research in everyday contexts (Lee and Sabanović, 2014; Papagni et al., 2022). It also allows looking at the study participants with the attention for wider socio-cultural and professional backgrounds, e.g., as non-expert caregivers (Louie and Nejat, 2020), rather than only "users" of a given robot (the overall need for a greater contextualisation of HRI studies has been by now well-recognised and articulated (Lee et al., 2016; Lee et al., 2022)). This is particularly true for social robots that in principle are designed for non-expert populations (e.g., elderly, children, or school-teachers) that dominate studies "in-the-wild" (Lee et al., 2022).

2.4 The everyday as methodology

Perhaps the most holistic view of the everyday, and a perspective closest to SSH research, is the HRI method of studying robots and human-robot interactions "in-the-wild." In general, conducting studies in the expected contexts of use, or field studies [6], refer to real-life environments that may vary form simulated real-world settings to the actual socio-physical spaces outside the laboratory. Such a methodology is viewed as instrumental in improving robot design and functionalities [including with the involvement of the study participants as co-designers (Ostrowski et al., 2022)] in a way that robots best fulfil people's expectations, preferences and needs, and fit into people's lives. Thus, field studies help increase ecological validity of the HRI studies, i.e., generalisability of the findings to the real world[1] [6]. At the same time, studies 'in-the-wild' involve serious technical and methodological challenges and play only a complementary role in the contemporary HRI research (Jung and Hinds, 2018; Syrdal et al., 2020). The very idea of designing robots for everyday life has sometimes been described as going "on the absolute outer limits of workability" [(Maibaum et al., 2022): 472] in robotics. For the purposes of this work, it is important to emphasise that studies 'in-the-wild' involve not only a specific type of environments but also the type of users and research subjects that cannot be successfully addressed in the laboratory settings. Also, such studies allow addressing the underlying socio-cultural assumptions on both the robot developers and end-users' side [17], or social environments and group dynamics that otherwise remain unnoticed or obscure (Jung and Hinds, 2018; Lee et al., 2022). An important feature of the studies 'in-the-wild' is an emphasis on and efforts to conduct long-term studies (Ostrowski et al., 2022) that would hence address not only spatial but also temporal settings typical of our daily life, and the type of activities such spatio-temporal settings involve. For example, the Everyday-life centered approach (ELCA) emphasises the need to capture and record encounters between humans and robots in unstructured situations and real-time. The key three dimensions of everyday life according to ELCA include actions, meaning and materiality (Weiss and Hannibal, 2018). All in all, while the HRI field is yet to assist development of theories, methods, technologies as well as institutional frameworks and practices that would allow studying social robots 'in-the-wild' systematically and on a large-scale, a large part of HRI research has been gradually shifting towards the subject of everyday life.

1 What exactly counts as a "real world" and for whom is a whole different question. The imperative of "going to the real-world" is of course not unique to HRI as it has been underlying many other disciplines, particularly sociology.

3 SSH perspectives on the everyday and HRI research

Across multiple and sometimes very different social and cultural theories of everyday life, there has been a general agreement that the everyday constitutes a dominant element of human existence and social world [10, 19]. In the capacity of the everyday to be "the largely taken-for-granted world" [(Gardiner, 2000): 2] or "the reality that seems self-evident" [(Schutz and Luckmann, 1973): 3], everyday life has often remained clandestine or overlooked in SSH research. It is only recently that the everyday has gained increased (and renewed) interest in SSH and has been recognised as a research topic in its own right and theorised as such (Adler et al., 1987; Gardiner, 2000; Bennett et al., 2004; Sztompka, 2008; Neal and Murji, 2015; Zimmerman et al., 2017). As the society changes, the lines of SSH inquiry into the everyday inevitably evolve, to include, for example, feminist, cultural and postmodernist perspectives (Gardiner, 2000). Incorporating everyday life into HRI research can be seen as developing one of those new perspectives that is potentially promising not only for a successful integration of social robots into society but also advancing interdisciplinary investigations of the contemporary everyday.

In general, different aspects of the everyday has always been addressed in SSH to a varying degree, and everyday life has been a fundamental research problem, particularly in sociology. Depending on the approach, different disciplines and perspectives, e.g., social phenomenology, or micro-sociologies, have explored a variety of human daily practices, knowledge systems and social facts that together constitute human social existence (Gardiner, 2000; Jacobsen, 2008; Sztompka, 2008; Zimmerman et al., 2017). Some approaches such as ethnomethodology have brought a particularly rich contribution to the sociology of everyday life, with different, sometimes competing views, methods and developments in the study of the everyday (Garfinkel, 1967; Attewell, 1974; Atkinson, 1988). Over time, there has been a shift in SSH from addressing everyday life as a largely homogenous, unproblematic and fixed feature of social life produced by specific structural forces towards conceptualising daily life as a highly complex and fluid reality that constitutes a mediator between the individual agent and the social structure, and is subject to change (Gardiner, 2000; Bennett, 2005). The status of everyday life as a research, theoretical and political subject, and its history and recent developments in SSH, is a fascinating topic *per se* and a matter of countless disciplinary discussions (Gardiner, 2000; Jacobsen, 2008; Sztompka, 2008; Olson, 2011; Neal and Murji, 2015; Ludtke and Ludtke, 2018) (just as the affirmation and centrality of everyday life in modernity and postmodernism (Taylor, 1989; Featherstone, 1992; McRobbie, 2003), or the plurality of the present-day sociologies and their perspectives on human social life (Sztompka and Burawoy, 2011)). What different perspectives have in common is that human everyday life has long been understood as the realm of the ordinary, or "the common-sense world" (Schutz and Luckmann, 1973) (the approach sometimes echoed in the HRI arguments for the study of "ordinary people" and their use of robots in daily life (Weiss and Hannibal, 2018)), which can be viewed as both an obstacle and an asset in SSH research. Over time, there has been a growing recognition of the importance of the ordinary or "the obvious" (Zimmerman et al., 2017). This includes the need to face a paradox of how to "give significance to what is insignificant" [(Olson, 2011): 176]), and efforts to "take the ordinary seriously as a category of analysis" [(Neal and Murji, 2015): 811], and to develop critical knowledge of our understanding of the "prosaic" [(Gardiner, 2000): 6]. The very understanding of the 'ordinary' in this context has been changing. For example, it has been argued that everyday life equally involves all people, irrespective of their class or other defining characteristics, and hence, it concerns as much elites as common people [(Sztompka, 2008): 31]. Others have argued that everyday life can also be seen as the domain of the "extraordinary," with all the ambiguity, fluidity, and a transformative capacity it involves (Gardiner, 2000; Neal and Murji, 2015). From this perspective, the everyday can be seen as "a site of normativity," as much as "a site of resistance" (Neal and Murji, 2015), where individuals and societies have the potential to transform the existing social conditions, to the point of searching for utopia "in the here and now, through the transfiguration of everyday life" [(Gardiner, 2000): 25]. Perhaps in line with such thinking, a large part of studies of the everyday have focused on people, practices and spaces that tend to be marginalised, anonymous or otherwise "unofficial" [(Gardiner, 2000): 8-9] (Jacobsen, 2008; Ludtke and Ludtke, 2018). Such an approach is at least partially due to the need to take "an explicit ethico-political stance" [(Gardiner, 2000): 9] when pursuing a critical study of the everyday, and contextualise the analysis within wider sociohistorical developments [(Gardiner, 2000): 7]. All in all, by the 21st century, the area of everyday life studies has been well-established, to the point of sometimes being considered a distinct field with its own canon and disciplinary developments, and new challenges to address (Sztompka, 2008; Olson, 2011; Neal and Murji, 2015).

4 The everyday and lived experience

Not surprisingly, the concept of everyday life goes hand in hand with that of lived experiences. This is because the notion of everyday life points to the existence "as it is lived" [(Gardiner, 2000): 1], and "presupposes a focus on the human being who lives it" [(Bakardjieva, 2005): 37]. This is also one of the reasons why, everyday life is often addressed in sociology in terms of 'life-worlds'. Such an approach to a large extent originated from the work by Husserl (2002) as he took a critical stand towards scientific inquiry where abstractions from everyday appearances were prioritised. Since life-worlds essentially aim to capture the worlds of experience, such an approach brings the attention to human subjects who experience the world and give meanings to their experiences that in turn constitute the order of reality [(Schutz and Luckmann, 1973): 5, 23] (hence, a frequent use of the term in its plural form). On the one hand, particularly in the philosophical phenomenological tradition, experiences are viewed as highly subjective, where "a lived experience is always essentially *one's own* direct experience" [(Burch, 1990): 135] [italics original]. Particularly with the work by Heidegger (1967), Sarte (1984), de Beuvoir (1953) and Merleau-Ponty (2012) such perspectives were developed into the existential-phenomenological tradition, which related these direct experiences of the world with investigations and discussions about the (universal) human condition. On the other hand, different sociological perspectives, especially symbolic interactionism (Prus, 1996), emphasise the intersubjective character of the human world, where the world is essentially known and lived in common with others (Schutz and Luckmann, 1973). Just as the everyday "requires the inclusion of almost everything" [(Weiss and Hannibal, 2018): 399], the "lived" character of human existence also concerns literally all its aspects, e.g., lived experience of time, space and the body [(Gardiner, 2000): 75]. Also, many of our everyday lives and experiences lay outside the realm of conscious reflection. As a result, defining "lived experience" and "everyday life" is highly problematic. In Gardiner's words, "Given the habitualized and recurrent nature of daily life, it is difficult to conceptualize or describe in theoretical terms, mainly because it is profoundly *lived*, and experienced as ceaseless recurrence" [(Gardiner, 2000): 87] [italics original].

For the purposes of this work, we provide an overview of those features of everyday experiences that we consider as being widely agreed upon and particularly useful for HRI research. These are also the features of human existence and elements of the SSH theories of the everyday that we consider as directly suitable for the HRI research, and the parts of human everyday experience that will not change with the expected introduction of social robots into daily life (at least not significantly nor immediately). The underlying assumption is that while the analysis of everyday life focuses on the third-person perspective (when looking at "life-worlds"), investigation of lived experiences always involves first-person accounts. Both approaches suit HRI studies that involve mixed methods research, from behavioural and observational measurements [e.g., (Siegel et al., 2009; Kont and Alimardani, 2020)], to tools designed for subjective evaluations and measures of the robot performance and interaction [e.g., (Siegel et al., 2009; Winkle et al., 2019; Hannibal et al., 2022)].

4.1 Being taken-for-granted and habituality

Across different SSH perspectives there is a consensus that the everyday is largely self-evident in people's lives or taken-for-granted (Schutz and Luckmann, 1973; Gardiner, 2000). This is due to the very content of everyday life that involves common-sense and habitual meanings and activities, i.e., "the routine, taken-for-granted experiences, beliefs and practices; the mundane ordinary world" [(Featherstone, 1992): 160]. A key element of daily life in this context is its recurrent character and a degree of familiarity it implies. This is also why everyday life is generally considered difficult to grasp and life-worlds inherently "intransparent" [(Schutz and Luckmann, 1973): 169]. Examples of sociological perspectives that have explored the taken-for-granted character of everyday life include particularly ethnomethodological research that have also started to appear in some HRI studies (Pitsch and Koch, 2010; Jarske et al., 2020; Yamazaki et al., 2022; Pelikan and Jung, 2023) (its focus on micro-interactions and extensive use of conversation analysis makes ethnomethodology particularly attractive for HRI research that involves human-robot social interactions). To what extent and whether people actually approach their daily world "unreflexively" is subject of different interpretations (to the point of considering the "extraordinary" a common component of the everyday, or everyday reflexivity as consisting of unconscious elements too [(Gardiner, 2000): 6]). On the one hand, a self-evident quality of everyday experiences is limited, since the life-world also includes the provinces that are yet unfamiliar and undetermined for a given person [(Schutz and Luckmann, 1973): 167], and every human experience has potentially unlimited new explications [(Schutz and Luckmann, 1973): 169]. On the other hand, everyday life tends to provide a stable order to people and what often seems to be an unalterable horizon of action [(Gardiner, 2000): 5]. This is true as long as people's everyday experiences and their meanings remain uncontradicted. The moment disruptions of daily routine occur, when what is familiar becomes defamiliarised, or incongruent with our previous experiences, an opportunity for increased reflexivity, and consequently a social change emerges [(Gardiner, 2000): 19-20; (Schutz and Luckmann, 1973): 11]. In line with such thinking, and from a postmodernist perspective, everyday experience has sometimes been viewed as a site of continuous struggle and contestation, and hence far from being ordinary or unproblematic. In this sense, everyday life constitutes a taken-for-granted reality in plurality of forms and meanings, and everyday experiences are highly diversified and complex (Sandywell, 2004).

Perhaps for different reasons (e.g., to address technical and design challenges), HRI and robotics research too has been concerned with the complexity, "wickedness" (Bischof et al., 2020) or 'messiness' of the human real-world (Auger, 2014; Dautenhahn, 2018; Matarić, 2018; Bartneck et al., 2020). This applies particularly to the complexity of the real-world problems and of the related data and socio-physical environments, as well as the unpredictability of human behaviour that often make it difficult to plan and execute HRI studies 'in-the-wild'. The very use of robots in everyday worlds has sometimes been described as "an enormous challenge" (Bischof et al., 2020) and "an absolute borderline case" (ibid.) for robotics. Also, the core of HRI research involving social robots focuses on the "natural" robot design and human-robot interactions. What is "natural" for humans and for the way they interact with and perceive robots is debatable, but in social robotics and HRI it includes exploiting those human characteristics and behaviours that appear to be largely unconscious or "automatic" (particularly with regards to human sociality and a tendency to anthropomorphise (Zawieska et al., 2012)). Such an approach has the potential to go beyond studying only human-robot interactions and build upon the existing SSH scholarship to systematically theorise and empirically investigate human everyday life as a whole. This may include not only studying what makes social robots and related interactions 'natural', but also deliberately exploring the element of the non-human or "extraordinary" (the idea inherent in the design that limits robot human-like features to the minimum (Duffy, 2003; Zaga et al., 2017)), that challenges a familiar or self-evident character of the everyday, particularly the underlying assumptions with regards to what it means to be human.

4.2 Immediacy and embodiment

Traditionally, different theories of everyday life have emphasised the immediacy of lived experiences. This conveys the image of persons as embodied subjects who engage with other people and the world around them through bodily experiences. In other words, "[e]veryday life is bodily life" [(Silverstone, 2002): 764]. The latter may refer to body-related features, e.g., age, or more broadly, particular material resources and limitations (Silverstone, 2002), as well as spatial and temporal immediacy, that together contribute to how we experience our everyday life, the Other and the social world. In a wider sense, a characteristic of being embodied and socially embedded points to the contextuality of human experiences or specific phenomena such as the human mind [(Linell and Valsiner, 2009): xxviii]. Immediate experiences are often synonymous with lived experiences and directly opposed to different forms of theoretical and cognitive abstractions. The emphasis on the immediacy of experience implies also the emphasis upon the present, and hence, an overall "non-reflexive sense of immersion" [(Featherstone, 1992): 161] in the everyday. Thus, just everyday life, the actual lived experiences are "pre-reflective," and hence difficult to grasp in their immediate manifestation [(Finlay, 2002): 533]. Past experiences or any new experiences become part of our current "stock of knowledge" within the life-world that, unless it is contradicted, constitutes a taken-for-granted valid reference schema in the everyday (Schutz and Luckmann, 1973). At the same time, it is important to note that the immediacy of experiences is subject to gradation between the immediate and mediate experiences (Schutz and Luckmann, 1973). In the times of a mediated culture and globally mediatised world, the concept of unmediated everyday life has sometimes been fully rejected (Sandywell, 2004), and mediation described as central to our everyday (Silverstone, 2002). This is particularly true for technology-enabled communication and related meaning-making processes, with the media becoming "the second order paramount reality" [(Silverstone, 2002): 763]. From a postphenomenological perspective, technologies have even lost their mediation role since they are no longer "between" humans and their world, as they merge with the human body and experience (Verbeek, 2012). An alternative approach is to address everyday life as a space or an intersection that overcomes different dualisms and dichotomies of the modern thought, e.g., between mind/body, abstract/concrete, immediate/mediate, or ordinary/extraordinary (Sandywell, 2004). This also applies to lived experience whose immediacy and bodily nature is an important but not the only possible characteristic, particularly under and after postmodernism.

From a methodological point of view, it is important to note that despite their immediacy, human experiences can be represented and studied as such, e.g., as textual representations of the lived experience of femininity [(McRobbie, 2003): 153], or visual representations produced by the study participants that represent specific aspects of their human experience (Lenette and Boddy, 2013).

One could argue that the emphasis on immediacy and embodiment goes to the core of HRI research. Robots are typically physically embodied systems, and the way human-robot interactions and human behaviours are understood and studied in HRI involves a significant degree of spatial and temporal immediacy. In other words, while HRI research often recognises the potential of robots to impact our everyday life as a whole, in practice, when studying human daily life with robots, the HRI studies typically address a close proximity and direct interaction with robots. We propose this is a major area for developments and experimentation in HRI, when addressing long-term human engagement with robots outside the laboratory and online settings. This may include an overall gradual shift from studying "interaction," "interaction experience," or "user experience" towards developing a more holistic view of "lived experiences" on both an individual and societal level. Such an approach requires attention for the factors that go far beyond a person's past or present immediate experiences involving robots, or a related novelty effect, and addressing people's "life-worlds" instead.

4.3 Situatedness and tangibility

When discussing lived experiences in SSH in connection to the immediacy and bodily nature of such experiences, the emphasis is also on the situatedness of lived experiences in a concrete space and time. What follows is a focus on "concrete persons" and a "concrete world" (Gardiner, 2000; Heller, 2015) that are always located within specific sociohistorical and material conditions (as against theorising an abstract, disengaged and purely cognitive relation a person may have with the Other and a related lived environment [(Gardiner, 2000): 48-50]). Also, the emphasis on the 'concrete' involves focusing on "life-worlds" that refer to the worlds of daily existence and reality of specific persons (Sandywell, 2004), with a particular attention for "action" or "practice" that largely contribute to the content and structure of everyday life (Schutz and Luckmann, 1973; Heller, 2015). This has important methodological implications for SSH research (and potentially HRI), since at least in principle, "if anything, everyday life is certainly 'visible', and therefore observable" [(Sztompka, 2008): 24]. At the same time, as already mentioned, routinised or habitual elements of everyday life can be difficult to grasp or articulate due to their quality of being largely outside of the conscious thought (Weiss and Hannibal, 2018). While the term "situatedness" has been well-established in robotics as it points to robotics systems existing in and being affected by complex, dynamic environments (Matarić, 2006) (and in HCI, particularly through Suchman's early ethnomethodological research on situated actions (Suchman, 1987; Suchman, 2007)), in HRI, a situated character of everyday experiences typically translates into the subject of "contextualisation." While still limited in number and scope, more and more HRI studies have been addressing different contextual factors that play a role in human actions, attitudes and the related use of robots, from individual features and backgrounds, through the accompanying social dynamics, to wider socio-cultural contexts (Lee et al., 2022). The process of contextualisation may also refer to the development of situated understanding of robots that emerges from the real-world interactions (Šabanović, 2010) or the need to interpret research results within larger HRI multidisciplinary frameworks inclusive of SSH (Seibt et al., 2021). This offers multiple new topics and lines of inquiry, e.g., into socially-situated HRI (Chang and Šabanović, 2015) or feminist perspectives on the embodied and gendered user experience in HRI (Winkle et al., 2023a). From this perspective, contexts and situations can be understood not as "static containers for ideas, thoughts, and interactions" [(Linell and Valsiner, 2009): 16] but rather as resources that "dynamically change with the participants' communicative and cognitive activities" (ibid.). The question is how to investigate these subjects in a way it helps advance not only the field of HRI but also the SSH-driven critique of the contemporary everyday life.

4.4 Sociality

Given the broad cross-disciplinary consensus on that humans are social beings (Enfield et al., 2006; Goodwin, 2018; Lee et al., 2022), human everyday life has often been seen as inherently and explicitly "social." It has been argued that "the reality of the everyday life-world is a social reality" [(Pedersen, 2016): xxx], where human sociality is not just complex but also under many aspects "special" (Enfield et al., 2006). In other words, "the social world is nothing other than an interpersonal field, an inter-human space. . . this embeddedness of human beings in the relationships with other human beings occurs nowhere else but in our everyday experiences" [(Dumouchel and Damiano, 2017): 30]. From this perspective, human life-worlds are neither private nor public but shared, i.e., built upon intersubjectivity and common experiences [(Pedersen, 2016): 68]. Lived experiences in particular may contain specific forms of sociality, i.e., "various forms of the experience of others" [(Pedersen, 2016): 27]. Of course, the concept and experience of sociality and human embeddedness in larger social structures continues to change, particularly in the present age of radical individualisation (Sztompka and Burawoy, 2011). Also, the very understanding of what makes a given domain or activity private or public is highly culture-specific, and the notion of privacy is being constantly redefined as the use of different digital technologies increases. In any case, the key focus of the SSH analyses of everyday life is on "the social," and it is also the crucial aspect of HRI research. It has been argued that investigations of human interactions with social robots, and hence, social interactions, is what constitutes the core of HRI and makes it unique as a discipline (Bartneck et al., 2020). This includes studies of what makes human-robot interactions a "social experience" and how to deliver it (Burch, 1990; Husserl, 2002), and occasionally the studies that explicitly address people's experiences of living with social robots in home settings (Heidegger, 1967; Sarte, 1984; Huang and Huang, 2021). However, assessing people's lived experiences regarding social robots is a difficult task with multiple variables and perspectives involved (de Beuvoir, 1953) that is yet to be fully addressed in HRI. The challenge is not only in developing suitable theoretical and methodological frameworks but also in recognising the importance of people's lived experiences as such (rather than, e.g.,. prioritise designers' and developers' technical expert knowledge (Miller et al., 2021)) and systematically addressing such experiences in their whole richness and complexity within wider socio-cultural contexts (Prus, 1996; Merleau-Ponty, 2012).

5 Towards HRI of everyday life

Given its scope and diversity, developing a conceptual framework for studying everyday life in HRI is not an easy task and it needs to be undertaken carefully. For example, the ELCA approach explicitly refrains from pointing to what to focus on when investigating human-robot interactions in the everyday (Weiss and Hannibal, 2018). At the same time, if it is true that social robots "sooner or later" will become a part of our daily life, incorporating everyday life into HRI is also inevitable. Far from claiming that this a complete or even approximate framework, we discuss here the key dimensions that we find essential for further conceptualisation of everyday life in HRI as a distinct research theme. While building upon the existing SSH theories of the everyday, in this section we aim to envision those aspects or elements of everyday life that due to the presence of social robots will become significantly altered, new or "extraordinary." It is also social robots with their specific applications, capabilities and limitations that will ultimately delineate boundaries for the otherwise infinite the human everyday we aim to address. Given a very limited presence of the actual social robots in our lives to date, and their significant novelty, research into human-robot daily life will require moving away from studying everyday life as the domain that is well-known and self-evident, towards 'stepping into the unknown' (just as any time when addressing "questions of change, futures and anticipated but as yet not experienced alterities" [(Pink et al., 2020): 135]). From this perspective, the HRI of everyday life focuses not on the everyday as we know it but as we make it.

5.1 Multi-sitedness

As discussed above, everyday life has typically been viewed in HRI as synonymous with a domestic life. It important to note however, that while home as a space and concept often holds a particular significance in people's lives, our everyday life is multi-sited (Bakardjieva, 2005). This is particularly important in a situation where a distinction between the private and public is increasingly blurred, and the very notion of a household or what we consider a family and couple changes (Beck, 2001). Also, in the contemporary society, daily life has been increasingly taking place in virtual or otherwise technologicaly-mediated spaces, including 'no-places' such as the internet. While multi-sited approaches are well-known in SSH, particularly in ethnographic research (Hasse, 2019; Pink et al., 2020), choosing specific sites for analysis is far from being a trivial task, and should always involve participation of the persons whose lives we actually study. Perhaps a useful analogy in this context that comes from the SSH research is that of 'horizons'. In general, the term 'horizons' refers to frameworks or temporal and spatial perspectives within which people construct the meaning and value of their actions in the world [(Gardiner, 2000): 21; (Taylor, 1989): 27], or the "inner and outer horizons" of all everyday experiences [(Schutz and Luckmann, 1973): 167] (or a "double horizon" of both external and bodily space described by Merleau-Ponty, as discussed in (Katz and Csordas, 2003)). On the one hand, using a horizon analogy includes looking at everyday life in terms of one's immediate experiences and limits within particular "life-worlds"; on the other hand, it also points to the potential and possibilities for human action beyond the life horizon (Schutz and Luckmann, 1973; Pickering, 2004; Bakardjieva, 2005). The use and presence of social robots may potentially challenge and redefine the existing inner and outer horizons in people's daily lives and link a number of dimensions our lives are made of into entirely new configurations. Also, we propose to have as a main frame of reference not a "site" understood as a specific geographical location but rather a "living space" of a person involved. Since human living spaces are inherently symbolic spaces (Seibt et al., 2021), they refer not only to spaces people and robots (will potentially) literally cohabit, where robots bring new meanings and values into such environments (Šabanović, 2010) but also social, moral, topical and other types of individual and common spaces, whether already existing or possible in future (Taylor, 1989; Taylor, 2002), that together constitute what a person experiences as 'life'.

5.2 Human subjects

With an increasing importance of the studies "in-the-wild," HRI research often involves human subjects. The term "human subjects" can be seen as synonymous with that of "participants" in this context (the two have often been used interchangeably, including in sociology (Giddens and Griffiths, 2006) or in different research ethics guidelines (Winkle et al., 2023a)) as it refers to the "real life people," or "living individuals" that are directly involved in the studies (Bruckman, 2002). Given the focus on the people's everyday experiences, we propose to address the study participants in HRI as 'subjects' in a wider sense, particularly in line with the classical sociological conception of the subject that to a large extent refers to the "person" (Black, 2000). Interestingly, in HRI community too there have also been discussions about how to conceptualise what is meant with 'human subject' in relation to their role (e.g., (Onnasch and Roesler, 2021; Lee et al., 2022)) and in broader terms of participation practices in HRI research (Winkle et al., 2023b). Without neglecting the intersubjectivity aspects, different sociological perspective follow the assumption that human beings are "acting and experiencing individuals" [(Overgaard et al., 2009): 101] who play an active role in shaping their own existence and giving meanings to the experiences such an existence involves. The emphasis on human subjects also allows contextualising the subject within the concrete historical reality a given person is part of [(Wieviorka and Tomasi, 2001): 82], and concrete biographic contexts. On the one hand, the key characteristic of the subject is its capacity to, at least in principle, assert personal liberty and ability to choose, while combining the universal with the particular; on the other hand, the notion of the subject points to the inherently social and intersubjective character of human condition, since "there can be no personal subject without the recognition of the subject in the Other" [(Wieviorka and Tomasi, 2001): 83]. From an analytical point of view, the focus on the human subjects allows a number of perspectives, e.g., a focus on the subject's activity and individual practices located within larger institutional and collective frameworks, or the study of the corporeal subject and the body as its integral part [(Wieviorka and Tomasi, 2001): 83]. It also emphasises the need to look at the actual lived experiences and meanings they have for the people and communities involved in daily life, including life with social robots. Finally, the emphasis on human subjects is well-suited for the analysis of everyday life understood in terms of 'life-worlds'.

5.3 Community focus

In order to advance our understanding of human daily life with social robots we emphasise the need to conduct HRI studies that focus on a "community." This is because human existence in the real-world is of course always a social existence to a varying degree. Thus, in order to be accurate, HRI studies "in-the-wild" should involve more than robot interactions with single end-users to start with. We view the notion of community as more useful as, e.g., groups in this context as it allows explore unique characteristics and experiences social robots offer in their capacity for human-like engagement with people. Also, bringing focus to communities is part of the efforts to conceptualise the everyday as a reality involving concrete persons and circumstances, as opposed to "generalizable humans" (Lee et al., 2022), the approach that dominates HRI research. From an analytical point of view, community can be understood as a social unit, a process, or a way of life. The notion and experience of community inevitably changes as the human condition does (it is also one of those concepts that have long been declared dead by sociologists and yet it continues to return) (Day, 2006). For the purposes of this work, it important to note that community can be conceived as "an active process through which individuals and groups strive to realise their potential" [(Day, 2006): 21]. Also, community typically involves a sense of belonging to place and having one's identity "wrapped up" within one's community. This is in a situation where community is firmly embedded in the daily life of social actors involved, as it plays an important role in organising people's day to day living (Day, 2006). Across different perspectives, the concept of community has often been associated with a notion of 'a good life' or otherwise positive experience (Taylor, 1989; Bauman, 2000; Day, 2006) (the approach sometimes criticised for being overly romantic when discussing traditional communities and their disappearance [(Day, 2006): 32] (Bauman, 2000)). Some works that have explicitly used such a notion in relation to social robots have also argued that the concept of a good life in this context should be understood as "a rich social life" [(Brand et al., 2023): 166]. Last but not least, communities can be seen as social and symbolic constructs that are "constituted by processes occurring close to the experience of everyday life" [(Day, 2006): 159]. From this perspective, it is people's feelings and experiences that are the key defining characteristics of the community. The core of the communities are the processes of differentiation and identification, which includes identifying or imagining those who do and do not belong to the community based on a given criterion of similarity (Day, 2006).

On the one hand, community can be viewed as a taken-for-granted reality, and a stable setting for everyday social relationships; on the other hand, community can also be actively pursued and used as a framework for imagining and striving for a better life [(Day, 2006): 25]. Particularly in the contemporary times, definition and participation in a community becomes increasingly a matter of an individual choice and a conscious strategy rather than structural or institutional factors (Day, 2006). Therefore, we propose to conduct HRI studies that explore new elements that bring people together and serve as a common identifying criterion when dealing with social robots in daily life. More specifically, in a situation of an ever-increasing division, plurality and heterogeneity of the contemporary communities and societies as a whole, one could be asking if social robots can play a potentially unifying vs. diversifying role, or whether the realm of the everyday really is where people become "truly *human* persons" [(Gardiner, 2000): 2] [italics original]. This is because a largely unique feature of everyday life with social robots may be the role such robots will have in bringing our attention to otherwise taken-for-granted human qualities, and potentially redefining our understanding of what it means to be a human subject on both an individual and collective level. In other words, as part of the HRI research agenda, we propose to investigate whether a sense of humanness, as defined and experienced when sharing a daily life with social robots, can constitute an new basis for a "human togetherness" (Schloßberger, 2016) and provide a holistic perspective in the otherwise fragmented and individualised contemporary communal life.

5.4 Everyday in making

Both SSH and HRI research are highly ambitious in their attempts to address and analyse the overarching realms of "everyday life" and "real-world" respectively. In practice however, it is possible to address only fragments of these complex and dynamic realties, and construct selective representations of the phenomena we study. The question is, e.g., not only how to increase and facilitate longitudinal studies in HRI (De Graaf et al., 2017; Ostrowski et al., 2022) [in a situation where a long-term fieldwork becomes generally less and less feasible as much for researchers as the study participants involved (Pink et al., 2020)] but also how to conceptualise and empirically investigate the everyday in a way we consider sufficiently accurate and explanatory. The very role of study participants also changes, as it has been increasingly accepted that research should be conducted "with" rather than "about" people (Pink et al., 2020) [the idea underlying participatory approaches in HRI (Šabanović, 2010)], with people actively contributing to the construction of research findings that concern them. Even when reducing the scope to studying people's lived experiences that involve social robots, one faces multiple social, practical and technical constraints and choices that often lead to only a quick and narrow glimpse into the human everyday life. That we can only obtain approximations of the phenomena we study is of course not unique to the field of SSH or HRI (Newell, 1982; Niiniluoto et al., 1986). In the case of HRI research, the challenge is even greater as to a large extent it involves investigating and envisioning "the future" rather than the actual everyday with social robots as it is now. The condition of not knowing that underlies any investigations of the future implies that research becomes a matter of "making" rather following a predefined research design (Pink et al., 2020). Therefore, we propose to conceptualise everyday life in HRI not as a domain that is largely familiar and taken-for-granted, and where social robots are supposed to 'fit in' to a varying degree, but rather as a territory for research and social experimentation like never before. Also, research into human-robot futures will need to consider all the challenges, risks and ethical dilemma that potentially come with it (the issues that the HRI community has to some extent already been reflecting on, particularly with regards to good scientific practices and search for disciplinary guidelines (Rosén et al., 2021)). By fully embracing the need to "step into the unknown" (Pink et al., 2020), both in terms of theories and methods used, HRI researchers would open the doors for exploiting the novelty or "extraordinary" elements that come with social robots, and embracing 'the unexpected' that is inherent to the HRI research "in-the-wild" (Lee et al., 2022).

6 The old/new everyday

In the HRI field, the human everyday social and physical world has often been considered 'real' or "natural." In particular, conducting studies "in-the-wild" is viewed as useful in that they allow addressing "natural" human behaviours and interactions with robots (Lee et al., 2022) as well as the circumstances that are also defined as "natural" [(Bartneck et al., 2020): 144]. The investigation of "natural" human environments or interaction settings has often been explicitly linked with the use of robots in everyday life (Šabanović et al., 2014a; Rosenthal-von der Pütten et al., 2016). Many HRI studies address "human nature," which involves the tendency to represent humans as "generalizable humans" (Lee et al., 2022). The very "natural interactions" between robots and humans have sometimes been seen as synonymous with "*normal interactions in everyday life*" [(Ferland et al., 2013): 118][italics original]. In its capacity to point to the "normal," "everyday" and essentially "human," the term "natural" (or the notion of a "real-world") is often taken-for-granted in HRI (or in SSH when, e.g., referring to "real social life" [(Linell and Valsiner, 2009): 5]). It is important to note however, that any assumptions about what is "natural" or "normal" for people immediately pose a whole range of questions and ethical dilemma, particularly regarding inclusion criteria. The very notion and experience of humanness is of course by no means homogenous, and different related claims of its universality have been questioned (Tharoor, 1990; Peterson, 2001; Valentine, 2017). At the same time, current robotics technologies are expected to bring profound changes across different domains, the process that in turn is viewed as part of larger fundamental transformation taking place in our society which includes the emergence of "a new kind of everyday life" [(Beck, 2001): 262].

Therefore, we argue here that if we agree that everyday life is not a fixed feature of social life [(Gardiner, 2000): 10], the next important role for HRI research may include not only helping conceptualise and systematically study human daily life with social robots but also engaging in a critique of the contemporary everyday life. Among its different meanings (Anker et al., 2017), we use the term "critique" to denote a specific method and type of argument made in academia with the goal to bring a social and political transformation. In particular, we propose to develop a critical approach and mode of inquiry that would be grounded in the unique features, capabilities and empirical insights of the HRI research. From this perspective, a primary role for HRI research could include contributing to a "diagnose" of the current everyday, and ultimately contribute to our quest for "a good" (or "better") life. Thus, in addition to studying human-robot interactions, one could be asking what are the big themes that HRI can shed light on that point to those aspects or elements of everyday life that need to be improved? For example, the use and presence of social robots has often been discussed in the context of a growing social isolation taking place in techno-capitalist societies (Šabanović, 2010; Ananto and Young, 2021). Another example of a critical HRI inquiry includes recent developments in the "Feminist HRI" (Winkle et al., 2021; Winkle et al., 2023a) or reflections on human adaptation (or a lack of thereof) to life with robots (Harrison and Johnson, 2023). What are the other aspects of not so much "human nature" as of the contemporary human condition that HRI and social robots could potentially unmask and transfigure? In the times of the increasing "homogenization of the concrete particularities of the everyday lifeworld" [(Gardiner, 2000): 13], but also "the confrontation with fundamental differences everywhere and the necessity to live (with) these contradictory certainties somehow" [(Beck and Tomasi, 2001): 189], what are the potential implications of exploiting the similarities vs. differences between "the human" and "the human-like" that come with social robots? As discussed above, familiarity in everyday life is usually graspable in the negative [(Schutz and Luckmann, 1973): 159], i.e., when familiar elements suddenly become unfamiliar to us, and before the "new" becomes "old." Thus, if we agree that critical thinking is "part of the everyday experiences of individuals forced to negotiate between conflicting spheres of value in complex societies" [(Anker et al., 2017): 14], then we may see how a critique of everyday life can be pursued with the use and presence of social robots that often call into question our existing views of what is "normal" in daily life or what it means to be human. One could argue that as much as contemporary technologies challenge any fixed concept of humanness (Capurro et al., 2006; Miah, 2008), when confronted with highly human-like AI and robotic systems, people tend to unite and perceive themselves as universally "human." Particularly when considering threats inherent to emergent technologies such as AI, the notion of "human" has often been used in affirmative terms, leading to the creation of a new type of solidarity among humans ("us") as opposed to "them" (AI-enabled systems). From this perspective, everyday experiences with social robots may lead to new ways to identify as a human being, and new types of human communities. Of course, the implications of everyday life and human engagement with social robots can be not only beneficial but also problematic and should be addressed as such. For example, what contradictions or paradoxes may potentially arise in people's everyday lives when shared with social robots? What would be the best course of action to deal with unexpected effects of robotisation?

It is important to note that since critique is typically characterised by a high degree of self-reflexivity, the matters that are particularly suitable for a critical analysis are those that appear to be self-evident: "Whatever is natural, taken for granted, essentialised or transparent become the critic's target: such qualities are seen as not only theoretically inadequate (in failing to acknowledge the linguistic and cultural construction of reality), but also politically troubling (in "naturalizing" social phenomena and thereby rendering them immune to criticism and change)" [(Anker et al., 2017): 8]. We argue here that engaging with the critique in the HRI field would be instrumental not only in helping bring a desired social change but also critically examine its own underlying assumptions and normative beliefs. The need for a critical analysis will be even greater the moment social robots become 'transparent' or invisible in our everyday lives (if ever), just as some other technologies that disappear from human experience and focus (Verbeek, 2012). A unique potential of HRI research is in uncovering meanings and phenomena through empirical analysis rather than only a specific mode of reading or interpretation that critique typically relies upon.

As already mentioned, in principle critique is not only a specific research tool or theory but also a practice that requires taking an explicit ethico-political stance, and a commitment to bringing social and political change [(Gardiner, 2000): 9][(Anker et al., 2017): 13]. While it has been increasingly recognised that HRI research should be ethically- and socially-engaged (Arnold and Scheutz, 2017; Vallès-Peris et al., 2018; Lee et al., 2022), a discussion of a political role that HRI may play however (not just of the political issues social robotics technologies may cause), is yet to take place. In other words, what are the political motivations, goals and interests for HRI as a field and community, and how can it make a political difference, if any? In line with recent developments in the area of critical studies (Anker et al., 2017), critique can be seen not just as a form of opposition or negation but rather an active and purposeful response to a given problem. One could argue that given the enormous efforts and expectations placed in robotics technologies, along with the related cross-sectorial involvement of a variety of public and private actors, social robots and HRI can have a very real and powerful impact on the current political and social world. To what extent such an impact will actually materialise, and whether it will be positive, is yet to be seen. However, the potential of social robotics to change people's everyday lives can certainly serve as both strong motivation and a fascinating challenge in the current HRI research.

7 Conclusion

In order to further advance HRI research, there can be no HRI studies of human daily life with robots without systematically addressing and conceptualising the key problems of the everyday as it unfolds in the "real-world." At the same time, there can be no empirically-grounded SSH research on social robots without actually engaging with robotics technologies and related disciplines. This is why there is a need and great potential in combining HRI and SSH perspectives and using such a combination as a basis for further developments of uniquely new approaches dedicated to the theme of everyday life and human lived experiences with social robots. The questions we have posed here can be seen as part of calls for pursuing HRI research that is socially-engaged (Lee et al., 2022) or a critical examination of tacit values and underlying socio-cultural factors that to a large extent shape the design and use of robots (Šabanović et al., 2014b; Šabanović, 2014; Čaić et al., 2018). In particular, the point that we have hoped to emphasise is that HRI research has the potential to significantly expand its range of theoretical and methodological perspectives, role and ultimately political commitments, to help conceptualise, study and actively create the old/new human everyday with social robots grounded in what we all consider a communal "good life".

Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding authors.

Author contributions

KZ conceptualised and wrote the manuscript while GH contributed to its structure and drafted several sections. From continous rounds of feedback and discussion, both authors read and revised the manuscript before approving the submitted version. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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"Ick bin een Berlina": dialect proficiency impacts a robot's trustworthiness and competence evaluation

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Background: Robots are increasingly used as interaction partners with humans. Social robots are designed to follow expected behavioral norms when engaging with humans and are available with different voices and even accents. Some studies suggest that people prefer robots to speak in the user's dialect, while others indicate a preference for different dialects.

Methods: Our study examined the impact of the Berlin dialect on perceived trustworthiness and competence of a robot. One hundred and twenty German native speakers (M_{age} = 32 years, SD = 12 years) watched an online video featuring a NAO robot speaking either in the Berlin dialect or standard German and assessed its trustworthiness and competence.

Results: We found a positive relationship between participants' self-reported Berlin dialect proficiency and trustworthiness in the dialect-speaking robot. Only when controlled for demographic factors, there was a positive association between participants' dialect proficiency, dialect performance and their assessment of robot's competence for the standard German-speaking robot. Participants' age, gender, length of residency in Berlin, and device used to respond also influenced assessments. Finally, the robot's competence positively predicted its trustworthiness.

Discussion: Our results inform the design of social robots and emphasize the importance of device control in online experiments.

KEYWORDS

competence, dialect, human-robot interaction, robot voice, social robot, trust

1 Introduction

1.1 Factors influencing robot's acceptance

Social robots are becoming more common in various social aspects of human life, such as providing interpersonal care, tutoring, and companionship (Belpaeme et al., 2018; Bendel, 2021; Breazeal, 2017; Broadbent, 2017; Zhou and Fischer, 2019; for review, see e.g., Cifuentes et al., 2020; Woo et al., 2021; Henschel et al., 2021). Unlike most manufacturing or surgical robots, a social robot is designed to have a physical body and interact with humans in a way that aligns with human behavioral expectations

(Bartneck and Forlizzi, 2004). Specifically, a humanoid robot is a type of a social robot with a body shape resembling a human, including a head, two arms, and two legs (Broadbent, 2017). According to Bendel (2021), social robots are sensorimotor machines created to interact with humans or animals. They can be identified through five key aspects. These are non-verbal interaction with living beings, verbal communication with living beings, representation of (aspects of or features of) living beings (e.g., they have an animaloid or a humanoid appearance or natural language abilities), proximity to living beings, and their utility or benefit for living beings. The assumption is that an entity is a social robot if four of these five dimensions are met. It can be hypothesized that the ability to speak and the voice used are likely to be among the central features of social robots. The present study focused on the role of speech to better understand social interactions with robots.

Which factors affect whether a person accepts a robot as a social interaction partner? Some of these factors include human-related aspects such as previous exposure to robots, the age and gender of the person interacting with robots (Broadbent et al., 2009; Kuo et al., 2009; Nomura, 2017; but also see Bishop et al., 2019; for a review, see Naneva et al., 2020). While it is generally observed that increased exposure to social robots corresponds to more favorable attitudes toward them, the evidence regarding age and gender as factors influencing acceptance is inconclusive. Previous studies suggested that older individuals and females tend to have less positive attitudes toward robots (Kuo et al., 2009; May et al., 2017). However, a systematic review (Naneva et al., 2020) contradicted this conclusion. According to this analysis, age and gender do not appear to have a significant impact on acceptance of social robots. Additionally, personality features might also play a role. According to Naneva et al. (2020), there is a positive correlation between acceptance of robots and the personality traits of agreeableness, extroversion, and openness, while conscientiousness and neuroticism do not appear to have any significant impact (Esterwood et al., 2021).

Apart from some human-related factors discussed above that could impact robot acceptance, many other factors that potentially influence human-robot interaction outcome concern the robot itself, including the purpose it is used for and its appearance. Whereas multiple studies demonstrated that users prefer human-like robots (Esposito et al., 2019; 2020), the systematic review by Naneva et al. (2020) could not find clear evidence for that. Here, we focus on some robot-related factors, in particular its voice, to motivate a novel research question, as will be reviewed in the next few paragraphs.

1.2 Anthropomorphism in robot design and its impact on interaction

People tend to ascribe human traits to non-human entities. There are two aspects to consider. Firstly, users attribute certain human behaviors to the robot by projecting their own expectations onto it. Secondly, individuals intentionally program the robot with human behaviors. Companies provide robots with a variety of physical appearances and voices that differ in gender, age, accent, and emotional expression, to cater to a wide range of needs and preferences of their users (Epley et al., 2007). An anthropomorphic robot design enables a more natural interaction with robots because people can rely on behaviors familiar from human-human interactions (Clodic et al., 2017). Moreover, a humanoid appearance results in more positive evaluation of the robot (Biermann et al., 2020).

1.3 Robot's voice in trust and competence evaluation

To have a productive interaction, humans need to have confidence in and trust a social robot (Marble et al., 2004). Trust can influence the success of human-robot collaboration and determine future robot use (Freedy et al., 2007). In human-human interactions, trust has been the subject of extensive research (Dunning and Fetchenhauer, 2011). Crucially, multiple studies have indicated that trust does not necessarily result from a logical evaluation of the probabilities of different outcomes and benefits involved in a given situation. Rather, it seems to stem from non-rational factors, such as feelings and emotions. Factors that contribute to trust are linked to the attributes of both the person, the circumstances, and their interplay (Evans and Krueger, 2009; for review see Thielmann and Hilbig, 2015). In particular, being part of the same group can heighten trust levels (Evans and Krueger, 2009).

Trust in human-robot interaction is defined as "the attitude that an agent will help achieve an individual's goals in a situation characterized by uncertainty and vulnerability" (Lee and See, 2004) or as "the reliance by an agent that actions prejudicial to their wellbeing will not be undertaken by influential others" (Hancock et al., 2011). These definitions imply that humans who trust a robot believe that it will not harm them or can be relied on in fulfilling tasks (Law and Scheutz, 2021).

Although numerous factors can impact trust in artificial agents (as demonstrated by Schaefer et al., 2016; Hancock et al., 2011 in their respective meta-analyses; for systematic review see Rheu et al., 2021; Law and Scheutz, 2021), the voice of a robot is considered one of the most critical factors in determining trust specifically related to robots.

In a questionnaire study conducted by Dautenhahn et al. (2005), most of the respondents expressed a desire for a robotic companion that can communicate in a way that is very similar to a human. Individuals also tended to get closer to a robot that had a human-like voice, in contrast to a robot with an artificially synthesized voice (Walters et al., 2008). Human-like voices were perceived as less uncanny and rated higher in terms of qualities such as sympathy, credibility, and trustworthiness (K. Kühne et al., 2020). Robots that had human-like voices were considered to be more efficient and were remembered more easily (Rodero, 2017). Finally, artificial agents with a human-like voice were perceived as more competent and credible (Sims et al., 2009; Fischer, 2021; Kim et al., 2022).

Competence is another attribute that is often intuitively assessed in everyday interactions (Kovarsky et al., 2013; Abele et al., 2021). The Behavioral Regulation Model defines confidence as the likelihood of task achievement (Ellemers et al., 2013). Alongside warmth, confidence underlies social evaluation and relies on such features as power, status, and resources (Rosenberg et al., 1968). In human-robot interaction, competence was one of the most important predictors of human preferences between different robot behaviors (Oliveira et al., 2019; Scheunemann et al., 2020). Also in evaluating competence, human-likeness in the robots' appearance played a major role (Goetz et al., 2003; Kunold et al., 2023).

It is important to note that there is a significant association between competence and trust (Hancock et al., 2011; Kraus et al., 2018; Steain et al., 2019; Christoforakos et al., 2021). Individuals have greater trust in a robot when they perceive it to be more competent.

1.4 The uncanny valley phenomenon and its relation to a robot voice

One caveat in robot design is that incorporating too much human-likeness may result in the uncanny valley phenomenon. As shown by Mori (1970), the level of robot acceptance drops and a sense of eeriness or discomfort arises, once a certain level of human-like visual resemblance has been reached. Although there is currently no evidence of an uncanny valley for robotic voices (K. Kühne et al., 2020), it is premature to completely dismiss or exclude this possibility.

Assigning gender to a robot through appearance and voice can enhance its human-like qualities and influence its acceptance. For example, a female-sounding robot speaking in a higher tone received higher ratings for attractiveness and social competence (Niculescu et al., 2011; 2013). However, this effect can be influenced by the gender of the participants: Participants of the same gender as the robot's given gender identify themselves more with the robot and feel closer to it (Eyssel et al., 2012). The process at work here is a tendency to favor those within one's own group (in-group-bias; Tajfel and Forgas, 2000), which may extend to other facets of communication, such as a particular way of speaking or adopting regional language variations (Delia, 1975).

Another way to enhance the human-likeness of a robot's voice is by incorporating an emotional tone or a particular dialect. Thus, robots with an emotional voice were found to be more likable (James et al., 2018). Researchers added a Scottish accent to Harmony, a customizable personal companion agent, in order to enhance her likability and charm (Coursey et al., 2019). Nevertheless, imparting a human dialect to a mechanically looking robot bears a risk of creating an uncanny valley effect (Mitchell et al., 2011). Therefore, we briefly review what is known about this mechanism of influence.

1.5 The impact of dialect-related social classifications and group identity

Interestingly, dialect-related social classifications and the sense of being part of a group based on accent or dialect are more robust than those resulting from gender or ethnicity (Kinzler et al., 2010). A dialect or accent refers to how individuals from diverse regions or social groups articulate words and phrases, leading to differences in their accent and speech patterns. While dialects and accents are interconnected, they are not identical. Dialects encompass a wider range of linguistic aspects, including vocabulary, grammar, and sentence structure, whereas accents primarily involve differences in pronunciation (Sikorski, 2005; for more detailed information on the topic of accent and dialect, see Planchenault and Poljak, 2021).

Evidence of the influence of dialect on the trust or competence of a robot is mixed. In general, according to the similarity-attraction theory, individuals tend to prefer artificial agents similar to themselves, for example, in terms of personality (Nass and Lee, 2000). However, similarity on a more superficial level, such as gender, was not found to predict trust (You and Robert, 2018).

In addition to identifying the speaker as a member of a particular geographical or national group, a dialect can also elicit favorable or unfavorable connotations and shape opinions about the speaker irrespective of the own group (H. Bishop et al., 2005). Listeners are sensitive to sociolinguistic information conveyed by a dialect or an accent. The standard language is typically viewed as prestigious and reliable, whereas regional accents tend to be regarded more unfavorably (H. Bishop et al., 2005; Tamagawa et al., 2011), so-called "accentism" (Foster and Stuart-Smith, 2023). However, certain languages may also have esteemed regional variations or dialects (H. Bishop et al., 2005).

Prejudices against dialects and their speakers cannot be ignored, as evaluations of dialects are often associated with evaluations of the corresponding population (Wiese, 2012). A meta-analysis by Fuertes et al. (2012) revealed that a spoken dialect is perceived as a sign of lower intelligence and social class. According to Wiese (2012), individuals who do not use the standard language are often viewed as linguistically incompetent. Furthermore, Fuertes et al. (2012) found that a spoken dialect can lower the perception of competence in general.

There are conflicting findings regarding the effects of different dialects on the perception of robots. On the one hand, imparting the standard language to a robot was shown to increase its trustworthiness and competence (Torre and Maguer, 2020). As an example, only around 4% of Torre and Maguer's (2020) participants wanted the robot to have the same accent as they had, whereas 37% preferred a robot speaking the Standard Southern British English. Similar findings were obtained by Andrist et al. (2015): More native Arabic speakers complied with the robots who were speaking standard Arabic. For the dialect-speaking robot, the compliance depended on other factors. Namely, robots speaking with both high knowledge and high rhetorical ability were complied with more. Another study found that a synthetic agent with Austrian standard accent was perceived as possessing higher levels of education, trustworthiness, competence, politeness, and seriousness (Krenn et al., 2017).

On the other hand, robots speaking a dialect, in this case, Franconian, were rated as more competent (Lugrin et al., 2020). Unlike in Torre and Maguer (2020), the evaluation of competence depended on the participants' own performance in the dialect. Those who spoke in dialect more frequently rated the dialect-speaking robot as more competent. In contrast to that, V. Kühne et al. (2013) found that participants liked a dialect-speaking robot more, irrespective of their own dialect performance. In the same vein, a robot was accepted in Norwegian hospitals more when it spoke the Trøndersk dialect (Søraa and Fostervold, 2021). This preference could have been impacted by the comfortable and pleasant connotation conveyed by the Trøndersk dialect. To embrace these discrepancies, there is currently an ongoing project to develop an optimal language or accent for an artificial agent to speak (Foster and Stuart-Smith, 2023).

In summary, standard language-speaking robots were perceived as more trustworthy or likable presumably due to the in-group bias and accentism, while according to other studies, participants preferred robots that spoke with a dialect. However, the preference for dialect-speaking robots was often influenced by human-related factors, namely, the participants' proficiency or performance in that dialect (Lugrin et al., 2020).

Most of the research on the utilization of dialect in robots has been conducted in Anglo-Saxon countries (Früh and Gasser, 2018). As for German-speaking countries, V. Kühne et al. (2013) found that a Rhine-Ruhr dialect-speaking virtual robot was perceived as more likable. Another study by Früh and Gasser (2018) also reports more positive attitudes toward a dialect-speaking care robot Lio in Switzerland. Importantly, in Switzerland, a dialect serves strongly as a means of social demarcation. However, a most recent study with a service robot Pepper in a hotel context showed that using the local dialect did not affect robot acceptance and attitudes (Steinhaeusser et al., 2022). The study was conducted online and participants speaking the Flanconian dialect vs. standard German were randomly assigned to the dialect or standard language conditions. While there was a non-significant tendency for individuals who spoke a dialect to have a more negative attitude toward a robot that used that same dialect, this could potentially be attributed to the use of Pepper's text-to-speech plugin to synthesize the dialect and accent. People with a local accent may have been more likely to notice any mistakes or errors in the robot's synthesized speech, which could in turn have influenced their attitudes towards it.

To address the inconsistencies reviewed above, we conducted an online study among Berlin and Brandenburg residents in order to investigate the relationship between the participants' proficiency and performance in the Berlin dialect and their trust in a robot, and the robot's competence evaluation.

1.6 The present study

From 1500 onwards, the Berlin dialect emerged as a unique local language variety, replacing Low German in the region. The Berlin dialect is associated with the working class and often portrayed as a proletarian language by media figures who depict it as a dialect spoken by simple, but likable people. Additionally, the Berlin dialect is intentionally employed as a stylistic choice to establish a sense of closeness with a specific audience, as observed in its written representation in daily newspapers (Wiese, 2012). Specific features of the Berlin dialect can be found in Stickel (1997).

Dialect *proficiency* means the self-evaluated ability to speak the dialect, whereas dialect *performance* denotes the frequency with which the participants speak the dialect. We formulated six hypotheses for our study. The first hypothesis was that the standard German-speaking robot would be trusted more and evaluated as more competent than the dialect-speaking robot (H1). The next two hypotheses posited that participants with (H2) higher dialect proficiency and (H3) higher dialect performance would trust the robot more than those with lower dialect proficiency and performance. The fourth and fifth hypotheses were that participants with (H4) higher dialect proficiency and (H5) higher dialect performance would evaluate the robot's competence higher than those with lower dialect proficiency and performance. Finally, we expected that the robot's competence would predict the trust ratings (H6). Hypotheses H2—H6 were tested independently for the dialect-speaking robot (H2a, H3a, H4a, H5a, H6a) and the standard German-speaking robot (H2b, H3b, H4b, H5b, H6b) as alternatives. We tested these formulated hypotheses in an online experiment with German-speaking participants using the NAO robot.

2 Materials and methods

2.1 Participants and procedure

The experiment was programmed and run using the online Gorilla Experiment Builder research platform (Anwyl-Irvine et al., 2020) and lasted approximately 30 min. The participants were recruited via the subject pool system SONA at the University of Potsdam. All the participants submitted their informed consent at the beginning of the experiment by clicking the corresponding checkbox and were reimbursed with course credits for their participation. They were instructed to first watch a video and then answer the survey questions honestly and spontaneously. The type of the video (Berlin dialect or Standard German) was counterbalanced between participants. After the survey, the participants were asked to fill in a demographic questionnaire, including questions about their age, gender, native language, dialect proficiency, dialect performance, and duration of residence in Berlin. Finally, participants were debriefed and given a link to enter their internal subject pool ID for receiving a credit.

The study was conducted in accordance with the guidelines laid down in the Declaration of Helsinki and in compliance with the ethics policy of the University of Potsdam. No explicit approval was needed because the methods were standard. There were no known risks and participants gave their informed consent. The study and the procedure were already evaluated by professional psychologists to be consistent with the ethical standards of the German Research Foundation, including written informed consent and confidentiality of data as well as personal conduct.

An *a priori* power analysis was conducted using G*Power (Faul et al., 2007) to determine the minimum sample size required to test the study hypothesis. Results indicated the required sample size to achieve 80% power for detecting a medium effect, at a significance criterion of $\alpha = .05$, was $N = 68$ per robot group for linear regression with two predictors ($N = 136$ in total).

2.2 Stimuli materials

We used a video lasting 31 s, showcasing the humanoid robot NAO (Aldebaran—SAS)[1]. In the video, the robot was positioned on a table and was in motion while providing details about a painting situated in the top right portion of the wall. The painting was pixelated to avoid copyright infringement. A snapshot from the video is depicted in Figure 1.

1 The video material used was made and provided by Tristan Kornher, student at the University of Potsdam.

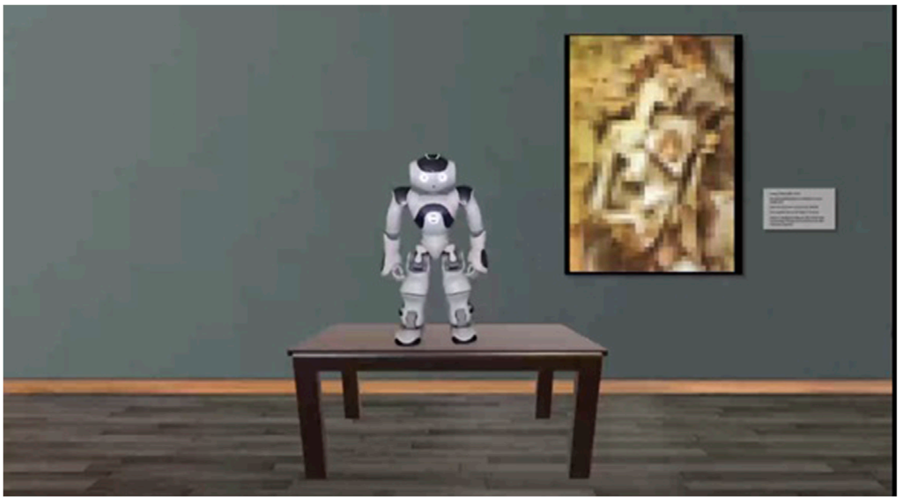

FIGURE 1
Screenshot of the Video Footage used *Note:* The artwork was pixelated in the videos to protect copyright. It is the painting *Girl with a Mandolin* by Pablo Picasso (1910).

The robot in the video used a male human voice to speak. The speech was recorded twice by the same speaker—once in standard German and once in the Berlin dialect. The transcription can be found in Supplementary Materials.

We opted to use a human voice based on earlier studies, which indicated that people prefer less robotic-sounding voices as they feel more at ease while listening to them (Dong et al., 2020; K; Kühne et al., 2020). Natural human voices are generally perceived as more trustworthy and competent compared to synthetic voices (Craig and Schroeder, 2017; Kühne et al., 2020; Sims et al., 2009). Moreover, listening to a synthetic voice can increase one's cognitive load (Francis and Nusbaum, 2009; Simantiraki et al., 2018) which, in its turn, can lead to trust misplacement (Duffy and Smith, 2014).

We selected a male voice because research suggests that NAO is more commonly associated with a male voice (Behrens et al., 2018). The stimuli can be found at: https://osf.io/pfqg6/.

2.3 Measures

2.3.1 Independent variables

2.3.1.1 Demographic factors

The following demographic factors were measured: age, gender, native language, and duration of residence in Berlin (in years).

2.3.1.2 Dialect proficiency

The dialect proficiency was measured using a single item: "How well can you speak the Berlin dialect?". The answers were given on a seven-point Likert scale from 1 (Not at all) to 7 (Very well).

2.3.1.3 Dialect performance

The dialect performance was measured using a single item: "In everyday life, I usually speak the Berlin dialect". The answers were given on a seven-point Likert scale from 1 (Does not apply at all) to 7 (Applies totally).

2.3.1.4 Device type

Device type was automatically measured by the experiment system as "mobile", "tablet", or "computer".

2.3.2 Dependent variables

2.3.2.1 Trust

We used the *Scale of Trust in Automated Systems* (Jian et al., 2000) to access the level of trust participants had toward the robot featured in the video. The scale consists of 12 items, measured on a seven-point Likert scale from 1 (Do not agree at all) to 7 (Fully agree), and was specifically designed to measure trust towards automated systems, such as robots. To suit the study's German setting, the items were translated into German, and the word "system" in each item was replaced with "robot" to better relate to the robot shown in the video. Sample items were: "I can trust the robot" („*Ich kann dem Roboter vertrauen*"); "The robot is dependable" ("*Der Roboter ist verlässlich*"). Supplementary Table S1 displays the original items and their corresponding German translations. Additionally, an extra attention-testing item was added to the scale, which instructed participants to choose response option 7 (Fully agree) as their response.

2.3.2.2 Competence

We used the *Robotic Social Attribute Scale* (RoSAS) (Carpinella et al., 2017) to measure the competence evaluation of the featured robot. The scale consists of 6 items, measured on a seven-point Likert scale from 1 (Do not agree at all) to 7 (Fully agree). Sample items were: "The robot is interactive" ("*Der Roboter ist interaktiv*"); "The robot is knowledgeable" ("*Der Roboter ist sachkundig*"). Supplementary Table S2 displays the original items and their corresponding German translations. Additionally, an extra attention-testing item was added to the scale, which instructed participants to choose the response option 1 ("Do not agree at all") as their response.

2.4 Sample and data pre-processing

One hundred and thirty-seven participants (94 females, 41 males, 2 non-binary), *Mean* age = 33 years, *SD* = 14 years) took part in the experiment. Eight participants were excluded from the analysis because their native language was not German. Nine participants were further excluded from the analysis because they failed the attention test items in both scales. This yielded the ultimate sample size *N* = 120 (*Mean* age = 32 years, *SD* = 12 years; 81 female, 38 male, 1 non-binary). Additionally, data from the TRUST items of two participants and data from the competence items of three participants were excluded because they failed the attention test items in the respective scale. The remaining data of these five participants was still used.

Data preparation and analyses were done using Microsoft® Excel® for Microsoft 365 and SPSS Version v.29 software package. Figures were built in R (R Core Team, 2020). The normality of the data distribution was confirmed using a *Kolomogorov-Smirnov* test. Before conducting the multiple regression analysis, the distributional assumptions for the multiple regression were assessed[2]. The regression analysis treated the gender category of "non-binary" as missing data.

3 Analysis and results

3.1 Trust

First, we employed a two-tailed independent samples *t*-test to examine the level of trust between the dialect-speaking robot and the standard German-speaking robot in all participants. Even though there was a minor trend in favor of trusting the standard German-speaking robot more (M = 4.716, SD = 1.259) than the dialect-speaking one (M = 4.591, SD = 1.056), this difference was not statistically significant (t (116) = −0.583, p = .561). Thus, we failed to confirm H1a. Participants did not trust the standard German-speaking robot significantly more than the dialect-speaking robot.

To examine if participants with higher dialect proficiency would trust the dialect-speaking robot more than those with lower dialect proficiency, we conducted a multiple regression analysis, using the enter method. In the first step, we added only dialect proficiency as predictor. In the second step, we added control variables: age, gender, duration of residence in Berlin, and device type. In line with the H2a hypothesis, only dialect proficiency explained a significant amount of the variance in the value of trust in the dialect-speaking robot (β = .272, t (60) = 2.189, $p < .05$, F (1, 60) = 4.792, R^2 = .074, R^2_{Adjusted} = .059). The dialect-speaking robot was more trusted by participants who were more proficient in the Berlin dialect.

We conducted another multiple regression analysis to see if participants with higher dialect performance would trust the dialect-speaking robot more than those with lower dialect performance. Again, in the first step, we added only dialect performance as predictor. In the second step, we added control variables: age, gender, duration of residence in Berlin, and device type. Contrary to the H3a hypothesis, dialect performance was not a significant predictor of trust in the dialect-speaking robot (β = .208, t (60) = 1.646, p = .105, F (1, 60) = 2.711, R^2 = .043, R^2_{Adjusted} = .027). Neither of the control variables contributed to the variance of trust neither.

In summary, for the dialect-speaking robot, only dialect proficiency was a significant predictor of trust. We confirmed H2a and failed to confirm H3a.

Further, we conducted a multiple regression analysis to test if participants with higher dialect proficiency would trust the standard German-speaking robot more than those with lower dialect proficiency. Again, using the enter method, in the first step, we added only dialect proficiency as predictor. In the second step, we added control variables: age, gender, duration of residence in Berlin, and device type.

Contrary to the H2b hypothesis, dialect proficiency did not explain the value of trust in the standard-speaking robot (β = .086, t (53) = 0.628, p = .533, F (1, 53) = 0.394, R^2 = .007, R^2_{Adjusted} = −.011). However, age, gender, duration of residence in Berlin, and device type were significant predictors of trust. The standard German-speaking robot was more trusted by individuals who were older, female, had a shorter duration of residence in Berlin, and used a computer device for watching the experimental videos.

Finally, we conducted another multiple regression to examine if participants with higher dialect performance would trust the standard German-speaking robot more than those with lower dialect performance. In the first step, we added only dialect performance as predictor. In the second step, we added control variables: age, gender, duration of residence in Berlin, and device type. Contrary to the H3b hypothesis, dialect performance was not a significant predictor of trust in the standard-speaking robot (β = .043, t (53) = 0.312, p = .757, F (1, 53) = 0.097, R^2 = .002, R^2_{Adjusted} = −.017).

In summary, for the standard German-speaking robot, age, gender, duration of residence in Berlin, and device type were significant predictors of trust, when together in model with dialect proficiency. We found no evidence for H2b and H3b.

The results are summarized in Table 1 and Table 2.

Figure 2 presents a visual summary of the outcomes obtained from regression analyses that assessed how dialect proficiency predicted trust in both the standard German-speaking and dialect-speaking robot.

3.2 Competence

Again, we used a two-tailed independent samples *t*-test to examine the level of competence between the dialect-speaking robot and the standard German-speaking robot in all participants. The findings were similar for the evaluation of trust. While there was a descriptive tendency to rate the standard German-speaking robot as more competent (M = 3.831, SD = 0.947) than the dialect-speaking robot (M = 3.777, SD = 0.999), the difference was not statistically significant (t (115) = −0.303, p = .763). Thus, we failed to confirm H1b. Participants did not evaluate the standard German-speaking

2 Multicollinearity was tested and rejected using VIF values ranging from 1.023 to 3.461 (substantially below the 10 threshold). Autocorrelation was absent, shown by Durbin-Watson statistics between 1.780 and 2.400 (within the acceptable range of 1.5–2.5). Normality of residuals was checked via P-P plots of standardized residuals.

TABLE 1 Results of the Regression Analysis on the Outcome Variable Trust with Dialect Proficiency as Predictor.

		Dialect-speaking robot				Standard German-speaking robot			
Model		β	*SE*	*t*	*p*	β	*SE*	*t*	*p*
1	Constant		0.227	18.401	<.001		0.315	14.457	<.001
	Proficiency	**.272**	**0.061**	**2.189**	**< .05**	.086	0.079	0.628	.533
R^2		.074				.007			
$R^2_{Adjusted}$		.059				−.011			
p		<.05				.533			
2	Constant		0.532	7.913	<.001		0.561	7.626	<.001
	Proficiency	.345	0.094	1.824	.074	.308	0.101	1.768	.083
	Age	.174	0.013	1.210	.231	**.426**	**0.015**	**2.916**	**<.05**
	Gender	−.144	0.306	−1.125	.265	**−.319**	**0.325**	**−2.528**	**<.05**
	Duration	−.179	0.078	−0.917	.363	**−.471**	**0.091**	**−2.537**	**<.05**
	Device	.082	0.266	0.645	.522	**.428**	**0.316**	**3.412**	**<.001**
R^2		.119				.325			
$R^2_{Adjusted}$		.040				.356			
p		.200				<.001			

Note: Dialect-speaking robot $N = 63$. Standard-speaking robot $N = 57$.
Method: enter. Significant results are marked in bold.

robot as significantly more competent than the dialect-speaking robot.

To examine if participants with higher dialect proficiency would evaluate the dialect-speaking robot as more competent than those with lower dialect proficiency, we again conducted a multiple regression using the enter method. In the first step, we added only dialect proficiency as predictor. In the second step, we added control variables: age, gender, duration of residence in Berlin, and device type. Contrary to the H4a hypothesis, dialect proficiency was not a significant predictor of competence in the dialect-speaking robot ($\beta = .047$, $t\ (60) = 0.363$, $p = .718$, $F\ (1, 60) = 0.131$, $R^2 = .002$, $R^2_{Adjusted} = -.014$).

To examine if participants with higher dialect performance would evaluate the dialect-speaking robot as more competent than those with lower dialect performance, we again conducted a multiple regression using the enter method. In the first step, we added only dialect performance as predictor. In the second step, we added control variables: age, gender, duration of residence in Berlin, and device type. Again, counter to the H5a hypothesis, dialect performance was not a significant predictor of competence in the dialect-speaking robot ($\beta = -.002$, $t\ (60) = -0.019$, $p = .985$, $F\ (1, 60) = 0.000$, $R^2 = .000$, $R^2_{Adjusted} = -.017$).

Neither of the control variables contributed to the variance of competence.

In summary, for the dialect-speaking robot, neither dialect proficiency nor dialect performance, or any control variable was significant predictor of competence. We found no evidence for H4a and H5a.

Further, to examine if participants with higher dialect proficiency would evaluate the standard German-speaking robot as more competent than those with lower dialect proficiency, we conducted a multiple regression using the enter method. In the first step, we added only dialect proficiency as predictor. In the second step, we added control variables: age, gender, duration of residence in Berlin, and device type. Contrary to the H4b hypothesis, dialect proficiency alone was not a significant predictor of competence in the standard-speaking robot ($\beta = .086$, $t\ (52) = 0.623$, $p = .536$, $F\ (1, 52) = 0.389$, $R^2 = .007$, $R^2_{Adjuste}$d $= -.012$). However, when controlled for age, gender, duration of residence in Berlin, and device type, it did explain a reliable amount of variance in the value of COMPETENCE, together with duration of residence in Berlin ($\beta = .695$, $t\ (48) = 3.463$, and $\beta = -.824$, $t\ (48) = -3.735$, respectively, $p < .001$, $F\ (5, 48) = 4.634$, $R^2 = .326$, $R^2_{Adjusted} = .255$). age, gender, and device type did not contribut to the final model.

To see if participants with higher dialect performance would evaluate the standard German-speaking robot as more competent than those with lower dialect performance, we conducted a multiple regression using the enter method. In the first step, we added only dialect performance as predictor. In the second step, we added control variables: age, gender, duration of residence in Berlin, and device type.

Contrary to the hypothesis H5b, dialect performance alone was not a significant predictor of competence in the standard German-speaking robot ($\beta = .051$, $t\ (52) = 0.365$, $p = .717$, $F\ (1, 52) = 0.133$, $R^2 = .003$, $R^2_{Adjusted} = -.017$). However, when controlled for age, gender, duration of residence in Berlin, and device type, it did explain a

TABLE 2 Results of the Regression Analysis on the Outcome Variable Trust with Dialect Performance as Predictor.

		Dialect-speaking robot				Standard German-speaking robot			
Model		*β*	*SE*	*t*	*p*	*β*	*SE*	*t*	*p*
1	Constant		0.206	21.069	<.001		0.272	17.127	<.001
	Performance	.208	0.090	1.646	.105	.043	0.095	0.312	.757
R^2		.043						.002	
$R^2_{Adjusted}$		.027						−.017	
p		.105						.757	
2	Constant		0.544	7.742	<,001		0.563	7.613	<.001
	Performance	.142	0.108	0.933	.355	.259	0.107	1.683	.099
	Age	.174	0.014	1.170	.247	**.430**	**0.016**	**2.924**	**<.05**
	Gender	−.129	0.313	−0.984	.329	**−.313**	**0.324**	**−2.480**	**<.05**
	Duration	.004	0.064	0.025	.980	**−.420**	**0.084**	**−2.462**	**<.05**
	Device	.074	0.271	0.568	.572	**.475**	**0.311**	**3.844**	**<.001**
R^2		.081						.321	
$R^2_{Adjusted}$		−.001						.252	
p		.434						<.05	

Note: Dialect-speaking robot *N* = 63. Standard-speaking robot *N* = 57.
Significant results are marked in bold.

reliable amount of variance in the value of competence, together with duration of residence in Berlin and device type (β = .410, t (48) = 2.433; β = −.529, t (48) = −2.768; and β = .281, t (48) = 2.188 respectively, $p < .05$, F (5, 48) = 3.193, R^2 = .250, R^2_{Adjusted} = .171). age and gender did not contribute to the final model.

In summary, for the standard German-speaking robot both dialect proficiency and dialect performance were significant predictors of competence, but only when controlled for age, gender, duration of residence in Berlin, and device type. Hypotheses H4b and H5b could be partially confirmed. Duration of residence in Berlin and device TYPE were also reliable predictors of competence for the standard German-speaking robot.

The results are summarized in Table 3 and Table 4.

Figure 3 presents a visual summary of the outcomes obtained from regression analyses that assessed how dialect proficiency predicted competence in both the standard German-speaking and dialect-speaking robot.

3.3 Association between robot's competence and trust

Lastly, we sought to determine if the evaluation of a robot's competence could predict the degree of trust that was placed in the robot. Indeed, for both the dialect-speaking robot (β = .631, t (59) = 6.249, F (1, 59) = 39.049, $p < .001$, R^2 = .398, R^2_{Adjusted} = .388) and the standard German-speaking robot (β = .646, t (52) = 6.096, F (1, 52) = 37.164, $p < .001$, R^2 = .417, R^2_{Adjusted} = .406), competence was a significant predictor of trust. Both H6a and H6b could be confirmed. Figure 4 presents a visual representation of the outcomes of the regression analyses.

The data set and the analysis script can be found at: https://osf.io/pfqg6/.

4 Discussion

4.1 Proficiency and performance in the Berlin dialect and evaluation of competence and trust

Our study investigated verbal aspects of human robot interaction quality. Specifically, we examined the association between participants' proficiency and performance in the Berlin dialect and their evaluation of competence and trust in a NAO robot that spoke either with or without this dialect. The study was conducted online, and dialect proficiency was defined as the self-evaluated ability to speak the Berlin dialect, while dialect performance referred to the frequency of dialect used by the participants.

In general, although the difference in trust and competence ratings were not significant, our findings tend to be consistent

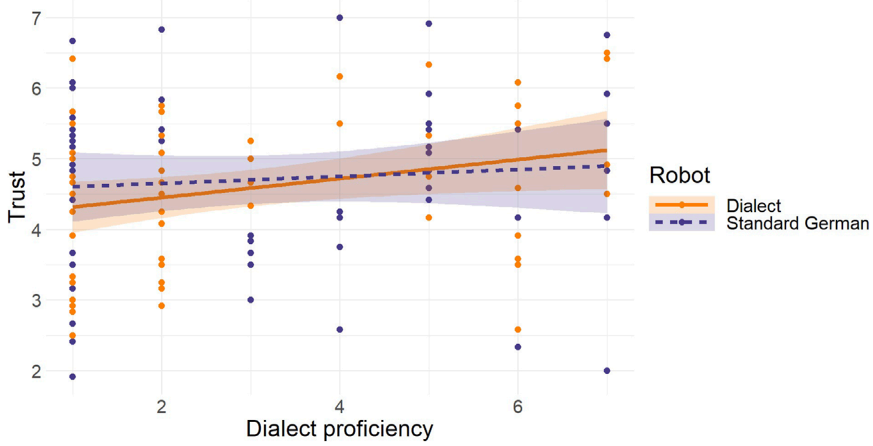

FIGURE 2
Regression Analysis for Dialect Proficiency as a Predictor of Trust in the Standard German-speaking and the Dialect-speaking Robot *Note:* The orange solid line represents the regression slope for the dialect-speaking robot. The dark blue long dashed line represents the regression slope for the standard German-speaking robot.

TABLE 3 Results of the Regression Analysis on the Outcome Variable Competence with Dialect Proficiency as Predictor.

		Dialect-speaking robot				Standard German-speaking robot			
Model		β	*SE*	*t*	*p*	β	*SE*	*t*	*p*
1	Constant		0.226	16.413	<.001		0.234	15.792	<.001
	Proficiency	.047	0.061	0.363	.718	.086	0.059	0.623	.536
R^2		.002				.007			
$R^2_{Adjusted}$		−.014				−.012			
p		.718				.536			
2	Constant		0.502	9.231	<.001		0.421	9.798	<.001
	Proficiency	.293	0.087	1.592	.117	**.695**	**0.086**	**3.463**	**<.001**
	Age	−.216	0.012	−1.489	.142	.125	0.012	0.807	.423
	Gender	−.152	0.289	−1.191	.239	−.199	0.250	−1.529	.133
	Duration	−.222	0.073	−1.131	.263	**−.824**	**0.083**	**−3.735**	**<.001**
	Device	.079	0.253	0.623	.536	.192	0.233	1.562	.125
R^2		.121				.326			
$R^2_{Adjusted}$		.042				.255			
p		.193				<.05			

Note: Dialect-speaking robot $N = 63$. Standard-speaking robot $N = 57$.
Significant results are marked in bold.

with previous studies conducted by Torre and Maguer (2020) and Andrist et al. (2015) which also found that people preferred a robot that speaks in standard language. This is in line with the overall research suggesting that individuals who speak the standard language are perceived as more competent (Fuertes et al., 2012). However, our findings are contradictory to the results of V. Kühne et al. (2013) and Früh and Gasser (2018) where a robot speaking in dialect was viewed more positively. It is essential

TABLE 4 Results of the Regression Analysis on the Outcome Variable Competence with Dialect Performance as Predictor.

		Dialect-speaking robot				Standard German-speaking robot			
Model		β	SE	t	p	β	SE	t	p
1	Constant		0.197	19.167	<.001		0.206	18.243	<.001
	Performance	−.002	0.082	−0.019	.985	.051	0.072	0.365	.717
R^2		.000					.003		
$R^2_{Adjusted}$		−.017					−.017		
p		.985					.717		
2	Constant		0.509	9.190	<.001		0.444	9.389	<.001
	Performance	.139	0.099	0.890	.377	**.410**	**0.087**	**2.433**	**<.05**
	Age	−.246	0.012	−1.619	.111	.005	0.012	0.029	.977
	Gender	−.132	0.294	−1.017	.314	−.122	0.256	−0.915	.365
	Duration	−.068	0.060	−0.423	.674	**−.529**	**0.072**	**−2.768**	**<.05**
	Device	.079	0.257	0.614	.542	**.281**	**0.244**	**2.188**	**<.05**
R^2		.094				.250			
$R^2_{Adjusted}$		.013				.171			
p		.341				<.05			

Note: Dialect-speaking robot N = 63. Standard-speaking robot N = 57.
Method: enter. Significant results are marked in bold.

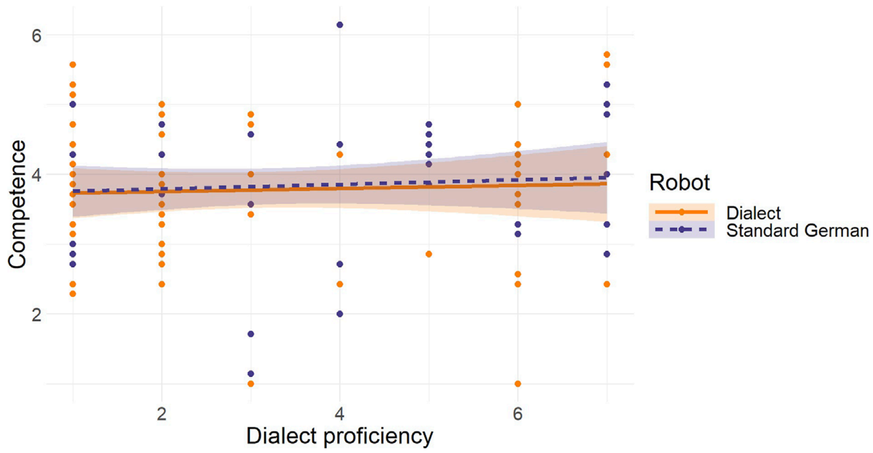

FIGURE 3
Regression Analysis for Dialect Proficiency as a Predictor of Competence in the Standard German-speaking and the Dialect-speaking Robot Note: The orange solid line represents the regression slope for the dialect-speaking robot. The dark blue long dashed line represents the regression slope for the standard German-speaking robot.

that their experiments were conducted in Switzerland, as the local dialect plays a crucial role, in distinguishing insiders from outsiders. Further, similar to Lugrin et al. (2020) we demonstrated that participants' ratings of the robot's trust and competence were influenced by their own proficiency in the dialect, but our study provided more nuanced results.

Importantly, as expected, the competence of the robot significantly predicted trust. Namely, the more competent the robot

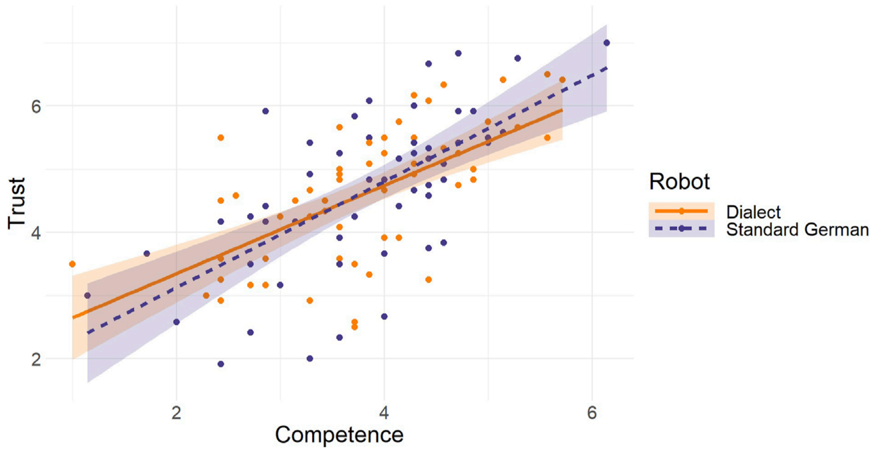

FIGURE 4
Regression Analysis of Competence as a Predictor of Trust Note: The orange solid line represents the regression slope for the dialect-speaking robot. The dark blue long dashed line represents the regression slope for the standard German-speaking robot.

was rated by the participants, the more they trusted it. This is in line with previous research (Hancock et al., 2011; Kraus et al., 2018; Steain et al., 2019; Christoforakos et al., 2021). Competence is perceived as an ability to carry out behavioral intentions (Kulms and Kopp, 2018). Being a positive quality, it creates a more favorable impression of the trustee. As a major dimension of social cognition postulated by the Stereotype Content Model, competence has been observed to foster the establishment of trust in interactions between humans (Fiske et al., 2007). Also according to another model, competence and benevolence of the trustee are positively related to trust (Mayer et al., 1995). Thus, we report evidence indicating that social mechanisms observed in human-human interactions can be transferred to human-robot interactions.

In the following paragraphs we will discuss the findings in detail. In the first place, although there was a slight trend of higher trust and competence evaluation for the standard German-speaking compared to the dialect-speaking robot for all participants, the difference was not statistically significant. The standard German-speaking robot and the dialect-speaking robot received largely comparable ratings in terms of both competence and trustworthiness.

Nevertheless, there were systematic differences in ratings between the two robots. Consider first the ratings obtained for the dialect-speaking robot. For the dialect-speaking robot, only dialect proficiency was a significant predictor of trust, with individuals who considered themselves more proficient in speaking the Berlin dialect having higher levels of trust. The other predictors (dialect performance, age, gender, duration of residence, and device type) did not have a significant contribution to the final statistical model of the ratings on trust. Our analysis for the outcome variable competence showed no significant predictors. Dialect proficiency, dialect performance, age, gender, duration of residence, and device type did not significantly contribute to the final model of participants' rating. Thus, for the dialect-speaking robot, only one reliable association was found, namely, that between dialect proficiency and the trust in robots. The more proficient the participants were in the Berlin dialect, the more they trusted the dialect-speaking NAO, exactly in the sense of the similarity-attraction theory (Nass and Lee, 2000). None of the factors were found to be predictive of the level of robot's competence.

For the standard German-speaking robot, the findings were more complex. We found that the final model included age, gender, duration of residence, and device type as significant predictors of trust, but only when included into the model together with dialect proficiency. Individuals who were older, female, had a shorter duration of residence in Berlin, and used a computer device for watching the experimental videos were found to trust the standard German-speaking robot more. Dialect performance did not make a significant contribution to the model.

Finally, dialect proficiency, dialect performance, duration of residence, and device type were significant predictors of competence, indicating that those who were more proficient in speaking the Berlin dialect, spoke it more often, had a shorter duration of residence in Berlin, and used a computer device for watching the experimental videos found the standard German-speaking robot more competent.

For the standard German-speaking robot, general factors such as age and gender appeared to be predictive of the trust level, while the participants' dialect proficiency and performance only played a role in the evaluation of competence. This finding collaborates with earlier research reporting the importance of demographic factors on robot's perception (Naneva et al., 2020). Similar to results obtained by K. Kühne et al. (2020), female participants evaluated the robot as more trustworthy. In comparison to that research, however, we found that, as participants' age increased, their TRUST in the standard German-speaking robot also increased. In conclusion, again following the principles of the similarity-attraction theory (Nass and Lee, 2000), participants who had been living in Berlin for a shorter period, presumably were less likely to be influenced by the Berlin dialect, were more likely to trust the robot that spoke in standard German and found it more competent.

It is noteworthy that not dialect performance as a relatively objective and quantitative measure of a dialect usage but dialect proficiency, a subjective and qualitative evaluation of one's dialect mastery, predicted the robot's perceived trustworthiness. The ability to speak a dialect can be integral to one's self-image and contribute to the identification of oneself with a particular group or set of qualities. According to recent research, it is so-called self-essentialist reasoning, that is beliefs about the essence of one' self, that underly the similarity-attraction effect (Chu et al., 2019). This reasoning focuses more on what one is and not on what one does; it is a personal characteristic that tends to be stable rather than situational or temporary in nature.

On a side note, participants who watched the video on a PC rated the standard German-speaking robot as more trustworthy and more competent, compared to participants working on a tablet or a mobile phone. This result indicates that, when examining human-robot interaction through video or audio stimuli, it is important to consider and control for the experimental device used. Possible reasons for the observed difference include different testing situations, such as doing the experiment at home on a PC or "on the go" on a mobile phone, which could have resulted in different distractions and response criteria, or differences in information processing on different screens (cf. Sweeney and Crestani, 2006; Wickens and Carswell, 2021). These factors could have potentially led to increased cognitive load on smaller screens and, consequently, to trust misplacement (Duffy and Smith, 2014).

4.2 Limitations of the study

It is worth noting that various intervening factors could have influenced our study. First, choosing a male voice might have affected the overall outcomes. Unlike in human-human interactions (Bonein and Serra, 2009; Slonim and Guillen, 2010), prior studies have shown that virtual assistants or robots with a male voice are generally viewed as more competent (Powers and Kiesler, 2006; Ernst and Herm-Stapelberg, 2020) and trustworthy (Behrens et al., 2018), although these ratings can be context-dependent (Andrist et al., 2015; Kraus et al., 2018). On the contrary, other recent research indicates that a female voice agent may be viewed as more likable, competent, or intelligent (Vega et al., 2019; Dong et al., 2020).

Second, due to social identification, people tend to rate voices of the same gender as more trustworthy (Crowelly et al., 2009) and perceive more psychological closeness to them (Eyssel et al., 2012). However, our research did not find evidence for this when using male voice stimuli exclusively. To resolve these contradictory results, more studies utilizing both male and female voices are necessary.

Third, dialects carry distinct connotations within German-speaking countries (cf. H. Bishop et al., 2005). For instance, the Berlin dialect is often associated with a lower socioeconomic class or working class (Stickel, 1997), whereas the Bavarian dialect is often viewed as more prestigious. It is even mandatory for politicians to speak the local dialect in Bavaria. In particular, the Bavarian dialect of Germany holds a significant and independent position within the conceptual framework of languages (Adler, 2019). A survey revealed that the Bavarian dialect is considered the second most appealing German dialect (29,6%), after the Northern German dialect (34,9%), while only about 7% found the Berlin dialect attractive (Gärtig et al., 2010; Adler and Plewnia, 2018). At the same time, a mere 5% of respondents found the Berlin dialect unappealing, whereas having no dialect at all was rated as unattractive by 32,6% of the participants (Gärtig et al., 2010). Thus, to obtain a more nuanced understanding, it would be beneficial to conduct a comparative study involving multiple dialects as well as add an assessment of subjective dialect connotations. Moreover, as dialects are a means of positive identification within a group and signify a sense of attachment to a particular region (Wiese, 2012), varying levels of identification may exist among different dialects. This can affect the degree of perceived similarity and subsequently influence assessments of trustworthiness and competence.

Fourth, our study employed a video featuring NAO, a compact and intelligent-looking social robot. It remains uncertain if its appearance aligns with all the connotations linked to the Berlin dialect. Humans may link voices with robots, and a mismatch in this connection could result in diverse outcomes in their interaction (McGinn and Torre, 2019).

Finally, we consider the limitations of our methodology for data collection and data analysis. With regard to data collection, it will be important to provide converging evidence for this internet-based study by conducting both laboratory-based and real-life research in future projects. With regard to data analysis, more advanced modeling techniques, like linear mixed modeling, can offer greater flexibility compared to stepwise regression and can usefully be employed to uncover additional effects in our data, including further variability driven by participant characteristics.

Also, the topic of communication can influence the assessment of a robot that speaks a particular dialect. Using standard German would likely be more suitable for discussing a painting, while a dialect such as the Berlin dialect could be more appropriate for conversations about everyday events or work-related topics (*topic-based shifting*) (Walker, 2019).

An overall point for future investigations is that certain scholars view trust as a construct that has multiple dimensions. For example, Law and Scheutz (2021) differentiate between performance-based trust and relation-based trust. Future research on trust should take into account these different aspects and explore their implications in various contexts. Finally, objective measures of trust, for example, following a robot's advice or task delegation should be used to better operationalize the outcome (Law and Scheutz, 2021).

Overall, our study provides valuable insights into how language proficiency and other demographic factors influence human-robot interaction and robot perception. Our results can inform the development of more effective robots that are tailored to meet the needs and expectations of diverse user groups. Further research is needed to explore the role of gender, age, and dialect in human-robot interaction and perception, and to identify additional factors that may influence trust and competence evaluation.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://osf.io/pfqg6/.

Ethics statement

The study was conducted in accordance with the guidelines laid down in the Declaration of Helsinki and in compliance with the ethics policy of the University of Potsdam. No explicit approval was needed because the methods were standard. There were no known risks and participants gave their informed consent. The study and the procedure were already evaluated by professional psychologists to be consistent with the ethical standards of the German Research Foundation, including written informed consent and confidentiality of data as well as personal conduct.

Author contributions

KK and EH contributed to the conception and design of the study. EH conceived the stimuli, programmed the survey, and conducted the study. KK and EH performed the analysis. KK wrote the first draft of the manuscript. KK, MF, OB, and YZ wrote, discussed, and revised several drafts before approving the final version. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frobt.2023.1241519/full#supplementary-material

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Assimilation of socially assistive robots by older adults: an interplay of uses, constraints and outcomes

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By supporting autonomy, aging in place, and wellbeing in later life, Socially Assistive Robots are expected to help humanity face the challenges posed by the rapid aging of the world's population. For the successful acceptance and assimilation of SARs by older adults, it is necessary to understand the factors affecting their Quality Evaluations Previous studies examining Human-Robot Interaction in later life indicated that three aspects shape older adults' overall QEs of robots: uses, constraints, and outcomes. However, studies were usually limited in duration, focused on acceptance rather than assimilation, and typically explored only one aspect of the interaction. In the present study, we examined uses, constraints, and outcomes simultaneously and over a long period. Nineteen community-dwelling older adults aged 75–97 were given a SAR for physical training for 6 weeks. Their experiences were documented via in-depth interviews conducted before and after the study period, short weekly telephone surveys, and reports produced by the robots. Analysis revealed two distinct groups: (A) The 'Fans' - participants who enjoyed using the SAR, attributed added value to it, and experienced a successful assimilation process; and (B) The 'Skeptics' - participants who did not like it, negatively evaluated its use, and experienced a disappointing assimilation process. Despite the vast differences between the groups, both reported more positive evaluations of SARs at the end of the study than before it began. Overall, the results indicated that the process of SARs' assimilation is not homogeneous and provided a profound understanding of the factors shaping older adults' QE of SARs following actual use. Additionally, the findings demonstrated the theoretical and practical usefulness of a holistic approach in researching older SARs users.

KEYWORDS

acceptance, aging, assimilation, human-robot interaction, older adults, quality evaluation, socially assistive robots, wellbeing

1 Introduction

Population aging is expected to be the most significant demographic transformation of the twenty-first century (Morina and Grima, 2021). This trend yields numerous social and economic challenges related to health and quality of life in old age (Zhu and Walker, 2021). Embodied technological solutions, and Socially Assistive Robots (SARs) in particular, are expected to play a central role in facing these challenges (Cortellessa et al., 2021; Sorrentino et al., 2022). Therefore, it is necessary to understand the factors affecting older adults' Quality Evaluations (QEs) of SARs.

Previous studies that examined Human-Robot Interaction (HRI) in later life indicated that older adults' overall QE of robots is shaped by three aspects: their uses, constraints to beneficial use, and use outcomes (Zafrani and Nimrod, 2019). However, previous research has two significant weaknesses: 1) studies typically focused on only one aspect of the interaction between robots and older adults (i.e., examining uses, constraints, and outcomes separately); and 2) most studies were limited in duration, and thus mainly focused on acceptance aspects rather than assimilation. The present study aimed to bridge the gaps in the existing literature. Accordingly, we carried out an assimilation study examining how the QE is shaped following actual interaction with the SAR by a simultaneous exploration of uses, constraints, and outcomes in real-life conditions over a long period.

2 Literature review

2.1 Quality evaluation of socially assistive robots (SARs)

Technology QE deals with people's emotions, perceptions, and responses created, derived, and shaped as a result of interaction or anticipated interaction with a system, product, device, or service (Hartson and Pyla, 2012; Lindblom and Andreasson, 2016). The literature on the subject distinguishes between pragmatic and hedonic aspects of evaluation (e.g., Hassenzahl, 2003; Mlekus et al., 2020). The pragmatic aspects of QE relate to the functionality, usability, usefulness, and utility of potential tasks that help users achieve their goals effectively and satisfactorily (da Silva et al., 2019; Hassenzahl and Tractinsky, 2006). Hedonic aspects refer to the users themselves and reflect the emotional benefits they experience when interacting with the technology (Hornbæk and Hertzum, 2017; van de Sand et al., 2020). Positive QEs are necessary to promote acceptance of SARs—a crucial condition for the assimilation process and the realization of the benefits of using robots (e.g., Bensch et al., 2017 Naneva et al., 2020).

Acceptance of technology is defined as "the demonstrable willingness within a user group to employ information technology for the tasks it is designed to support" (Dillon and Morris, 1996; Dillon, 2001). The assimilation of technology is defined as the extent to which the use of technology becomes routinized in daily activities (De Mattos and Laurindo, 2017; Purvis et al., 2001). The ability to successfully assimilate new technology depends on users' absorption or purchase of information and their ability to exploit this information (Kouki et al., 2010). The combination of acceptance and assimilation research suggested that an assimilation pattern can be predicted according to the level of acceptance.

2.2 Human-Robot Interaction (HRI) in later life

Research on HRI in later life suggests that three main aspects shape older adults' overall QE of robots: uses, constraints, and outcomes (Zafrani and Nimrod, 2019). Below are the principal insights concerning each factor.

Uses. This category includes explorations of a) users' acceptance of new robotics technology, b) processes of adaptation to such technologies, and c) factors affecting user experience. Studies suggested that although older adults were excited about the idea of robots, their acceptance of robotics technologies was ambivalent (Hebesberger et al., 2017; González-González et al., 2021). For example, older adults worried that robotic technologies would replace and even control humans, even though they perceived them as a future extension of existing communications technologies such as the internet and smartphones and expected them to be widely adopted (Liu et al., 2021). In addition, although they believed that robotic systems could support daily activities, older adults said they did not want to use robots (Wang et al., 2017).

Older adults sought robots for object manipulation, physical training, information management, and chores, but preferred humans for leisure activities, information delivery, and personal care (Shen and Wu, 2016; Getson and Nejat, 2021). In this context, they were less receptive to personal assistance such as dressing and bathing but more open to using robotic systems for simple tasks such as managing reminders and communicating (e.g., Robillard and Kacabińska, 2020; Huang and Huang, 2021; Fiorini et al., 2023; Wengefeld et al., 2022).

Although older adults know they are using machines, these users often attribute human qualities to robots and expect them to exhibit human intelligence and behavior (Frennert et al., 2017; Onnasch and Roesler, 2021). In addition, older users expect the robotic technologies to be useful and adaptable to their needs (Olatunji et al., 2020; Kim et al., 2021). A longitudinal study that investigated adaptation to robots demonstrated that giving robots a function in the daily routine of older adults may lead to greater appreciation and approval (De Graaf et al., 2015; Luperto et al., 2022). Furthermore, if users did not ascribe specific functions to robots, they enjoyed the interaction less, gradually lost interest (Torta et al., 2014; Søraa et al., 2022), and eventually returned to their previous habits without robots (Frennert et al., 2017).

Constraints. This category includes explorations of a) antecedent constraints, namely, factors that limit or reduce motivation to use robotic systems, and b) intervening constraints that come between the desire to use robotic systems and the actualization thereof. Among the prominent antecedent constraints were uneasiness with robots (Erel et al., 2021; Gasteiger et al., 2021) and a perception that they had no added value compared to existing modern technologies (Caleb-Solly et al., 2014; Wu et al., 2016; Tonkin, 2021). Yet, the stigma associated with using a robot in old age was probably the most dominant antecedent constraint. Healthy older adults perceived the potential robot user as someone frail, lonelier, and more in need of care than them (Pripfl et al., 2016;

Bradwell et al., 2021). Therefore, trying to dissociate themselves from these negative stereotypes of old age, they rejected the use of robots.

Major intervening constraints found in the literature were usability and affordability. Concern over robot costs was commonly discussed (Abbott et al., 2019; Koh et al., 2021a). Usability, i.e., the extent to which specified users can use a product or service to achieve specific goals (Nielsen and Madsen, 2012), was of significant worry. Operational difficulties were also an intervening constraint. For example, some studies described users' dissatisfaction with the robots' response speed, verbal skills, and comprehension of instructions (Pripfl et al., 2016; Wang et al., 2019).

Outcomes. The literature indicated various outcomes from using robots in later life, mostly divided between benefits and risks. Interacting with robots was experienced as enjoyable (Lazar et al., 2016) and cognitively stimulating (Tsardoulias et al., 2017; Louie and Nejat, 2020). It had positive and beneficial effects on older adults' psychological wellbeing (Henschel et al., 2021), including better communication with friends and family members (Tsardoulias et al., 2017), elevated mood (Khosla et al., 2012), and decreased frustration and stress (Van Patten et al., 2020). Functional benefits often included the robotic technologies' (e.g., Paro, Nao) contribution to older persons' quality of life and independence (Tsardoulias et al., 2017; Coşar et al., 2020; Koh et al., 2021; Wang et al., 2021). For example, studies have found that robots support physical exercise and rehabilitation (Avioz-Sarig et al., 2021; Krakovski et al., 2021; Zafrani et al., 2023). In addition, a longitudinal study that used SAR to monitor, assist, and provide social, cognitive, and physical stimulation in elderly homes, provided empirical evidence that SAR can be successfully used for long-term support for older adults (Luperto et al., 2023).

The literature also addressed the risks and negative impacts arising from the use of robots by older people. Regarding psychological risks, concerns related to discomfort or stress resulting from the robot's appearance, speech, and motion were mainly discussed (Hussain and Zeadally, 2019; Salvini et al., 2021). Ethical ramifications such as invasion of privacy and feelings of a loss of control may result from using robots (Caine et al., 2012; Kernaghan, 2014). For example, the presence of cameras and hearing sensors on the robot may cause a feeling of being spied on or under surveillance, which in turn may lead to stress and anxiety (Salvini et al., 2021). Moreover, physical interactions with SARs such as walking support robots (Cifuentes et al., 2014), person-following robots (Olatunji et al., 2020), and mobility robots (Leaman and La, 2017) may create hazards such as accidents or malfunctions (Mansfeld et al., 2018).

The holistic approach suggested by Zafrani and Nimrod (2019) postulates that simultaneous exploration of uses, constraints, and outcomes (including both positive and negative effects), rather than focusing on one or two of these issues, may explain how they correlate with one another and provide a broader and more accurate picture of users' experiences. Moreover, it stresses that extended simultaneous exploration may explain how the HRI and the resulting QE change according to users' experience, to what extent the interaction is integrated into their daily lives, what factors affect the frequency of use and its benefits, and what constrains beneficial use and leads to decreased frequency or even cessation of use. In contrast to lab experiments, the most common methodology in HRI research, a longitudinal study may help researchers learn and interpret people's behavior, including how they acquire new knowledge about technology and to what extent they use and retain it over time (King, 2006). Furthermore, it provides more accurate insights regarding the assimilation of new technologies into the users' lives (Cullen, 2018; Nagarajan et al., 2020). It also helps reduce the robot's novelty and establish its functioning in more realistic situations where the participants are alone with the robot (Yamazaki et al., 2014).

Accordingly, this study applied the holistic approach (Zafrani and Nimrod, 2019) to answer the following questions:

1. What are the uses, constraints, and outcomes that older adults experience while assimilating a SAR into their lives?
2. Do the uses, constraints, and outcomes change during the assimilation period? If so, how?
3. How do older adults' experiences with a SAR over a long period and in real-life conditions shape their QE of that SAR in particular and of SARs in general?

3 Methods

3.1 The robotic system

To answer the research questions, we used a SAR developed in our lab (Figure 1). This SAR—named 'Gymmy' to elicit the associations of the word "gym"—was designed to serve as a personal trainer that would support aging individuals' physical activity. During the training sessions, the robot demonstrates a series of physical exercises and follows their execution. The users perform the exercise with the robot, and a camera monitors their movements. If needed, the robot corrects the execution. In addition, during the physical training, cognitive training sessions, such as memory and thinking exercises, are randomly presented to the users. Furthermore, the system offers users relaxation exercises to release stress and relieve pressure, according to Jacobson's relaxation technique (Jacobson, 1938). The system includes a humanoid mechanical-looking robot (Poppy Torso) and a computer system (NUC mini-PC) to demonstrate the exercises, an RGB-D (red-green-blue-depth) camera to monitor the user's performance (Intel RealSense™ D435), speakers and a touch screen for instructions and feedback (for additional information about the development of the system, see Krakovski et al., 2021; Zafrani et al., 2023, or watch https://www.youtube.com/watch?v=zQ4T1NhS25Q).

This robotic system we developed was used in our previous studies where each study had its own novelty. In Krakovski et al. (2021) we presented the development of "Gymmy", and conducted 1-day experiments in home environments to examine the effect of users' characteristics (age, gender, education and attitude toward robots), on the acceptance of the robotic trainer. In Zafrani et al. (2023) we conducted an online survey to explore the anticipated interaction through video viewing of a SAR (Gymmy). The novelty of this work is that we investigated how the QE is shaped following actual interaction with a SAR (Gymmy) by a simultaneous exploration of uses, constraints, and outcomes in real-life conditions over a long period.

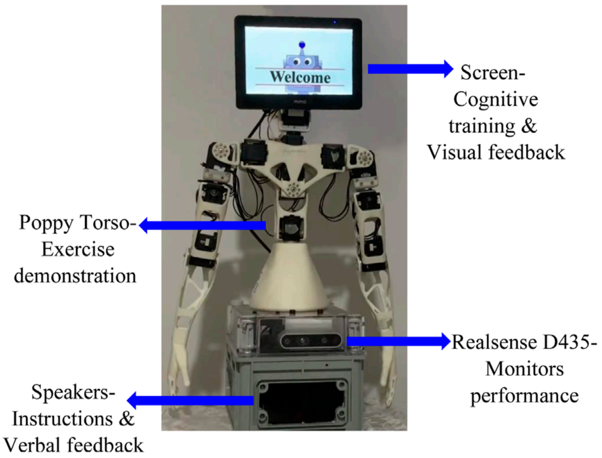

FIGURE 1
'Gymmy'—personal training robot.

3.1.1 Physical exercises

Gymmy's physical training focused on exercises for the upper body, which matched the functionality of the Poppy robot's torso version. These exercises improve muscle strength and help older adults maintain their independence and perform daily activities such as lifting objects. A total of 14 physical training exercises were developed (Avioz-Sarig, 2019; Krakovsky et al., 2021; Figure 2) according to the recommendations of the National Institute on Aging (NIH; https://go4life.nia.nih.gov/exercise-type/strength/retrieved July 2019).

3.1.2 Cognitive exercises

Gymmy's cognitive training was designed to address different aspects of memory, processing speed, and concentration, which are crucial for older adults' ability to live independently (Eggenberger et al., 2015; Arora, 2021). Three cognitive games were randomly integrated during the physical training sessions. These games were chosen based on the literature (e.g., Nacke et al., 2009; Ezzati et al., 2016). Each game started with instructions, and then, using the touch screen, users confirmed that they were ready to start the game.

3.1.3 Relaxation exercises

Designed according to Jacobson's relaxation technique (Jacobson, 1938), Gymmy's relaxation exercises were provided to release stress and relieve pressure. This tool is essential for older adults' wellbeing (Rudnik et al., 2021) and allows them to perform relaxation exercises for three muscle systems: arms, neck, and face.

3.2 Participants and sample description

Participants were recruited through mailing lists of retirees, public announcements, and snowball sampling. Criteria for participation were age 75 years and over, namely, the "old-old" category (Kubota et al., 2012; Boot et al., 2020) and independent living. Nineteen community-dwelling older adults (age ranged between 75 and 97, mean = 81.05, SD = 6.19) who resided in cities (N = 12) or 'kibbutzim' (i.e., a rural community defined by its commitment to mutual aid, community living, and social justice, N = 7) in the southern part of Israel participated in this study. Nine participants were men (47%), and 10 were women (53%). Nine participants were married, eight were widows, one was in a permanent relationship, and one was divorced. All participants had children (range = two to five, mean = 3.31, SD = 1.05). The majority had secondary education, and eight had post-secondary education. Most participants were not born in Israel (N = 17), and 14 were secular. All participants were retired except for one who still worked full-time.

3.3 Data collection

For all study participants, a unit of Gymmy was installed in their homes for 6 weeks. In-depth semi-structured interviews were conducted with each participant at their homes before and after the study. The first session with the participants opened with oral and written explanations about the study. After signing a consent form, the participants filled out a demographic, sociodemographic, and health background questionnaire (Appendix A). Then, each participant was given detailed explanations about Gymmy, watched a video that presented its functions, and was interviewed. In these in-depth interviews (Appendix B), participants shared their biographical and occupational backgrounds, daily routines, and Information and Communication Technology (ICT) use. The main goal of these interviews was to explore their expectations of SARs in general and from Gymmy in particular. Therefore, they were also asked questions about the advantages, disadvantages, risks, and benefits that they believed existed in SARs and questions that specifically focused on their expectations from Gymmy.

To prevent participants' exhaustion, Gymmy's installation was done several days after the preliminary interview. This session included installation (15–20 min), guidance (25–30 min), and demonstration of full training with Gymmy (about 15 min). It was explained to the participants that the use of the robot is according to their will, only when they want, and in a proactive way, that is, if the user wants to use Gymmy, he/she has to press the dedicated power button. In addition, it was explained to the participants that communication with the robot is multimodal, based on speech, movement (hand waving), and touch (Krakovski et al., 2021). Throughout the study period, participants were offered unlimited technical support. After 6 weeks, at the end of the study period, concluding interviews were conducted with the participants (Appendix C). These interviews examined their overall experience with Gymmy vis-à-vis their initial expectations. Thus, they were asked direct questions about the frequency of use, difficulties of use, and the advantages, disadvantages, risks, and benefits that they thought existed in using Gymmy. All interviews were audio-recorded and transcribed verbatim.

In addition to the in-depth interviews, a short weekly telephone survey (Appendix D) was conducted with study participants. They were asked to rate their level of satisfaction with Gymmy and the extent to which they faced operational problems using a five-point Likert scale ranging from 1 ("not at all") to 5 ("a lot"). Lastly,

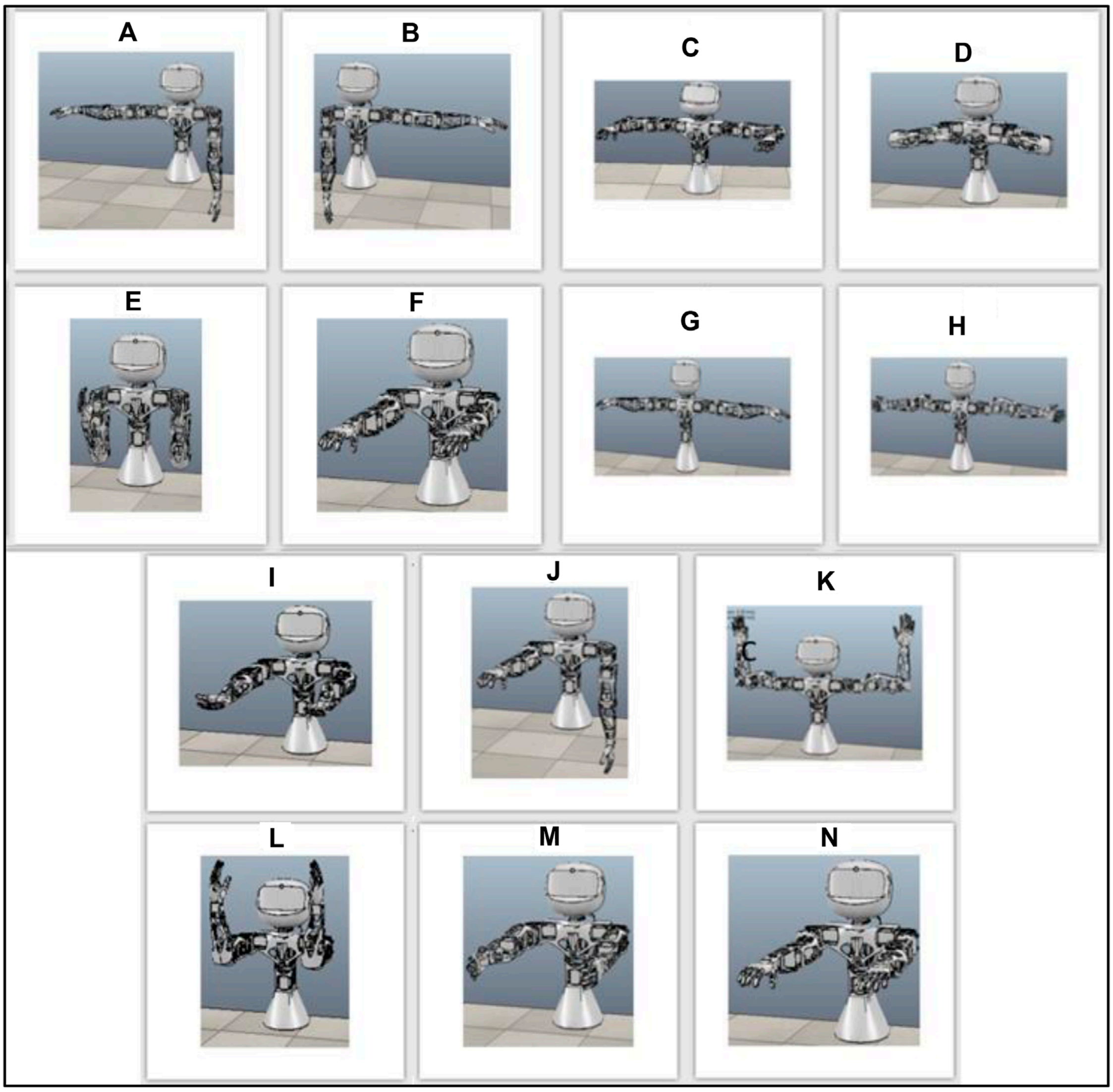

FIGURE 2
(A, B)- raise arms horizontally separately, **(C)**-raise arms and bend elbows forward 90, **(D)**-raise arms and bend elbows, **(E)**-bend elbows, **(F)**- raise arms forward static **(G)**-raise arms horizon-tally, **(H)**-raise arms horizontally and turn hands, **(I)**-raise arms forward and turn hands, **(J)**-raise arms forward separately, **(K)**-raise arms 90 and up, **(L)**-open and close arms 90, **(M)**-raise arms forward and to sides, **(N)**- raise arms forward.

the robot automatically produced usage reports, which included accurate information about the frequency and usage dates. Due to a limited number of Gymmy units, the data were collected in five cycles, with four-five participants in each cycle.

3.4 Data analysis

Analysis began with the qualitative data collected in the interviews and followed Miles and Huberman's (1994) strategies of noting patterns, contrasting and comparing, and clustering. This phase started with within-case analysis and proceeded to cross-case analysis. Hence, each participant's pre-use and concluding interviews were first independently coded. Then, they were compared with other participants' interviews to elicit similarities, contrasts, and overlaps in relation to the codes found. The coding method was inductive, using open coding and axial coding techniques to make connections and group the codes into categories according to content (e.g., risks, benefits). Applying this method allowed the findings to emerge from the text without any preexisting concepts. The analysis was performed by the first two authors and then meticulously reviewed by the other authors. The authors discussed and re-analyzed unclear codes and discrepancies to strengthen validity (Hammersley, 1992). Accordingly, the meta matrix was reorganized several times and expanded with new categories and codes.

As the qualitative analysis revealed two distinct groups of study participants representing different assimilation patterns, the quantitative data (i.e., the usage reports) were used to further explore the differences between the groups. Accordingly, the next chapter will combine quantitative and qualitative findings. Pseudonyms were used to guarantee anonymity.

4 Findings

The analysis revealed two distinct assimilation patterns: (A) The 'Fans' - participants who enjoyed using Gymmy very much, trusted it, attributed added value to it, and experienced a successful assimilation process, and (B) The 'Skeptics' - participants who did not like Gymmy, experienced a disappointing assimilation process, and therefore expressed no interest in using it after the research period was over. The identified groups differed in their background, attitudes towards robots before and after using Gymmy, and actual use experience. The following sections describe in detail the process of assimilation of the two groups, including their characteristics, attitudes, and experiences.

4.1 The 'Fans'

4.1.1 Personal background

The average age of the nine participants who liked Gymmy ranged between 75 and 97 years, with a mean age of 82.88 years (SD = 7.57), and their mean number of years of education was 12.1 (SD = 2.89). Most (N = 7) of these participants came to the study without experience or knowledge of robotics. Before the period of use of Gymmy, six participants in this group performed only basic physical activity several times a week, such as walking, two participants did not exercise at all, and one participant exercised in a gym. In addition, their use of various media focused mainly on traditional uses such as making phone calls and watching television.

4.1.2 Attitudes towards SARs before use

Seven participants from the 'Fans' group came to the study without actual attitudes towards SARs because, as mentioned, they had no previous experience or knowledge of SARs. Yet, all participants in this group showed great curiosity and a desire to experience the use of robotics. Helen (W, 86, Widow) explained: "Even at my age, I still want to learn new things … I have curiosity, it is always good to know more things, and it is just interesting, to keep evolving, not to stand still," and Daphna (W, 97, Widow) shared: "I agreed to participate in the study because I am interested in new things, I am very interested in it."

4.1.3 Actual use experience

Participants in the 'Fans' group loved Gymmy very much (Figure 3; Figure 4), trusted it, appreciated its pragmatic and hedonic aspects, its 'unique use characteristics' and its 'advantages,' used it regularly throughout the study period (Figure 5), experienced 'positive evaluations' towards it, and even reported 'positive outcomes' from its use. Moreover, this group of participants directly connected Gymmy's 'unique use characteristics' to the 'advantages' they found in it. That is, its unique use characteristics are its advantages, and its advantages lie in the characteristics of its unique use. Its unique uses characteristics included pragmatic aspects)*easy to operate, convenient to use,* and *provides guidance and demonstration*) and a hedonic aspect (*has humanity*).

A powerful influence on the participants' experience was that Gymmy was *easy to operate*. The participants did not experience any use problems or difficulties during the study period (Figure 3). Miley (W, 75, Married) indicated that using it was "super easy … there is no need to have Einstein's intelligence to operate it." Another factor that played an essential role in the participants' experience was Gymmy's *convenience of use*. This factor contained two interrelated characteristics, Gymmy's *accessibility* and *availability*. Gymmy was placed in the most accessible place for the participants, i.e., in their homes. Therefore, they could exercise "without leaving their home." Additionally, the fact that Gymmy was always available allowed them to use it whenever they wanted. Sami (M, 86, Married), for example, pointed out that "compared to a human trainer, who will not come to your home whenever you want, Gymmy is always available to you."

Another unique characteristic of Gymmy noted by these participants was that it *provided guidance and demonstration*

FIGURE 3
Word clouds that describe the actual use experience of the 'Fans' (green) and the 'Skeptics' (red). Note: The bigger the word in the word cloud, the more frequently it appeared in the interviews.

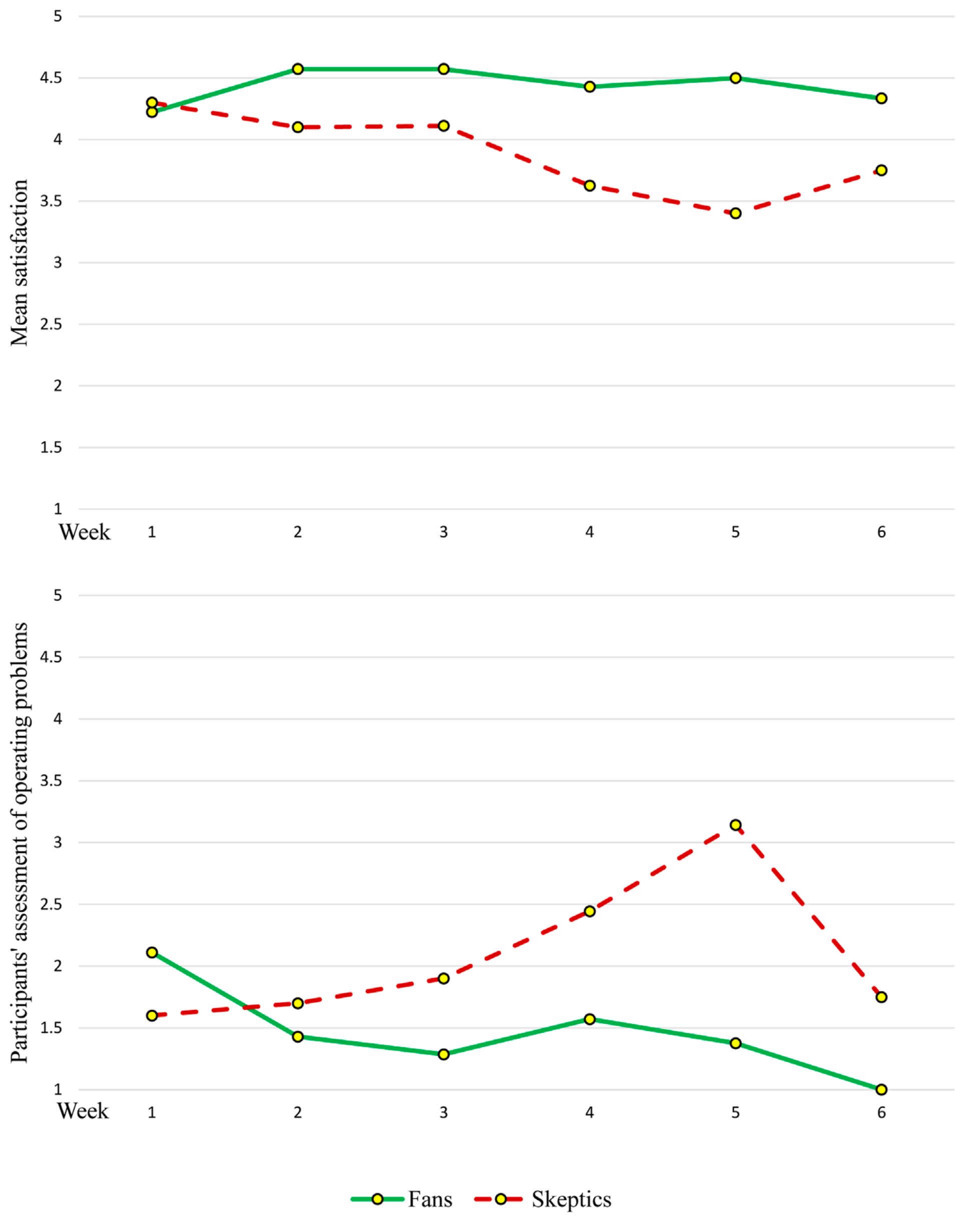

FIGURE 4
Six-weeks self-report use trends among the two groups of study participants.

regarding how to perform the exercises. As Helen (W, 86, Widow) avowed: "I really like getting guidance on what to do." Finally, Gymmy's *humanity* was frequently discussed when participants regarded it as a human presence at home. For example, Paula (W, 91, Divorced) always *anthropomorphized* Gymmy when she talked about training with it and described the routine of her encounters with Gymmy as a human routine for all intents and purposes: "Every time I met him, I said hello to him, I made the movements with him, and it answered me very well," and explained: "I did the exercises according to what he said."

The 'positive evaluations' described by the 'Fans' were for Gymmy itself, the experience of its use, and the functions it offered. First, the participants chose to describe it with many affectionate adjectives such as "so sweet," "amazing," "very nice," "pleasant," "gentle," and "friendly." In addition, they praised it with compliments for being an "excellent idea," "interesting," and "intriguing." Moreover, they indicated that Gymmy *suited their daily needs* and provided a *good physical and cognitive training level*. They experienced *enthusiasm and enjoyment* and had a *positive experience* thanks to it.

Participants described Gymmy's *suitability for their daily needs* in a variety of superlatives and explained that it "suited me exactly," "came to me at the right time," and was "exactly what I needed." Helen (W, 86, Widow) detailed that "Gymmy allows me to do exactly what I can, it suits me very well … it keeps me busy in a pleasant way." This adequacy between the participants' needs and the use of

FIGURE 5
Average weekly uses among the two types of study participants according to the SAR's reports.

Gymmy was made possible thanks to the fact that Gymmy provided the 'Fans' with *a good level of physical and cognitive training*. From the point of view of physical training, participants in this group noted that they experienced "diversity in the type of physical activity," that "Gymmy's movements were nice," and that "the number of repetitions was good." From a cognitive training perspective, participants reported that the assignments were "good," "clear," and "without problems."

In the concluding interview, when these participants were asked to describe the period of their use of Gymmy, they pointed out that they experienced *enthusiasm and enjoyment* and had *a positive experience* thanks to it. *Enthusiasm and enjoyment* referred to positive feelings that Gymmy and its features aroused among the participants during the study period. For example, Daphna (W, 97, Widow) shared that "moving the muscles and making an effort is the best thing I can do."

The feelings of pleasure experienced during the study period directly affected the participants' sense at the end of the study period, which they defined as a *positive experience*. For example, Alex (W, 79) remembered longingly: "Gymmy made me smile in the morning when it said good morning, my name is Gymmy … I approached it happily; it was pleasant and comfortable for me. It was a good experience. I'm a little sad because Gymmy is leaving; I really like it."

As a result of the successful use they experienced, the 'Fans' obtained several interrelated 'positive outcomes.' They reported that Gymmy strengthened their *awareness and motivation to exercise* and increased their *exercising frequency*. Gymmy's presence in the participants' homes contributed to their general *exercise awareness*. As Nina (W, 77, Widow) shared: "It is really a problem to move the body … I was more aware that I had to get up from the computer." In addition to awareness, they noted that Gymmy *motivated participants to exercise more*. Participants explained that Gymmy was actually like a training partner, one who "moves with me," "spurred," "encouraged," and "pushed me to exercise at home."

As the awareness and motivation to exercise increased, so did *the frequency with which participants exercised*. That is, the awareness, motivation, and the fact that Gymmy was accessible and available led to an increase in the participants' total physical activity time during the study period. When asked by the interviewer in the concluding interview if the robot made them perform more physical activity, most of the participants in this group answered 'yes,' and shared a variety of positive responses, such as "Of course it added."—Luca (M, 79, Married); "Certainly, definitely, now more."—Helen (W, 86, Widow).

4.1.4 Attitudes towards SARs after use

The use of Gymmy led to a positive overall evaluation of SARs among Gymmy's 'Fans' and positively influenced their perceptions. These participants shared in the concluding interviews that they believe that using SARs "can undoubtedly" *help the older adults*. "For older adults? For sure! A thousand percent, it will make a great contribution to a person," stated Tom (M, 76, Widow). Similarly, Luca (M, 79, Married) highlighted that "robotics can benefit older people in many areas … it can save time, money … it can only be beneficial." Further evidence that the use of Gymmy positively affected the perception and evaluation of SARs among this group of participants stemmed from the question about the dangers and risks of robots asked during the concluding interviews. Without exception, all the participants in this group indicated that "there are no risks at all," only "positive things."

4.2 The 'skeptics'

4.2.1 Personal background

The average age of the ten participants in the 'Skeptics' group ranged from 75 to 86 years, with a mean age of 79.4 years (SD = 4.41). This group's mean number of years of education was 13.5 (SD = 2.28). Hence, they were somewhat younger and more educated than the 'Fans.' Compared to the first group, most (N = 8) of the 'Skeptics' also came to the study with knowledge, previous experience, and familiarity with the world of robotics. This may explain why they expressed some skepticism during the preliminary in-depth interviews and mentioned many disadvantages that they believed existed in using SARs and a variety of potential risks that may result from this use. Most of the 'Skeptics" exercise habits before the study were extensive and diverse. Finally, the media use of all participants in this group included both basic and advanced uses of ICT.

4.2.2 Attitudes towards SARs before use

Eight participants in this group joined the study with previous knowledge and experience with SARs. The accumulated knowledge came from "books," "movies," and "lectures on the subject," and as a result of experiences shared with them by acquaintances. It seemed that their early familiarity and being 'knowledgeable' about robotics made them come to the study with a sense of skepticism. Michael (M, 82, Married), for example, shared: "We must find a way to balance the wisdom of the robots so that they cannot do everything … otherwise we will close the hospitals, kill the people, and use only robots," and summarized: "I hope I can get along with Gymmy."

In accordance with these sentiments, they described several disadvantages that characterize the use of SARs and risks that they believed may be caused by this use. The 'disadvantages' included: *robots are not a substitute for a human,* and *robots depend on the person who programs them*. *Robots are not a substitute for a human* was frequently discussed when comparing the interaction with a robot to that with a human. Participants repeatedly emphasized that "robots lack human contact." Maggie (W, 77, Widow), for example, explained that: "There is no substitute for a look in the eyes and a hug, for laughing together, for all the things that a human being gives." In addition, the 'Skeptics' explained that SARs could not be a worthy substitute for humans as they cannot experience and express emotions whereas "human and emotion cannot be separated," as highlighted by Clara (W, 75, Married). The participants noted that, like other modern technologies, *robots depend on the person who programs them* for better or worse. Therefore, participants said they hope the programmer has "lofty goals and aims to help users."

Along with the disadvantages, participants also noted three potential 'risks' that may result from using SARs: *Invasion of privacy, impairment of independence in daily functioning,* and *risk of being replaced by robots*. *Invasion of privacy* was discussed in terms of informational privacy. Participants shared their concerns about their understanding of how the information shared with the robot is processed and used (or misused). For example, Nathan (M, 75, Married) said: "Actually, I have no idea what the robot is doing, and I am afraid there will be an invasion of my private life."

The second risk discussed by the participants was *impairment of independence in daily functioning,* both physically and cognitively. From a physical perspective, this risk was derived from the participants' concern about being replaced by robots in daily activities at home. The participants claimed that robots might threaten their autonomy by replacing them in home tasks they should perform by themselves. Sofie (W, 77, Married), for example, clarified: "I get along great without it, I leave it for the future." From a cognitive perspective, the fact that robots are an extremely 'intelligent' technology that can efficiently perform cognitive actions was a potential risk, according to participants' perceptions. They claimed that the robots may threaten users' cognitive abilities in knowledge tasks they can perform independently, as Gabriel (M, 80, Married) shared: "We will think less, and the robots will think for us."

The *risk of being replaced by robots* was discussed in the employment context. "This is a pretty difficult problem for the world … if robots come into our lives … people will lose their jobs etc.," explained Sarah (W, 83, Widow). Michael (M, 82, Married) even portrayed the future as an apocalyptic scenario and explained: "Robots pose a danger of replacing people … you will have no job, and you will have nothing."

4.2.3 Actual use experience

The 'Skeptics' first days of using Gymmy can be described as a success. The participants learned how to use it, were satisfied with it, and experienced enthusiasm. However, the excitement was only temporary and preliminary, a finding reflected in the usage data produced by Gymmy (Figure 5) and in the participants' words. For example, Daniel (M, 75, Married) explained: "At first it was nice … it was a new experience to play with a robot." In fact, the initial enthusiasm cooled down and turned into disappointment, which was reflected in the participants' negative evaluations (Figure 3). These evaluations were due to several pragmatic factors (*too simple and not challenging enough, technical problems, too slow,* and *few activities*) and a result of one non-hedonic factor (*lack of humanity*).

The biggest disappointment with Gymmy among the 'Skeptics' was that the participants perceived its use as *too simple and not challenging*, and even boring. As Clara (W, 75, Married) said: "I was expecting something more challenging, but it was not … it is too simple for my abilities." This was true for physical training, cognitive training, and relaxation exercises. This simplicity and lack of challenge made the participants feel that the use of Gymmy was "somewhat frustrating," "nagging," and "not fun."

Another major issue noted by the participants was *technical problems*. The 'Skeptics' showed less patience for technical faults, a tendency clearly reflected in their weekly reports (Figure 4) and directly affected their sense of disappointment. "The difficulty is that there were some exercises where the robot did not catch my movements," noted Nathan (M, 75, Married). *Too slow* referred to the time it took Gymmy to turn on and perform the exercises and the waiting time between them. Maggie (W, 77, Widow), for example, noted that "it takes a long time for Gymmy to wake up." In addition, Daniel (M, 75, Married) said: "The exercises should be much faster … more vigorous." Nathan (M, 75, Married) commented that the waiting time between exercises "is very long, so I did a run-in-place activity meanwhile."

Few activities were discussed in the context of two aspects: First, regarding a too-small pool of physical exercises, and second, regarding the fact that the physical training was for the upper limbs only. Regarding the first aspect, several participants expressed disappointment that the physical training time was too short. "I just started, and immediately it was over," indicated Arik (M, 86, Widow). In terms of the second aspect, participants perceived the physical training for upper limbs only as a disadvantage, were disappointed by this, and hoped for additional activities that would allow them to train their lower body. For example, Clara (W, 75, Married) mentioned that "the lower part of the body did not participate … it was completely missing."

Lack of humanity as a factor that caused a negative evaluation among the 'Skeptics' stemmed from the fact that they expected the communication with Gymmy to be as similar as possible to human-human interaction. Therefore, when expectations did not match reality, most experienced disappointment. Daniel (M, 75, Married), for example, described that "it would have been perfect if it had said, 'Come on, Daniel, time to practice.'" In almost the same way, Maggie (W, 77, Widow) explained: "The only thing I wanted was that the robot would talk to me … but it did not talk."

Following all the factors listed above, most 'Skeptics' felt that Gymmy "does not provide any added value" and that "there is no novelty in it." Accordingly, Gymmy "did not live up to expectations," and they felt "no desire for permanent adoption." For instance, Clara (W, 75, Married) concluded sarcastically: "There was nothing special here; I did not shed a tear because Gymmy was leaving."

Notwithstanding the disappointment these users experienced, and despite their disinterest in adopting 'Gymmy' permanently, their attitude towards it after use was that it had a 'potential for others.' Although Gymmy was less relevant for them, they believed that it could certainly help *lonely older adults* and *older adults with disabilities.* Help for *lonely older adults* referred to the perception that Gymmy can act as a kind of companion or friend. As Gabriel (M, 80, Married) explained: "This robot can be an advantage for lonely persons … Gymmy can definitely guide them and make them exercise." Another perception that participants shared about Gymmy was that it could help *older adults with disabilities.* The fact that Gymmy is placed at home and can be used at any time allows "people who cannot leave their homes" or "people who are confined to a wheelchair" to exercise.

4.2.4 Attitudes towards SARs after use

This group's skepticism in the opening interviews seemed to impact their evaluation of robots after the study period. Nevertheless, the disadvantages and risks that this group of users associated with SARs appeared to be somewhat moderated by their experiences with Gymmy. Accordingly, their evaluations of SARs at the end of the study were, in most cases, a little more positive than they were before it began. For example, Maggie (W, 77, Widow) explained before the study period that "robots have advantages and disadvantages, but you have to get used to it, it is something so new." At the end of the study, when asked if, after using Gymmy, she is more open to future experiences with robots, she replied: "I think so … I'm open to that." Not all Skeptics, however, demonstrated greater openness and better evaluations of robots after the study. For example, Sofie (W, 77, Married), who said in the opening interview that she was doing fine without a robot, maintained the same mindset after the study was over: "I never had any issues that required the use of robots."

Notwithstanding the differences mentioned above, all 'Skeptics' noted 'potential benefits' they believed could result from using SARs. The benefits included *assistance to the older population in general* and *to lonely older adults and older adults with disabilities in particular.* Similar to the 'Fans,' but less decisively, the 'Skeptics' also believed that using SARs could help the older population. At the same time, their focus was on sub-populations within the older population. Like their attitude towards the specific potential of Gymmy, they believed that SARs could help mostly *lonely older adults* and *older adults with disabilities.* Finally, when the 'Skeptics' were asked if, after using 'Gymmy,' they thought SARs could be dangerous, apart from two participants, all the others stated that they were "not afraid of using them" nor did they think they might be hazardous.

5 Discussion

Following the users' experiences in real-life conditions and over time made it possible to identify two distinct assimilation patterns in terms of uses, constraints (both antecedent and intervening), and outcomes (both benefits and disappointments). The two patterns suggested that the process of SARs' assimilation is not homogeneous and provided a more profound understanding of the factors affecting older adults' QE of SARs following actual use. Below is a discussion of the two assimilation patterns vis-à-vis the three main topics explored regarding HRI in later life, namely: uses, constraints, and outcomes (Zafrani and Nimrod, 2019).

Uses. In the present study, the two groups of users reported a completely different use experience. Whereas the 'Fans' experienced Gymmy as easy and convenient to operate and use, the 'Skeptics' experienced it as too simple, unchallenging, and boring. A possible explanation for this gap in the user experience lies in the participants' exercise habits before the study. Gymmy provided the 'Fans' with a new value-added function to their daily routines, i.e., physical activity, which they either did not engage in at all or did so to a very limited extent prior to the study. In contrast, this function was adequately implemented in the Skeptics' daily routines. Accordingly, they did not attribute added value to the use of Gymmy, which, in turn, led to decreased intensity of use.

This explanation is consistent with previous research suggesting that user attributes significantly affect the user experience (e.g., Morillo-Mendez et al., 2021). It also echoes studies demonstrating that older adults expect robots to be tailored to their needs (Tsardoulias et al., 2017; Karkovsky et al., 2021). If they cannot ascribe new valuable functions to the robot, they will evaluate the interaction with it less favorably and eventually abandon its use (Frennert et al., 2017).

The present study's findings also supported previous research, according to which direct experience with SARs promotes acceptance (Shen and Wu, 2016). Most of the participants in the 'Fans' group came to the study without any explicit attitudes towards SARs because, as mentioned, they had had no prior familiarity with the field of robotics. However, at the end of the study period, they developed positive attitudes towards SARs in general. Moreover, despite the disappointment with Gymmy, the direct interaction with it reduced the ambivalence towards SARs among the 'Skeptics.' These participants came to the study with firm negative attitudes towards SARs and mentioned a variety of disadvantages and risks that they believed were associated with their use. Nevertheless, their overall evaluations of SARs at the end of the study period were more positive than beforehand.

Constraints. The discussion of constraints refers solely to the 'Skeptics,' as the 'Fans' hardly reported any constraints. The gap between the 'Fans' and the 'Skeptics' resulted not only from the differences in exercise habits, but also from a most significant antecedent constraint found among the 'Skeptics.' As stated above, unlike the 'Fans,' most of the participants in the 'Skeptics' group joined the study with previous attitudes towards SARs, which were constructed by contents to which various media exposed them. In such contents, robots are often demonized and presented as attempting to take over the world and replace humans (e.g., the Terminator; Bartneck et al., 2007). These negative connotations, in turn, can trigger negative attitudes and emotions toward robots (Lee et al., 2012).

This gap may also stem from the characteristics of the sample. As mentioned above, the 'Skeptics' were somewhat more educated than the 'Fans.' It is thus reasonable to argue that older adults with a higher level of education and prior knowledge of robotic technologies would be characterized by a more realistic perception and greater awareness of their shortcomings. Simultaneously, the education variable may also affect the degree of exposure to various media content (Huffman, 2018) and the ability to acquire and absorb information and content from modern technologies (Simoni et al., 2016). Therefore, the initial negative attitudes of the 'Skeptics' could result from exposure to content in the various media, from being more educated, or from the correlation between these variables.

Another antecedent constraint found among the 'Skeptics' came from the stigma associated with using a robot in old age (Neven, 2010; Bradwell et al., 2021), which is one of the most dominant constraints found in the literature on HRI in later life (Zafrani and Nimrod, 2019). The 'Skeptics' tended to perceive the prospective robot user as a much older person who needs substantial support with everyday tasks. This negative perception limited the Skeptics' motivation to use SARs even before the study and may have helped them dissociate themselves from ageist stereotypes.

Intervening constraints found were technical problems and slow operation. The 'Skeptics' showed less patience for these issues than the 'Fans'—a finding reflected in the concluding interviews that seemed to affect their evaluations of Gymmy. These findings support previous literature indicating that usability, including various operative difficulties in robot performance, constitutes a significant intervening constraint (Pripfl et al., 2016; Wang et al., 2019) that leads to dissatisfaction and negative QE (De Graaf et al., 2015; Wang et al., 2019).

Outcomes. The discussion of outcomes is divided into negative and positive outcomes (i.e., benefits). Similar to the constraints, the entire negative outcomes category was relevant only to the 'Skeptics.' These outcomes were reflected in the fact that throughout most of the study period, they experienced a host of negative sentiments (dissatisfaction, boredom, frustration, resentment, and lack of enjoyment, patience, and interest) and were overall disappointed with using Gymmy.

Besides describing the negative outcomes, the participants addressed the benefits gained from using Gymmy and the potential benefits that they believed existed in SARs following the study. Here, the division between the 'Fans' and the 'Skeptics' was noteworthy: Whereas the benefits mentioned by the 'Fans' were directed at themselves, the benefits described by the 'Skeptics' were directed at others. The positive feelings reported by the 'Fans' echoed previous research on HRI in later life, suggesting that interacting with robots was experienced by older adults as an enjoyable activity (De Graaf et al., 2015; Lazar et al., 2016) that had positive effects on their mood (McGlynn et al., 2017) and wellbeing (Henschel et al., 2021). The 'Fans' noted additional benefits related to the central function that Gymmy provided - physical training. They reported that Gymmy raised their awareness and motivation to exercise and increased their exercise frequency.

Among the 'Skeptics,' Gymmy's specific potential benefits were the same as the potential benefits of SARs in general. They believed that Gymmy, like any SAR, could assist the older population, especially lonely and frail older adults. It can be assumed that this perception was related to the antecedent constraint mentioned above regarding the stigma of this group associated with using a robot in old age.

Overall, the application of simultaneous exploration of uses, constraints, and outcomes over time and in real-life conditions explained how these topics correlate with one another and presented a broader and more accurate picture of factors shaping older adults' QE of SARs. Specifically, this exploration explained how the QE may vary according to the assimilation pattern, the factors affecting the use and the benefits gained, and the constraints to beneficial use. Moreover, this study showed an inevitable connection between these three topics, as the interchange between uses and constraints seems to influence outcomes. Accordingly, it is suggested that future research should apply a similar approach.

The findings also suggest two integrative practical recommendations for improving SARs' evaluation by older adults. First, to promote a more positive QE, acceptance, and successful assimilation process, developers and designers of SARs for older adults are advised to consider the needs of older adults and take steps to reduce their fears, concerns, and sense of inconvenience about robots. The features that make the robots pleasant to use should be stressed in all educational and marketing communication targeting older people. Moreover, a proper training session on the SAR and its functions should be provided, during which participants are given relevant information and allowed to ask questions to remove their doubts and fears. Second, it is essential to invest efforts in developing and designing SARs that are adjustable to the user's needs, functional, convenient, simple, provide added value, easy to use, and have unique features such as a multi-modal communication (Kirby et al., 2009; Krakovski, 2022).

6 Limitations and future research

Despite its many strengths, this study has several limitations that should be acknowledged. First of all, the study was limited to one specific SAR designed for a particular purpose (physical training), and thus the findings cannot be generalized to other robotic systems. Using a SAR intended for another purpose or using a multi-purpose SAR might have yielded different results. In addition, most of the participants in the study were healthy older adults without physical or cognitive impairments. Therefore, we cannot generalize its findings to frail older adults. Finally, the study was conducted during the COVID-19 pandemic, which may have affected the participants' exercise patterns, general mood, and assessments.

Future research should expand the present study to explore factors affecting QE of SARs among additional older audiences including "oldest old" (85+ years; Le et al., 2014) participants, older individuals residing in other countries and cultural environments, and older adults with different levels of education, income, previous experience with robots, media usage and exposure, self-efficacy, and physical and cognitive functioning. Such studies should also follow up assimilation processes for longer periods to explore how uses, constraints, and outcomes continue to evolve over time, and compare assimilation of SARs by using additional types of robots, including multi-function vs single-function SARs, stationary vs mobile SARs, and proactive vs reactive SARs.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Ben-Gurion University of the Negev ethics commit. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

OZ: Writing–original draft, Methodology, Investigation, Analysis. GN: Writing–review and editing, Methodology, Investigation, Analysis. MK: Writing–review and editing, Software. SK: Writing–review and editing, Software. SB-H: Writing–review and editing, Investigation. YE: Writing–review and editing, Methodology, Investigation, Analysis.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Corrigendum: Assimilation of socially assistive robots by older adults: an interplay of uses, constraints and outcomes

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The authors apologize for this error and state that this does not change the scientific conclusions of the article in any way.

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Promising directions for human-robot interactions defined by older adults

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Introduction: Older adults are engaging more and more with voice-based agent and social robot technologies, and roboticists are increasingly designing interactions for these systems with older adults in mind. Older adults are often not included in these design processes, yet there are many opportunities for older adults to collaborate with design teams to design future robot interactions and help guide directions for robot development.

Methods: Through a year-long co-design project, we collaborated with 28 older adults to understand the key focus areas that older adults see promise in for older adult-robot interaction in their everyday lives and how they would like these interactions to be designed. This paper describes and explores the robot-interaction guidelines and future directions identified by older adults, specifically investigating the change and trajectory of these guidelines through the course of the co-design process from the initial interview to the design guideline generation session to the final interview. Results were analyzed through an adapted ethnographic decision tree modeling approach to understand older adults' decision making surrounding the various focus areas and guidelines for social robots.

Results: Overall, over the course of the co-design process between the beginning and end, older adults developed a better understanding of the robot that translated to them being more certain of their attitudes of how they would like a robot to engage with them in their lives. Older adults were more accepting of transactional functions such as reminders and scheduling and less open to functions that would involve sharing sensitive information and tracking and/or monitoring of them, expressing concerns around surveillance. There was some promise in robot interactions for connecting with others, body signal monitoring, and emotional wellness, though older adults brought up concerns around autonomy, privacy, and naturalness of the interaction with a robot that need to be further explored.

Discussion: This work provides guidance for future interaction development for robots that are being designed to interact with older adults and highlights areas that need to be further investigated with older adults to understand how best to design for user concerns.

KEYWORDS

older adults, social robots, co-design, participatory design, ethnographic decision tree modeling, qualitative analysis

1 Introduction

As more and more technology enters our lives, it is critical for us to be designing these systems with users. Social robots are increasingly being introduced into many different social contexts, including homes, schools, and hospitals, stressing the need for users to be more frequently engaged in social robot design processes. Researchers in human-robot interaction (HRI) have highlighted the promise of social robots assisting older adults, proposing several areas where these technologies could be beneficial (Smarr et al., 2014; Ostrowski et al., 2019b; Abou Allaban et al., 2020; Bardaro et al., 2022) (that have informed the selection of the focus areas for this work). However, older adults are often not included in the design process where researchers, engineers, and designers generate ideas and develop requirements for the technologies. This is often due to stereotypes such as older are unable to use technology (Light et al., 2015; Knowles et al., 2020).

In recent years, there has been more emphasis on engaging users in more participatory design methods, such as co-design, and, specifically, working collaboratively with older adults in the design of social robots. Older adults are essential stakeholders in the design of social robot systems and contribute immense value to the design of these technologies due to their lived experiences and ability to create interactions tailored to their lives (Ostrowski et al., 2021b; Sakaguchi-Tang et al., 2021). Engaging older adults in co-design processes where they partner with researchers and designers empowers them in the design of these technologies as their lived experiences and expertise are valued in the process.

In our work, we explore how older adults' ideas and future design directions of social robots and design guidelines for social robot interaction change and develop over the course of a year-long co-design process. We analyze older adults' desired functions and design features from the initial interview and the final reflection interview; from the beginning to the end of the co-design process. We also explore the design guidelines and priorities generated by older adults for the next stage of robot interaction development. Previous works from the larger co-design study have described the overall co-design process (Ostrowski et al., 2021a), presented long-term divergent-convergent co-design guidelines for designing social robots (Ostrowski et al., 2021a), examined the shift in who is called a robot designer (Ostrowski et al., 2022a), explored older adults' usage of social robots in the home (Ostrowski et al., 2022b), and explored the value of stories in co-design work (Ostrowski et al., 2021b). In this work, we specifically look at the longitudinal change of older adults' desired features and functions for social robots and their design guidelines from the end of the study. The main contribution from this work is guidance for future robot interaction development generated by older adults. We also highlight specific areas with high promise in older adult-robot interaction and specific areas in need of further investigation and design collaboration with older adults to address concerns surrounding these interactions.

2 Background

As we work to design social robots that people will interact with in their homes and other spaces during the course of their day, it is critical for us to design social robot interactions that are created with users.

2.1 Designing robots for everyday HRI

We need to think about robot interaction design when we consider everyday interactions and how a social robot will fit into people's lives. Social robot application research is expansive and has looked at areas from healthcare to education settings (Leite et al., 2013; Sheridan, 2020; Mahdi et al., 2022). Social robots in the home are another important focus area for HRI (Leite et al., 2013), including considering older adults interacting with robots in their home as they age in place (Alves-Oliveira et al., 2015; Mois and Beer, 2020). As the world's older adult population continues to grow (United Nations Department of Economic and Social Affairs, 2020), there is an increasing need for ensuring older adults are supported holistically while aging in place. It is also critical for more research to be conducted around older adults' interaction and design preferences since there are many perspectives in the literature on social robots designed to engage with older adults. For example, some research has found that older adults do not want social robots to exhibit any emotional aspects (Thunberg and Ziemke, 2021); while in other research, older adults want the social robot to exhibit these appearances (Eftring and Frennert, 2016). These previous results seem conflicting, however, there is a need to understand the complexity of these results with studies providing more discussion on how to consider these results contextually and the nuances for why people may choose not to engage with social robot interactions and/or designs. Overall, technologies, such as social robots, offer promise for older adults to use in their everyday lives and support their wellbeing (Alves-Oliveira et al., 2015; Mois and Beer, 2020). Considering the development of these technologies that will be used by a variety of older adults and their social and, potentially, healthcare networks, it is critical for us to engage older adults in the design process of social robots to support them in finding ways that these technology systems can best address their needs and to support researchers in understanding how best to approach challenging design areas.

2.2 Co-design with older adults in HRI

Co-design (or collaborative design) and participatory design in HRI support deeper engagement with users in the design of robots. Co-design processes support user empowerment in the design process where researchers collaborate with users as partners in the design process (Harrington et al., 2019). When users, such as older adults, engage in co-design processes, they inform the design of technologies, such as social robots, from their expertise and lived experiences (Bate and Robert, 2006; Harrington et al., 2018).

Older adults have engaged in co-design and/or participatory design of social robots in varying ways. For example, older adults have engaged in a co-design processes to design robots through interviews and workshops where they learned about physically assistive and socially assistive robots and created sketches with the research team of their desired robot interactions (Šabanović et al., 2015; Lee et al., 2017; Randall et al., 2018). In a 3 week community-based participatory design study exploring how older adults want social robots to be designed, older adults lived with a social robot in their community space and engaged in card-sorting to express their desired functions for social robots in their community space (Ostrowski et al., 2019a). Co-design processes with older adults designing social robots for emotional wellbeing have employed the dialogue-labs method to support ideation and concept development through structured approaches considering aspects such as the design process, the physical design environment, and the materials used in the design activities (Lucero et al., 2012; Alhouli et al., 2023). Participatory design workshops have also been used in co-design with older adults. For example, in (Fraune et al., 2022), older adults reflected on their technology experiences and social challenges before iteratively designing a robot to solve their social challenges. In another study, older adults partnered with researchers to design a care robot for the home through participatory design workshops, prototyping, interacting with mock-ups, and testing the robot in the home (Eftring and Frennert, 2016). This work gathered user requirements around how the robot should interact with older adults in the home, including details on the embodiment (e.g., maximum height, appearance) and interactions (e.g., picking up objects, assisting with exercises). Design scenarios can also be incorporated into participatory design activities to support older adults in considering how robot interactions could be designed for various contexts, including investigating how various types of robots could be used in design scenarios (Thunberg and Ziemke, 2021). Participatory design sometimes includes techniques that allow older adults to prototype on the robots (as seen in this study and discussed in (Ostrowski et al., 2022a)). In an adaptation of participatory design, termed Situated Participatory Design, older adults designed and tested robot interaction scenarios in their homes through experiences with the robot, and Wizard of Oz techniques to simulate interactions (Stegner et al., 2023). These examples of co-design and participatory design with older adults demonstrate how older adults can be more deeply engaged in the design process and how their lived experience can be valued in the design of social robots. They also call for more longitudinal studies to support the robot development process in partnership with older adults (Thunberg and Ziemke, 2021). Overall, co-design and participatory design are less common methods when engaging older adults in design processes and these methods are not commonly used within HRI (Björling and Rose, 2019). Our work demonstrates how older adults' experience in a co-design process can support them in creating design guidelines for social robots and how their thoughts and opinions may shift overtime in this process.

3 Methodology

Embedded in a year-long co-design process, we conducted interviews and a design guideline generation session with older adults to understand their ideas for robot interaction in their everyday lives. As discussed in this paper, the initial and reflection interviews delved into discussing the core domains of impact. The design guideline generation session was a collaborative session with older adults to identify key areas of development and improvement moving forward with social robots. This section outlines the protocols for these sessions and the analysis process for the different types of data.

3.1 Overview of co-design process

We conducted a year-long seven stage co-design process collaborating with older adults to understand the key focus areas that older adults see promise in for older adult-robot interaction in their daily lives (Ostrowski et al., 2021a) (Figure 1). The co-design process provided opportunities to be expansive in their idea generation, creating new areas for robot use, and also provided scoped exploration of seven focus areas: connecting with others, medical adherence, memory assistance and monitoring, exercise and physical therapy, body signal monitoring, emotional wellness, and financial management (informed by previous research in HRI). Over the course of the year, we engaged in multiple different activities including interviews, art sessions, interactive prototyping, and a design guideline generation session (for more details on the overall process, please refer to Figure 1; Ostrowski et al. (2021a)). In this work, we specifically explore three of these sessions: the initial interview, the design guideline generation session, and the reflection interview. This work describes robot-interaction priorities identified by older adults, tracking these priorities from the beginning to the end of the co-design process.

3.2 Participants

In the year-long co-design process, we collaborated with 28 older adults between 70 and 94 years of age (mean: 79.5, std: 7.8; female N = 15) from three states in the United States. Participants chose whether they would like to complete their sessions at the MIT Media Lab or their home based on their preference. Participants who were not located in the state of Massachusetts completed their sessions remotely through video calls. The co-design study was approved by the Institutional Review Board (IRB) and all participants volunteered to participate, completing an IRB approved consent form. For the three activities that we focus on in this paper, all participants participated in the initial interview, 79% participated in the design guideline generation session, and 75% participated in the reflection interview. Those who could not attend the design guideline generation session were unable to attend due to travel or health-related issues. The COVID-19 pandemic was just starting while we were conducting the reflection interviews, therefore, some participants did not complete this session due to the start of the pandemic or lack of online access. Additionally, due to the COVID-19 pandemic, some of the reflection interviews were conducted through video call.

3.3 Interviews in co-design process

The interview protocols for the initial interview and reflection interview were structured using an ethnographic decision tree modeling approach (Gladwin, 1989). The structure for the two interviews was similar with some variations based on the stage of

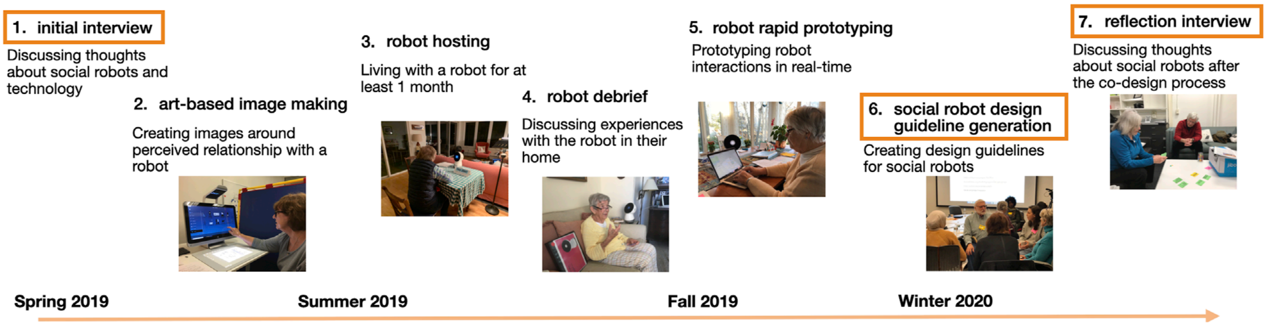

FIGURE 1
Year-long co-design process with seven sessions detailed. The sessions that are the main focus of this paper (initial and reflection interviews, and design guideline generation sessions) are highlighted in boxes.

the process. The initial interview began with an opening providing an overview of the co-design process and introduction to the seven focus areas: connecting with others, medical adherence, memory assistance and monitoring, exercise and physical therapy, body signal monitoring, emotional wellness, and financial management. The participants were then asked to discuss their everyday lives, interactions with technology, and their initial thoughts on social robots and the roles they see social robots potentially playing in their lives. This section was only asked in the initial interview. At the beginning of the reflection interview that occurred after the design guideline generation session, the interview started with the participant reflecting on the design guideline generation session.

After these beginning sections, the interview progressed into looking at each of the focus areas specifically. For each focus area, for the initial interview, participants were asked (1) what they thought of when they heard the focus area, (2) if the focus area is part of their life and if so, how do they engage in the focus area, (3) their initial thoughts for a social robot assisting with this area, and (4) if such a social robot interaction would fit into their lives. These questions were only asked in the initial interview. In the reflection interview, each area was revisited and participants were asked their thoughts on social robots assisting in the focus area and how it may fit into their lives.

For both interviews, the interviewer then asked participant's thoughts about specific actions that a robot could do in each focus area. For example, for *medial adherence*, one interaction asked about was if a person would like the social robot to remind them when to take their medicine. Another example for *connecting with others* was if the person would like the social robot to remind them to call or talk to friends and family.

This part of the interview was formatted differently for the two interviews because of co-design participant input. In the initial interview, the participant and interviewer completed this section verbally. Participants mentioned that it was a bit tedious to go through these questions verbally. Therefore, based on this suggestion, for the reflection interview, the researchers turned these questions into physical cards that the participants could sort based on their preferences for the various interaction types (Figure 2). For both interviews, participants were asked to explain their preferences for or against the various interactions. Another modification informed by participant feedback was removing the financial management category for the reflection interview. In the initial interview, there was a majority negative reception to the category and the category was removed from the subsequent activities.

After participants completed this section stating their preferences for some interactions that may be included in the focus areas, they were asked how they felt about a social robot in this focus area overall and any concerns and/or benefits they could see of a social robot in this focus area. As a closing for the interview, participants lastly discussed the most intriguing and most appalling or shocking scenario, barriers for having a social robot in their home, and benefits of having a social robot. For the reflection interview only, participants also reflected upon the overall co-design process. The full protocol for both interviews can be found in the Supplementary Materials.

3.3.1 Interview analysis: Adapted ethnographic decision tree modeling

Ethnographic decision tree modeling is a qualitative method where through interviews researchers explore decision criteria and motivation (Gladwin, 1989). The methodology is grounded in participants' expertise, lived experiences, and beliefs that their decision making is based upon (Gladwin, 1989; Roth and Botha, 2009), aligning with values supported by co-design. In this paper, we used ethnographic decision tree modeling as a foundational analysis technique to explore older adults' decisions for or against social robot interactions across the focus areas. We adapt the ethnographic decision tree modelling process to explore the reasons that are motivating older adults decision making, restructuring the tree to support visualizing these decisions. We also expand the methodology by the creation of meta-analysis and final trees (more information below), providing an overall scope of the older adults' decision making around robot interactions. In this way, we align with the phases of exploration and model development common in ethnographic decision tree modeling. We do not engage with the model testing phase as this is one aspect of future work.

A set of Ethnographic Decision Model Trees were created from each participant interview to understand the participants' decision making process while they conceptualize their ideal social robots

FIGURE 2
On the left, older adults participating in the reflection interview card sorting; on the right, participant arranged cards for the memory focus area, sorted into "yes [I want this function]", "maybe [I would want this function]", and "no [I do not want this function]".

and interpret whether participants were receptive or against seeing focus area interactions in a robot. The decision model trees were created in three stages. All decision model trees are based on participant transcripts that were created from audio recordings of the interviews. Two researchers reviewed the transcripts and iteratively developed the decision model trees.

In the **first stage**, we created a set of decision model trees for each participant interview, which consists of seven focus areas: medication adherence, body signal monitoring, memory, emotional wellness, connecting with others, exercise, and financial management. As a decision model tree is created for each focus area, each participant set typically consists of seven model trees. Each decision model tree consists of three branches (Figure 3A). Under the first branch, "Usages + Benefits," are the functions that the participant would readily accept in a social robot. In the second branch, "Prioritization + Caveat," are functions that were rejected by the participant, or treated with hesitation. Under the third branch, "Concerns," are broader concerns that the participants have about social robots that contribute to their hesitation or rejection of certain functions. After each model tree was completed, the main emphasis of the participant was summarized in a "Main Points" box, recapitulating the general outlook that the participant has towards social robots and the focus areas and specific functions to which they are the most receptive or resistant.

After the participant level decision model tree sets were completed, for **stage 2**, the decision model trees are organized into groups of 8–14 to construct composite Meta-analysis Decision Model Tree sets for a broader analysis of the participants' shared attitudes towards the focus areas and individual functions. As a Meta-analysis Decision Model Tree is constructed for each category, each decision model tree set contains seven individual model trees (Figure 3B). Each decision model tree has three branches. The first branch, "Basic Functions," include functions that were readily accepted by the participants. The second branch, "Solvable Obstacles," are functions that were accepted by some, but not all participants, or treated with hesitation. The third branch, "Barriers," includes the broader concerns that participants have about technology that could underlie their rejection of certain functions. The pertinent opinions that the participants had for each category are summarized in the "Main Points" box. The participants' acceptance for each category is ranked using a "Traffic Light System." The Traffic Light System is a color coding system that demonstrates the participants' degree of acceptance for each category and is based on the traffic light systems in the United States where the research was based. Each category is marked with a circle colored: (1) green, denoting that participants were very receptive and enthusiastic for this category; (2) yellow, stating that participants hold some reservations for this category; or (3) red, meaning that participants do not find this category useful, or are reluctant to use the robot for functions in the category.

In **stage 3**, the two Meta-analysis Decision Model Tree sets are consolidated to create the Final Analysis Decision Model Tree set, which captures the themes that emerged from the participants as a full group (Figure 3C). The branches of the trees are the same as those of Meta-Analysis trees. Similarly, the participants' degree of acceptance for each category is ranked by the Traffic Light System. This model tree analysis process was the same for the initial and reflection interviews (with the exception of excluding the financial management focus area for the reflection interviews as discussed above).

3.4 Design guideline generation session in co-design process

The design guideline generation session was modelled from Gonzales and Morrow-Howell (2009)'s focus groups with inspiration from resources including "Research from the Periphery: Resources for Community-Led Action Research at Instituto Banco Palmas" (MIT CoLab, 2015), "DiscoTech" Zine (Digital Detroit Justice Coalition, 2012), "Design Justice In Action" (Design Justice Network, 2018), and "Principles for Design Justice" (Design Justice Network, 2016). The goal of this

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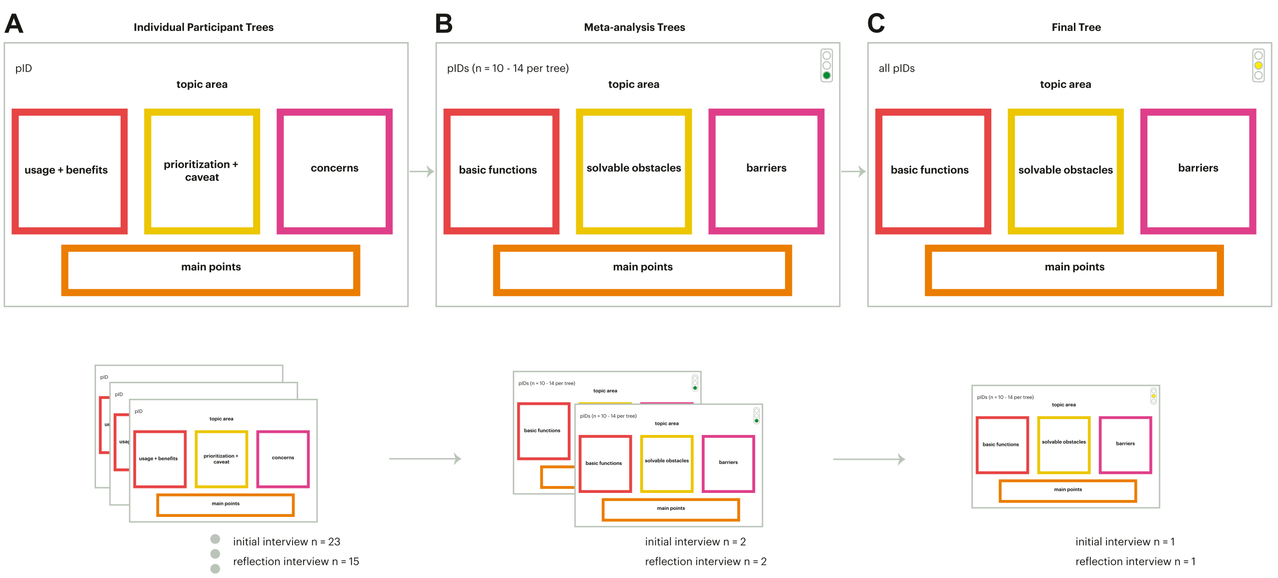

FIGURE 3
Iterative process of developing model trees beginning with individual trees **(A)**, meta-analysis trees **(B)**, and the final tree **(C)**. The numbers of trees per stage for the initial interview and reflection interview, respectively, are shown on the bottom.

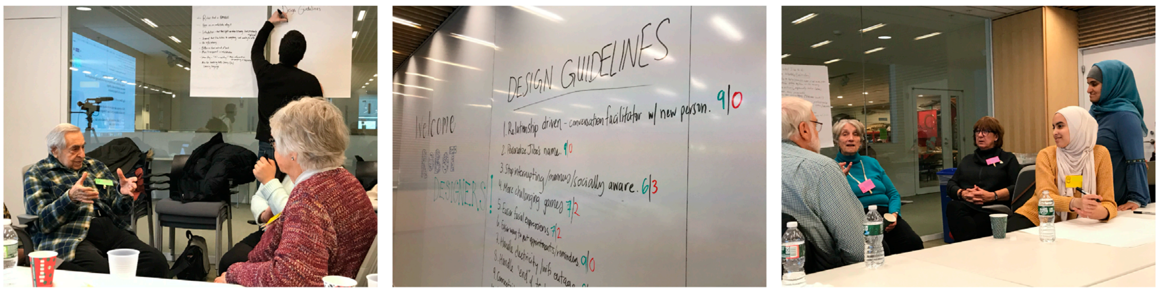

FIGURE 4
Older adults and researchers during the design guideline generation sessions where older adults generated design priorities and voted on design guidelines for social robots.

session was for the co-design participants to generate the design guidelines for the future development of robot interactions. We engaged in two main activities in the design guideline generation session in collaboration between the larger research team (12 researchers) and older adults (Figure 4). The first activity asked participants in small groups to generate a list of design priorities for their social robots. We encouraged the small groups to generate at least 10 design priorities while reflecting on their co-design experience and future desires for the technology. In the second activity, participants voted on the design priorities generated by all the small groups. The session lasted 3 hours long. The design priorities generated and voted upon by the participants were categorized by researchers to reveal the overall design guidelines for the future of the robot interaction design.

4 Results

4.1 Initial interviews

4.1.1 Individual model trees

The functions for the various focus areas were organized as usage and benefits, prioritization and caveat, and concerns for each individual participant model tree.

The usage and benefits branch included functions that were most readily accepted by the participant because they were seen as the most useful (example show in Figure 5). The functions under this branch generally were: (1) administrative - setting reminders, providing and storing information, and phone-like functions such as text dictation and video calling; (2) motivational - offering suggestions and encouragement, and

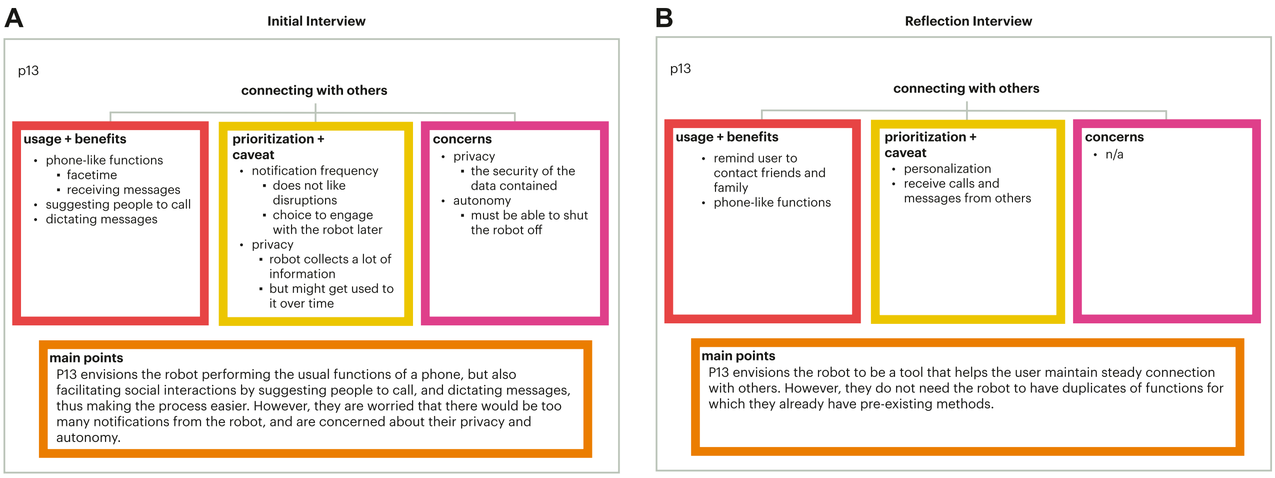

FIGURE 5
Example of individual tree set. **(A)** Initial interview individual tree for p13 for the connecting with others focus area; **(B)** Corresponding individual tree for p13 for the reflection interview.

keeping users accountable by setting goals and checking-in; or (3) light entertainment - telling jokes and fun facts. For the prioritization and caveat branch, functions were those rejected by the participant, or treated with hesitation. However, the reasons for the participant's hesitation or rejection could be abated with time, stipulations, and/or customization, allowing the participant to be more accepting of the functions in the future. The reasons and solutions for the participant's hesitation could be the following: (1) personalization - the participant would like to customize the robot to their needs. For example, participants could opt in/out of the functions they want, or customize the frequency of reminders; (2) othering—the participant does not want the function personally, but could see it being useful for others; or (3) changing skepticism—the participant may grow to accept certain functions as they become more comfortable with the robot. For example, a participant may not want to use mood tracking at first due to their lack of trust in the robot, but could envision using it in the future when their trust in the robot increases. Lastly, the concerns branch included sentiments shared by the participant that were reminiscent of greater concerns for technology. These concerns and skepticism contribute to the participant's hesitation and rejection of certain functions. Unlike the reasons for hesitation described in the previous branch, these concerns are broader and more abstract. Thus, they cannot be addressed with stipulations, but rather require a change in the user's perception of technology based on how technologies address these concerns. Some common concerns were: (1) losing autonomy, such as becoming overly dependent on the robot and consequently losing certain capabilities from disuse; (2) privacy and security of user data; (3) the robot's lack of humanness, which inhibits the robot from providing the same quality of care as human connections; or (4) the robot's lack of expertise in areas such as medicine, and is therefore unqualified to offer suggestions and advice in those fields.

4.1.2 Meta-analysis and final model tree sets

The meta-analysis model tree sets and final model tree sets were both organized with three branches (basic functions, solvable obstacles, and barriers), including a main points section emphasizing key takeaways on older adults' decision making (example show in Figure 6). The results from the final model tree were similar to those in the meta-analysis trees. The full set of initial final tress can be found in the supplementary materials. Therefore, results for both are discussed in this section.

In the basic function branch, the functions were those that were readily accepted by most of the participants. Across the focus areas, these functions could be categorized as: (1) administrative, such as setting reminders and tracking and visualizing data, (2) motivational, such as offering encouragement and coaching, and (3) light entertainment, such as telling jokes and fun facts. These results are similar to what was seen in the individual trees. The solvable obstacles branch was modified from the personalization branch in the individual trees. The solvable obstacles branch included functions that were accepted by some, but not all participants. The functions that were rejected by participants could be accepted with time or stipulations. The reasons and solutions for the hesitation towards certain functions felt by participants are: (1) customization/personalization - the participants would like to customize the robot to their needs, such as when and with whom the robot should share data; (2) pre-existing methods - participants may already have methods in place for certain functions, such as medication refill reminders, and feel that having those functions in the robot would be redundant; or (3) othering—participants may feel that certain functions may not be useful for themselves, but could see them being helpful for others. For example, some think emotional support functions may be more useful for those living alone. Barriers included the broader concerns surrounding technology that could

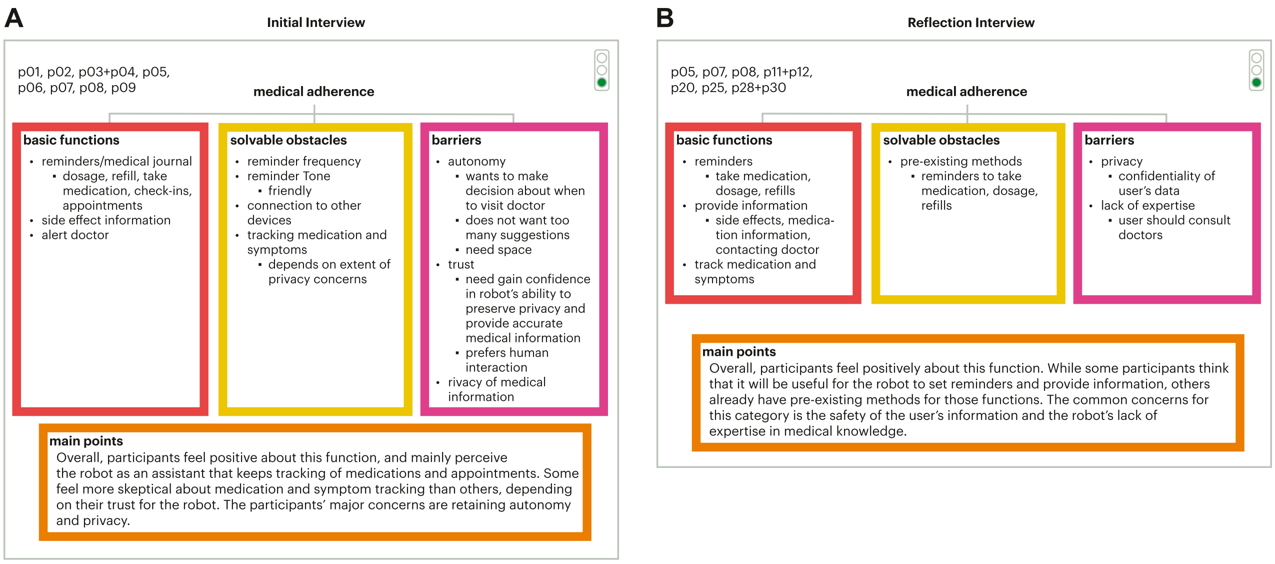

FIGURE 6
Example of meta analysis tree set. **(A)** Initial interview meta analysis tree for a portion of the participants for the medical adherence focus area; **(B)** Corresponding meta analysis tree for the reflection interview.

underlie the hesitation and reluctance that participants feel towards certain functions. Some common concerns are (1) autonomy; (2) privacy and security of user data; and (3) the robot's lack of humanness.

In this iteration of the trees, we introduced the traffic light system (as described in Section 3.3.1). For the meta-analysis model trees and final model tree sets, the focus areas of medication adherence, memory, and exercise were all categorized as green, meaning well-accepted and a clear area for future robot interaction development. Emotional wellness, body signal monitoring, and connecting with others were categorized as yellow, indicating promise for this space for robot interaction development but there needs to be more exploration in this space to understand the nuances for development. Financial management was the only focus area categorized as red as older adults were opposed to a social robot assisting in this area.

4.2 Reflection interviews

4.2.1 Individual model trees

The functions for the various focus areas were organized as before with these three branches, usage and benefits, prioritization and caveat, and concerns, for each individual participant model tree. For usage and benefits, the functions generally were categorized as: (1) administrative and (2) light entertainment. For prioritization and caveat, a participant's hesitation towards certain functions could be due to (1) personalization, (2) pre-existing methods, (3) othering, or (4) potential future usage. Potential future usage described when the participant may not need a function at the current moment, but could envision it being useful in the future when they would need more assistance with memory and health. For the last branch, the concerns held by the participant could be (1) autonomy, (2) privacy and security of data, (3) the robot's lack of humanness, or (4) the robot's lack of expertise.

4.2.2 Meta-analysis model trees and final model tree sets

As with the initial interview analysis, the meta-analysis model tree sets and final model tree sets were both organized with three branches (basic functions, solvable obstacles, and barriers), including a main points section emphasizing key takeaways on older adults' decision making. The results from the final model tree were similar to those in the meta-analysis trees. The full set of reflection final tress can be found in the supplementary materials. Therefore, results for both are discussed in this section.

For basic functions, the functions could be categorized as (1) administrative and (2) light entertainment. For solvable obstacles, the participants' hesitation towards certain functions could be due to (1) personalization and/or (2) pre-existing methods. Some common barriers shared by participants were (1) autonomy, (2) privacy and security of user data, (3) the robot's lack of humanness, and (4) the robot's lack of expertise.

By the traffic light system, the focus areas of medication adherence, memory, and exercise were all categorized as green and a promising area for robot interaction development. The focus areas of emotional wellness, body signal monitoring, and connecting with others were categorized as yellow, demonstrating promise but in need of more investigation to design these interactions properly with older adults.

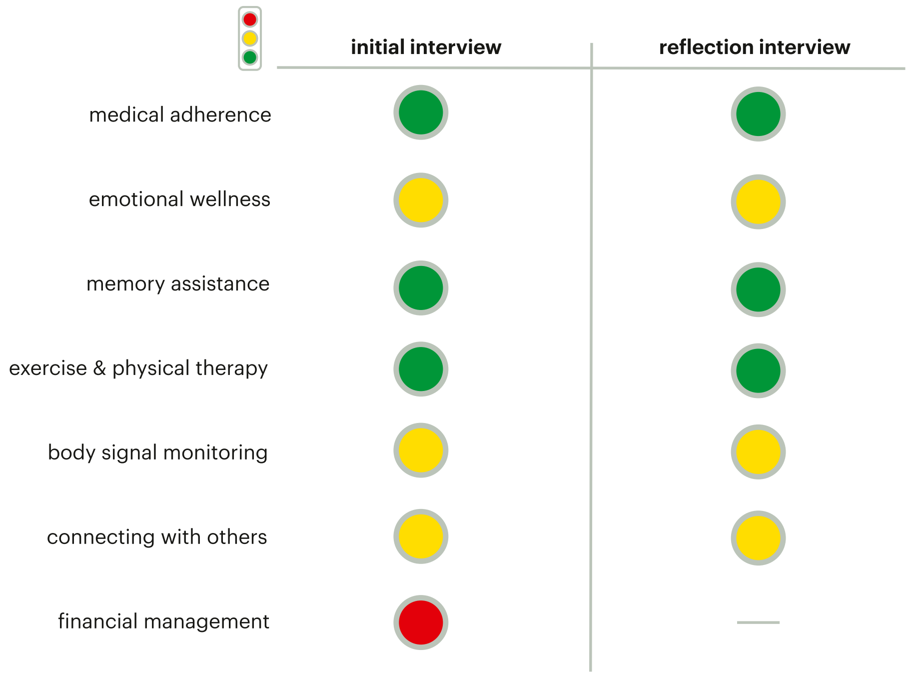

FIGURE 7
Summary of traffic light system results demonstrating no change in the overall categorization of the functional categories (except for financial management that was removed because of the extreme negative sentiment after the initial interviews).

4.3 Comparing initial and reflection interviews

Between the initial and reflection interview ethnographic decision tree analysis, there were differences and similarities, demonstrating how through the co-design experience older adults changed their perspectives toward focus areas or remained with their original perception. With regard to older adults' sentiments, for both rounds of interviews, the participants were more accepting of administrative functions such as reminders and scheduling, and less open to what were seen by older adults as more invasive functions such as tracking and emotional support. The traffic light system results are the same for the initial and reflection interviews (Figure 7). This means that the participants' overall sentiments towards the functional categories did not change as a result of their experience with the social robot, Jibo, or the change in interview format. The greater concerns regarding technology that underlie the reservations that participants had for certain functions remained constant throughout both interviews. This shows that experience with the robot did not alleviate those concerns, and that a general shift in the attitude towards robots and technology may need to occur for these concerns to be addressed. A key difference seen between the initial and reflection interviews was in how older adults delivered and discussed their opinion of the various focus areas. In the co-design process, participants lived with a Jibo social robot for at least a month period (though some participants chose to live with the robot longer), allowing participants to get a better understanding and lived experience of what it could mean to have a robot in their home. Over the course of this experience, the participants developed a better understanding of the robot and, therefore, they were more certain of their attitudes towards the functions. We saw this change of certainty between the initial and reflection interviews.

4.4 Design guideline generation session categorizations

The design guideline generation session happened right before the reflection interview and provides an understanding of participants' design priorities at the end of the co-design process. The design guidelines from the session were categorized into 10 areas: assistant-like tasks, operations, role and personality, ethics, learning, social connection, integration, health and safety, and programming (Table 1). Older adults desired more assistant-like abilities with social robots able to assist with reminders, storing contact information, organizing older adults' calendars, and general memory assistance. For operations, older adults detailed design guidelines that could improve the general usability of the social robot, including the robot having multiple accounts, being easily cleaned, being able to handle a WiFi or electrical outage, providing closed captions, having the ability to modify robot speech speed, providing multiple ways to get the robot's attention, and having physical proactivity that can be personalized. In another design guideline category, older adults emphasized the need for integration with other devices with the social robot being able to share information with other devices, control the function of other devices (e.g., lights, doors, etc.), and have seamless function across devices. Older adults also desired the ability to program their social robot in their home. This was possibly inspired by the robot rapid prototyping

TABLE 1 Categorized design guidelines and older adults' acceptance of the guidelines with their corresponding votes for guideline category.

Design guideline category	Average percentage (%)
Assistant-like tasks (e.g., reminders of appointments, note-taking, etc.)	90
Operations (e.g., closed caption option, memory of previous experiences, etc.)	88
Role and personality (e.g., empathetic personality, relationship drive, etc.)	87
Ethics (e.g., trust and privacy features, data security, etc.)	85
Learning (e.g., teach a language, reading audiobooks, etc.)	84
Social connection (e.g., video call functionality, socially aware and will not interrupt, etc.)	81
Integration (e.g., connected to multiple devices, transfer information between devices, etc.)	80
Healthcare and safety (e.g., medication reminders, medical alarm, etc.)	79
Programming (i.e., user can program the robot)	67

session in the co-design process that occurred before the design guideline generation session.

Older adults also mentioned design guidelines around the role and personality of a social robot, such as the robot being empathetic and companion-like, being relationship-driven, and having more interpretable facial expressions and human mannerisms. As seen in the barriers and concern areas of the model trees, ethics was an important area of the design guidelines, ensuring data security, trust, and privacy features that the user can control. Learning was also valued by older adults and they wanted the social robots to support their learning through ways such as learning a new language, answering questions through search engines, reading audiobooks, and supporting lifelong learning. Another area of importance was social connection with older adults wanting social robots to have video call functionality, notify them of new photos of their family that have been posted, and start/prompt conversations with family and friends. They noted the importance of the robot to be socially aware with manners and not interrupt people. Healthcare and safety was an important area as supported in the decision model trees. Older adults wanted the social robots to be equipped with medical sensors to monitor their health and safety, including having emergency functions to alert emergency services and family in case of an emergency, medication reminders, and overall diet and exercise recommendations. Older adults created design guidelines that captured a range of design aspects from operations and basic functions of the robot to specific robot interaction design features.

5 Discussion

Older adults expressed their opinions and directed future design directions for social robots in their lives. Throughout the co-design experiences, older adults gained a better understanding of social robots that informed their generated design guidelines and thoughts for social robots across the seven focus areas, demonstrating the value of the lived experience with the technology and the larger co-design process as older adults collaborated with the research team. Overall, older adults were accepting of transactional functions seen in both the final set of the decision model trees and design guidelines. Focus areas that involved sensitive information, monitoring, and/or tracking were less accepted and/or desired by older adults in our study. This was expressed through older adults' concerns around autonomy, privacy, and the naturalness of the interaction. While there was high acceptance for focus areas of medical adherence, memory assistance, and exercise and physical therapy, the focus areas of connecting with others, body signal monitoring, and emotional wellness were less accepted in part due to older adults' concerns around autonomy, privacy, and naturalness of the interaction, signalling the need for more research in this space to understand how these should be developed, if at all, in partnership with older adults. For more details on these three focus areas and older adults' concerns, refer to Figures 8–10. In this section, we explore future areas of exploration for social robots as defined by our older adult collaborators informed by current HRI research and reflect upon components related to social robot transparency that influence older adults' experiences with social robots.

5.1 Older adult defined areas for exploration

Older adults expressed varying levels of support for the focus areas, outlining future directions for these focus areas. Table 2 highlights potential future investigations for the focus areas that older adults were accepting or potentially accepting for, noting HRI work that is beginning to explore this space or provide avenues for HRI researchers to integrate these areas into robot interaction design. By drawing attention especially to the areas where there is potential for the interaction though not quite accepted at the moment, we hope to promote greater research and collaboration

FIGURE 8
Example of final tree set. **(A)** Initial interview final tree for the emotional wellness focus area; **(B)** Corresponding final tree for the reflection interview.

FIGURE 9
Final tree set for body signal monitoring. **(A)** Initial interview final tree; **(B)** Corresponding final tree for the reflection interview.

with older adults on these specific function categories. We do not include financial management in this discussion as older adults were largely opposed to this interaction with social robots.

There are several proposed directions of research across the six focus areas that older adults were either acceptable to or hesitant towards. Many of these important research areas touch on integration of systems, whether that is the healthcare system connecting together older adults, care takers, doctors, physical therapists, and other members of their healthcare team or multiple devices integrating together for an interaction such as a smart watch or cellphones with the social robot (Cresswell et al., 2018; Hung et al., 2019; Van Wynsberghe, 2020; Lee et al., 2023). This also calls for researchers to consider what technologies and other non-technology solutions work well already in older adults' lives and how they can integrate and pair social robot technologies with these already existing solutions (Boada et al., 2021). With regards to interactions that require health data or data that could be used for healthcare applications, older adults expressed a need for expertise and how not trusting the robot's expertise could make the interaction untrustworthy, stressing the need for researchers to explore if the robot should take the role of an expert, how to design transparent interactions on the level of the robot's expertise, and how the

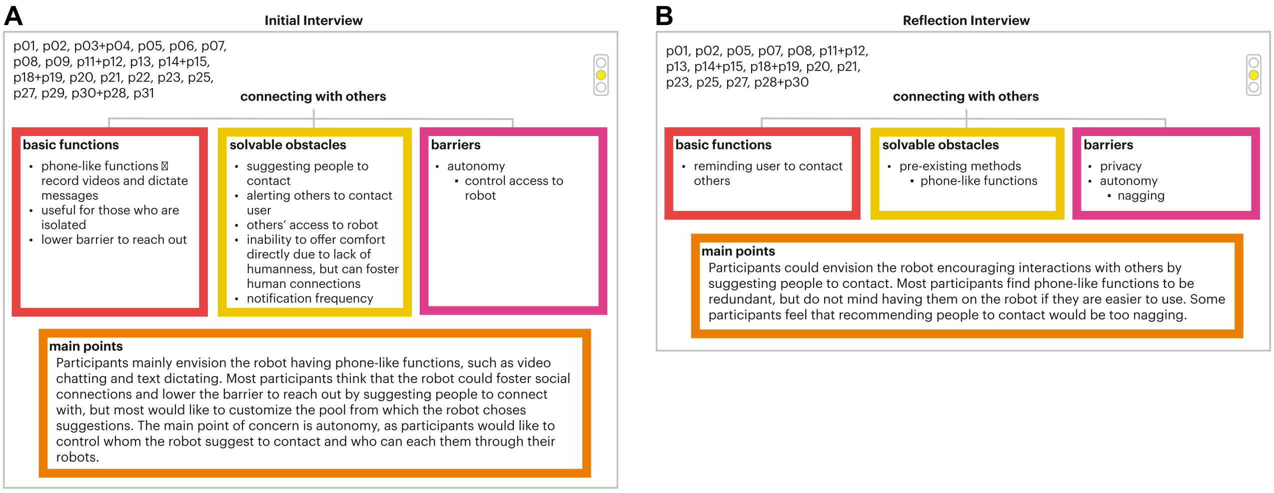

FIGURE 10
Final tree set for connecting with others. **(A)** Initial interview final tree; **(B)** Corresponding final tree for the reflection interview.

role the healthcare team takes in a network with a social robot as a tool (Cresswell et al., 2018; Felzmann et al., 2019; Aymerich-Franch and Ferrer, 2022). Developments in customization and personalization for these systems hold promise for older adults to gain the most benefits, especially as these systems can be tailored to older adults' preferred exercise styles, communications styles, and other preferences supporting more custom engagements and support (Umbrico et al., 2020; Coghlan et al., 2021; Khosla et al., 2021; Jeong et al., 2023). This approach could also help solve the incongruencies that may exist between various research studies. For example, with regards to the emotional wellness focus area, previous literature has found that older adults would not like the robot to engage with them through emotional aspects or aspects that could be interpreted as companionship (Thunberg and Ziemke, 2021), while others have found that older adults would support these aspects (Eftring and Frennert, 2016). Our work saw both aspects of this. In the interviews, emotional wellness was discerned as not quite accepted and we were able to identify the barriers that may prevent people from being open to this interaction on a robot. In the design guidelines generated by older adults, role and personality, including an empathetic personality and relationship driven personality, were identified as areas that need to be further explored and supported perhaps through personalization to accommodate various preferences. In order to understand the incongruencies between studies, researchers should apply the lens on how to understand these results contextually and what the confounding variables are, in order to address the wide spectrum of older adult preferences and personalization strategies. The works highlighted in Table 2 are not representative of all works that are engaging in the six focus areas but provide directions for research that is being done in these areas and around some of these proposed directions of research. It is important to note that the works cited do not address all proposed directions of research and more work is required especially around investigating the fine line between data collection, intrusiveness, and transparency.

5.2 Considering older adults' interaction experiences related to transparency

Ethics, including trust and privacy features, and data security were front of mind for many participants as seen through the decision model trees and the design guidelines, stressing the importance of investigating ethics and older adults' concerns related to ethics when designing social robots. Older adults' concerns around robots and their transparency in interactions focused on privacy, autonomy, and lack of naturalness in our work. Older adults' concerns related to privacy, including who has access to the data on the robot, if the data collected is secure on the robot, and the intrusiveness of the robot and data collection, building on previous work around privacy in social robots (Sharkey and Sharkey, 2012; Lutz et al., 2019; Wangmo et al., 2019; Belk, 2021; Boada et al., 2021). Autonomy concerns and features to address autonomy concerns voiced by older adults included the ability to turn the robot off and having the ability to program the robot themselves, demonstrating how older adults were generating design features that enabled them to have greater autonomy in their interactions with robots (Coghlan et al., 2021; Ostrowski et al., 2022a). In another dimension of autonomy, older adults were concerned about their own independence and autonomy and how they did not want to become reliant on the robot, echoing findings from previous research when older adults consider using new technologies (Sharkey and Sharkey, 2012; Belk, 2021; Boada et al., 2021; Coghlan et al., 2021). Previous works have also emphasized the need for robot technologies to support older adults' freedom, control, and independence (Frennert, 2016). As we've seen in other areas where robots are being proposed as new tools and solutions (Sharkey and Sharkey, 2012; Belk, 2021), older adults were adamant that social robots should not replace people, especially thinking about those in the their healthcare and social networks (Wangmo et al., 2019; Belk, 2021; Boada et al., 2021). This was connected to the lack of naturalness in interactions that older adults focused on especially in their design guidelines

TABLE 2 Key areas for further investigation for focus areas as identified by older adults and relevant work that is engaging in these spaces.

Focus area	Proposed directions of research	Relevant research exploring areas
Medical adherence	• Exploring how social robot interactions in this area can interact with already existing ways that older adults manage their medical health • Investigating trust within interactions with older adults that surround medical health • Understanding the role of social robots within the medical healthcare network with regards to expertise and how that is communicated to older adults	Bardaro et al. (2022); Anghel et al. (2020); Wilson et al. (2020)
Emotional wellness	• Investigating the variety of roles that social robots can take when engaging with someone in this area • Exploring patterns of customization and personalization that will support how these systems can be effective for older adults • Understanding how to balance leveraging technologies that provide information about emotional state and intrusiveness to the user	Abdollahi et al. (2022); Jeong et al. (2023)
Memory assistance	• Investigating and designing interactions that promote older adults' independence *versus* dependency on the robot • Exploring how memory assistance can be both functional (i.e., object location, reminders) and personal (i.e., photo books, personalized memory reminders)	Lima et al. (2021); Kubota (2023); Lee et al. (2023); Van Maris et al. (2020)
Exercise and physical therapy	• Exploring patterns of customization and personalization that will support how these systems can be effective for older adults depending on strategies that work best for each older adult • Understanding the role of social robots within the healthcare team network with regards to expertise and how that is communicated to older adults	Shao et al. (2019); Rea et al. (2021); Antony et al. (2023)
Body signal monitoring	• Understanding the role of social robots within the healthcare team network with regards to expertise and how that is communicated to older adults • Exploring how multiple systems and devices can be integrated together (i.e., smart watch, smart speaker)	Chen et al. (2023); Nasr et al. (2021)
Connecting with others	• Exploring patterns of customization and personalization that will support how these systems can be effective for older adults depending on strategies that work best for each older adult • Understanding the unique capabilities that social robots offer for this focus area without being redundant to existing technologies (i.e., phones) • Supporting easier use of existing technologies (i.e., cellphones) through voice technology or speech-to-text displays	Fan et al. (2021); Coghlan et al. (2021)

such as wanting a social robot to mirror social conversational norms to make the interaction more natural and intuitive. Lack of naturalness has been identified as a barrier in interactions stressing the continued importance of increasing the fluency and naturalness of interactions with robots (Edwards et al., 2019). These are a few ethical and transparency dimensions that older adults specifically mentioned in the interviews and design guideline generation session. Researchers need to consider these ethical and transparency dimensions and other ones that will continue to develop as more interactions are designed for social robots in these areas (Van Wynsberghe, 2020). These could include greater focuses and interrogations of emotional deception (Van Maris et al., 2020), emotional attachment (Van Maris et al., 2020; Boada et al., 2021), interaction deception (Wangmo et al., 2019; Danaher, 2020; Boada et al., 2021; Sharkey and Sharkey, 2021), and manipulation (Belk, 2021; Fronemann et al., 2022), to name a few. While not specifically mentioned by older adults in this work, it is essential for researchers and designers to interrogate the justice of these devices, considering distributive justice (i.e., who has access to robots and the benefits of robots?), politics of technosolutionism (Morozov, 2013), social equality, and ecological sustainability (Boada et al., 2021).

5.3 Limitations and future work

Our work has illuminated several exciting and critical directions for social robot research. The work also has limitations to be noted when exploring future directions. Due to the evolving nature of co-design work that allows participants to help direct the research process and activities, we modified the reflection interview protocol based on participant feedback from the initial interview protocol to include a card sorting exercise. The card sorting exercise encompassed the same questions asked in the initial interview, though it did lead to often more concise responses to that portion of the interview. This was balanced out by the open-ended questions that surrounded the card sorting exercise. Participants voiced the value of this format overall.

The participants we collaborated with live in the United States with the majority of participants living in areas with many colleges and universities where it may be common to engage in research projects. The geographic area where the majority of participants were from may have contributed to our participant sample being all-white. Participating in social robot studies often requires participants to have WiFi access in their home, such as the case of our study where if participants did not have WiFi access they could not participate. This contributes to the need for more attention and conversations around how to engage those that do not have WiFi access or other such resources and the ethical considerations of not engaging these populations and basing research in this space solely on populations who have access to WiFi and other such resources (Wu et al., 2015; Veinot et al., 2018; Hargittai et al., 2019). Due to these limitations, future work when exploring and co-designing social robot interactions should work with more older adults that represent varying geographic areas and ethnic, economic, and cultural backgrounds.

In addition to doing future work to engage more participants to express their opinions and lead future social robot interaction design, future work should engage further with the areas that were identified as "yellow" in the traffic light system to work with older adults to better understand how to design these systems. This may include investigating the trend of "othering" that we often saw (also seen in Deutsch et al. (2019)), when older adults could see perceived benefit for this interaction not for themselves in this moment but for other people or for themselves later in life, to understand how opinions to these focus areas may change as older adults' lives change. Future work can also test the decision models generated in this work (the next step in the ethnographic decision tree model process, model testing (Gladwin, 1989)) and explore the barriers to usage that older adults identified, including exploring how robot interaction features can be designed to foster older adults feeling empowered around privacy, autonomy, and trust.

6 Conclusion

This paper explores older adults' perspectives towards specific focus areas of social robot interactions over the course of a year long co-design process informed by interviews and a design guideline generation session. While there was no overall change of opinions towards the focus areas, older adults articulated their thoughts and opinions with more detail as the co-design process progressed, identifying key areas of development for social robot interactions and areas of concern. These findings contributed to proposed directions of research across six focus areas for future investigations into social robot interactions around medical adherence, emotional wellness, memory assistance, exercise and physical therapy, body signal monitoring, and connecting with others that robot designers and researchers should engage with to support older adults' engagement with and usage of social robots. We also outline critical ethical dimensions, including transparency, intrusiveness, privacy, and social robot implementation, that need to be further investigated to promote responsible design of social robot interactions. Through this work, we encourage designers and researchers to address these research directions in collaboration with older adults to create social robots designed and supported by older adults.

Data availability statement

The datasets presented in this article are not readily available because the gathered participant transcripts are not shareable. Requests to access the datasets should be directed to akostrow@media.mit.edu.

Ethics statement

The studies involving humans were approved by Massachusetts Institute of Technology's Committee on the Use of Humans as Experimental Subjects. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

AO: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing–original draft, Writing–review

and editing. JZ: Formal Analysis, Writing–original draft. CB: Funding acquisition, Project administration, Resources, Supervision, Writing–review and editing. HP: Conceptualization, Data curation, Funding acquisition, Investigation, Project administration, Resources, Software, Supervision, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frobt.2024.1289414/full#supplementary-material

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Recommendations for designing conversational companion robots with older adults through foundation models

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Companion robots are aimed to mitigate loneliness and social isolation among older adults by providing social and emotional support in their everyday lives. However, older adults' expectations of conversational companionship might substantially differ from what current technologies can achieve, as well as from other age groups like young adults. Thus, it is crucial to involve older adults in the development of conversational companion robots to ensure that these devices align with their unique expectations and experiences. The recent advancement in foundation models, such as large language models, has taken a significant stride toward fulfilling those expectations, in contrast to the prior literature that relied on humans controlling robots (i.e., Wizard of Oz) or limited rule-based architectures that are not feasible to apply in the daily lives of older adults. Consequently, we conducted a participatory design (co-design) study with 28 older adults, demonstrating a companion robot using a large language model (LLM), and design scenarios that represent situations from everyday life. The thematic analysis of the discussions around these scenarios shows that older adults expect a conversational companion robot to engage in conversation actively in isolation and passively in social settings, remember previous conversations and personalize, protect privacy and provide control over learned data, give information and daily reminders, foster social skills and connections, and express empathy and emotions. Based on these findings, this article provides actionable recommendations for designing conversational companion robots for older adults with foundation models, such as LLMs and vision-language models, which can also be applied to conversational robots in other domains.

KEYWORDS

participatory design, co-design, human-robot interaction, companion robot, open-domain dialogue, foundation models, large language models, elderly care

1 Introduction

Robots in elderly care are increasingly targeted towards not only fulfilling practical needs, such as medication reminders or physical assistance, but also as companions to prevent and mediate loneliness through offering social and emotional support in their everyday lives, thus enhancing the psychological wellbeing of users (Banks et al., 2008; Robinson et al., 2013; Pu et al., 2018). Research in companion robots for older adults focused primarily on pet robots, such as PARO (a seal-shaped robot), that do not have natural language processing (NLP) or generation capabilities (Pu et al., 2018). One of the underlying reasons is the limitations in NLP technology, leading to heavy reliance on humans to control robots, either through telepresence or the Wizard of Oz technique (Kelley, 1984) to give the illusion that the robot is autonomous, or by rule-based architectures that allow one-way transactional (e.g., providing medication reminders) interactions or small talk that are not suitable for daily dialogues with older adults.

The recent introduction of "foundation models", i.e., deep learning models, such as BERT (Devlin et al., 2019), GPT-3 (Brown et al., 2020), DALL-E (Ramesh et al., 2021), and CLIP (Radford et al., 2021), that are trained on broad data (often through self-supervision) that can be applied in or adapted to a wide range of downstream tasks, transformed the scope of what is achievable in many robotics applications (Bommasani et al., 2022). Most prominently, large language models (LLMs) enabled the development of companion robots with social skills due to their ability to process and produce language in an open-domain manner, without restriction on topics or concepts. Recent work incorporated LLMs for open-domain dialogue with robots in therapy (Lee et al., 2023), service (Cherakara et al., 2023), and elderly care (Irfan et al., 2023) domains, revealing their strengths and weaknesses in multi-modal contexts across diverse application areas. These studies underscore the versatility of LLMs in facilitating human-robot interaction (HRI).

Integrating LLMs into human-robot interaction requires awareness of the user's perceptions, needs, and preferences to ensure that these robots are aligned with human values and can successfully be employed in real-life contexts. Alignment techniques like reinforcement learning with human feedback can improve some model capabilities, but it is unlikely that an aggregate fine-tuning process can adequately represent the full range of users' preferences and values (Kirk et al., 2023). Participatory design (co-design) approaches enable incorporating these aspects into the design process of robots, through focus groups, interviews, concept generation and design activities, prototyping, and interactions with designed robots (Šabanović, 2010; Frennert and Östlund, 2014). These studies investigate HRI as a relational and social phenomenon, where contextual factors and longitudinal effects alter the interactions with the robot (Bradwell et al., 2020; Søraa et al., 2023). An emphasis is based on how robots are shaped in interaction with the wider socio-cultural and physical environment into which robots are introduced. Against this background, it becomes important to explore the shared understanding of companion robots for open-domain dialogue, which influences the expectations, values, norms, and possible contradictions that older adults have towards companion robots.

This study investigates older adults' expectations towards conversational companion robots to provide social and emotional support in their daily lives, and provides design recommendations on how to achieve these expectations through foundation models. Participatory design workshops were conducted with 28 Swedish-speaking older adults, aged 65 and over (Figure 1). The workshops involved a demonstration of open-domain dialogue with an autonomous Furhat robot employing an LLM (GPT-3.5 text-davinci-003), and (6-8 participant) focus group discussions deriving from conversational design scenarios that can occur in their everyday lives. The contributions of this article encompass two key aspects:

1. Through a qualitative approach, identifying socially shared expectations of older adults regarding conversational companion robots for everyday life (Section 4, summarized in Table 1),
2. Formulate actionable design recommendations for integrating foundation models into these robots to meet these expectations, focusing on LLMs for their advanced linguistic capabilities, combined with vision-language models and other state-of-the-art technology for multi-modal aspects (Section 5).

2 Background

2.1 Companion robots for older adults

Companion robots are socially assistive robots that are designed to respond to the social, emotional, and cognitive needs of older adults and enhance their quality of life, activity, and participation. Studies involving companion robots are focused on the acceptance and use among older adults and caregivers in organizational contexts (e.g., Heerink et al., 2008; Pino et al., 2015), therapeutic effectiveness of companion robots to agitation and anxiety (e.g., Bradwell et al., 2020), and design features of companion robots to promote dignity and autonomy (e.g., Coghlan et al., 2021). A high level of individual differences in willingness to interact and establish a relationship with the companion robot has been observed in older adults (Thunberg et al., 2021). Their acceptance is influenced by functional variables related to social interaction (Heerink et al., 2010), as well as age-related perceptions of their self-image and user-image (Dudek et al., 2021), and individual values and aspirations (Coghlan et al., 2021). Robinson and Nejat (2022) provide a recent overview of the robot types and features used in socially assistive robots for senior care.

Design features of companion robots should reinforce older adults' autonomy, dignity, and skill level, which often remains a challenge in robot design (Kuoppamäki et al., 2021). Participatory design (co-design) has been proposed as a solution to design more inclusive and suitable companion robots for older adults, and to promote mutual learning between participants and researchers (Lee et al., 2017; Kuoppamäki et al., 2023). This approach takes participants' self-perceived thoughts and opinions into consideration and highlights factors that influence their attitudes towards robots in developing robot concepts, applications, and interaction modalities. These studies make use of interviews and focus group discussions after having been shown pictures or videos of companion robots (e.g., Søraa et al., 2023), and empirical material collected in real-world settings where older adults get to engage with companion robots for short or longer period of time (e.g., Chang and Šabanović, 2015; Ostrowski et al., 2021).

Due to the lack of a robust solution for open-domain conversation (i.e., conversations that are not limited to any topics) that can arise in the daily lives of older adults, most prior studies that provided recommendations to design companion robots for older adults focused on non-conversational aspects based on robot pets (e.g., Lazar et al., 2016; Bradwell et al., 2019). Only a few studies touched upon the potential for conversational

FIGURE 1
Participatory design workshop with older adults.

aspects, however, these recommendations did not explore beyond one-way transactional interactions, such as providing medication reminders, exercise, entertainment, and motivation, rather than mutual everyday conversations (e.g., Lee et al., 2017; Thunberg and Ziemke, 2021; Søraa et al., 2023). Other work solely outlined desired high-level functionality rather than providing actionable solutions (e.g., algorithms) on how to achieve the expectations of older adults for companion robots (e.g., Pino et al., 2015; Deutsch et al., 2019; Lin et al., 2020; Bradwell et al., 2021; Gasteiger et al., 2021). In this work, we gather expectations of older adults towards conversational companion robots based on focus groups deriving from everyday situations, in addition to providing concrete suggestions on achieving the desired functionality based on foundation models, such as LLMs and other state-of-the-art architectures, which does not exist in prior work.

Similarly, despite the numerous studies investigating the use of conversational companion robots with older adults, only a few studies have employed autonomous conversational robots for open-domain dialogue (e.g., Sorbello et al., 2016; Kuo et al., 2021; Ostrowski et al., 2022; Khoo et al., 2023). Other studies focused on task-oriented dialogue that gives reminders, answers questions, provides weather reports, and plays games with this age group (e.g., Khosla and Chu (2013); de Graaf et al. (2015); Carros et al. (2020). The earliest study that involved an autonomous conversational robot for older adults was that of Yamamoto et al. (2002). The robot was able to recognize 300 Japanese words for daily greetings and functional commands with 47% accuracy, and respond accordingly. It was evaluated with 7 older adults on an average of 62 days. In contrast, current speech recognition systems can mostly accurately recognize more than 100 languages, with 70%–85%[1] accuracy in adult speech (Irfan et al., 2021a) and 60%–80% in children's speech (Kennedy et al., 2017). All task-oriented dialogue studies used rule-based architectures (i.e., pre-written templates for input and output responses), and only one of the open-domain dialogue studies integrated foundation models (LLMs) into a companion robot (Khoo et al., 2023). Only one study applied co-design in the development of autonomous conversational robots with older adults (Ostrowski et al., 2021). In contrast, our study integrates a foundation model (LLM) into the robot to guide participatory design with older adults and offers corresponding design recommendations to meet those expectations in conversational companion robots.

In real-world applications of companion robots for older adults, there are only a few that are available for purchase, such as non-conversational robot pets (PARO robot seal[2] and Joy for All cat and dog robot toys[3]) and ElliQ conversational desktop robot with a screen (Intuition Robotics[4], only available for US customers). To alleviate loneliness, ElliQ proactively provides daily reminders and check-ins for health measures, gives news, weather and sports updates, makes small talk, encourages connection with family and friends, plays music, and offers games and trivia for older adults. It learns from user interactions to personalize its suggestions. However, it is unclear how this learning occurs due to proprietary software, which is updated every 3–4 weeks (Broadbent et al., 2024). The robot was deployed to older adults across 15 programs from various healthcare organizations in the US and Canada since its release in 2022. A study with 173 users who used the robot over 30 days showed that 80% agreed to feel less lonely with the robot. However, despite the effectiveness of proactivity in addressing loneliness (Ring et al., 2013), some users were surprised or annoyed by the proactive features (Broadbent et al., 2024). Other studies supported the negative perceptions of proactive features of the

1 https://www.statista.com/statistics/1133833/speech-to-text-transcript-accuracy-rate-among-leading-companies

2 http://www.parorobots.com

3 https://joyforall.com/

4 https://elliq.com/

TABLE 1 Older adults' expectations towards companion robots for open-domain dialogue.

Main category	Subcategory	Contextual example
Active listening	Eliciting information from the user through follow-up questions	Urging the user to tell their concerns in loneliness
	Inspiring the user to think positively	Encouraging the user to think of something funny for overcoming boredom
	Facilitating self-reflection	Asking for explanations on the user's (negative) perceptions and thoughts
Passive listening	Registering information from social events	Listening quietly to group conversations during a game with friends, and talking to the user about it when alone
	Debriefing and reminiscence	Providing awareness for the user (e.g., on their relationship with others) based on their conversations with friends
Personalization	Learning and referring to details in previous conversations	Remembering names and ages of family members, and shared history
	Providing advice based on situational context	Giving suggestions about grandchildren
	Providing recommendations based on user preferences	Suggesting a movie
	Forming a relationship	Having a personality and stating own opinions based on shared history
Privacy protection and data control	Preventing others from accessing user data	Identifying the user prior to conversations
	Ensuring confidentiality of personal data	Using embedded systems or privacy-preserving frameworks for cloud-based services
	Allowing users to delete learned information	Forgetting difficult situations with family members, or deleting incorrectly provided information
Information retrieval	Reminding daily agenda	Mentioning the doctor's appointment on the day
	Taking initiative in providing daily information	Reporting weather and news in the morning
	Explaining contextual information for social and emotional support	Interpreting a doctor's diagnosis and recommending ways to help
	Enabling fact-checking through natural language communication	Asking for facts based on a disagreement during a game with friends
Social connectedness	Connecting with other people to counter loneliness	Offering to call family members or friends, or finding new connections online
	Strengthening communication skills of older adults over 90	Encouraging conversation to retain vocal articulation when living alone
	Supporting maintenance of cognitive skills for adults with dementia	Singing with the user, or encouraging them to sing
	Engaging in leisure activities together	Watching television together and discussing content
Emotional expressiveness	Responding empathetically	Expressing joy (e.g., celebrating becoming a grandparent) or sorrow (e.g., mourning a loss) verbally
	Changing voice intonation based on the context of the conversation	Sounding happy when congratulating the user for being a grandparent
	Having contextual facial expressions	Laughing and smiling when appropriate

robot, such as being perceived to be talking a lot, threatening their independence, lacking compassion, and being rude, invasive, intrusive, or patronizing (Deutsch et al., 2019; Coghlan et al., 2021).

Previous studies have shown that robots can help combat loneliness in older adults as companions or catalysts for social interactions (Gasteiger et al., 2021). User's self-perceived loneliness (defined as a subjective experience of lack of social connectedness with other people (Newall and Menec, 2019)) is also positively associated with willingness to buy a robot companion (Ghafurian et al., 2021; Berridge et al., 2023). Nonetheless, older adults tend to think that a companion robot cannot make them feel less lonely (Berridge et al., 2023). These studies, however, have been limited to companion robots with limited or lack of capabilities for having a (open-domain) dialogue with a human. In this study, we analyze older adults' reflections on conversational companion robots' roles in their daily lives to provide social and emotional support and alleviate loneliness.

In addition to robots, spoken dialogue agents, such as Amazon Echo, and embodied conversational agents (i.e., virtual agents) that provide task-oriented interactions and small talk were shown to address loneliness in older adults (Loveys et al., 2020; Gasteiger et al., 2021; Jones et al., 2021). However, speech recognition errors and unfamiliarity with spoken dialogue systems (e.g., using a wake word and transactional commands) created adverse user reactions. Older adults did not find valuable use cases for these systems, and considered them as toys, with limited conversational capabilities being the most critical challenge in these systems (Trajkova and Martin-Hammond, 2020; Kim and Choudhury, 2021). In addition, there is extensive literature that shows the benefits of robotic embodiment in improving user perceptions of the agent (Deng et al., 2019). Thus, this study focuses on a companion robot with open-domain dialogue capabilities.

2.2 Foundation models in conversational agents

Prior research initially focused on BERT (Devlin et al., 2019) for dialogue state tracking, intent classification, and response generation (e.g., Dong et al., 2019; Tiwari et al., 2021) primarily in task-oriented dialogue, which is designed for a specific goal, such as restaurant booking. Recently, LLMs (e.g., GPT-3 (Brown et al., 2020), LLaMA (Touvron et al., 2023), Falcon (Penedo et al., 2023), Pythia (Biderman et al., 2023), Mistral (Jiang et al., 2023)) that are trained on vast amounts of textual data, showed promise for generating coherent text and speech by using prompts for inferring the context, thereby, enabling open-domain dialogue with unrestricted topics (Huang et al., 2020). Traditionally, LLMs have been employed within text-based chatbot systems, article generation, code generation, and copywriting (Zhao W. X. et al. (2023) provide an extensive survey of LLMs). On the other hand, multi-modal LLMs (e.g., GPT-4 (OpenAI et al., 2023), Gemini (Reid et al., 2024), see (Li C. et al., 2023) for a review) combine text with audiovisual features to provide end-to-end solutions for dialogue generation in agents.

To date, very few studies have empirically investigated users' experiences of interacting with LLMs in a companion function for social and emotional support. Ma et al. (2023) explored the benefits and challenges of using LLMs (ChatGPT) for mental wellbeing with a conversational agent to help decrease loneliness by generating friendly or empathetic responses that simulate a conversation with a human therapist. Perceived benefits were increasing accessibility to therapists and the opportunity to receive non-judgmental support in therapy, in addition to improving self-confidence and promoting self-reflection and self-discovery. The main perceived challenges included harmful content, limited dialogue memory capacity, inconsistency in communication style, concerns about dependency on LLMs for mental wellbeing support, and the associated stigma of seeking such support from a virtual agent. For enhancing a user's wellbeing, a key aspect of the companionship of an agent is to foster closeness, such as trust, warmth, and understanding. This involves sharing personal information, providing support, and engaging in joint activities, all facilitated by verbal and non-verbal cues, like empathy, humor, encouragement, and politeness (Loveys et al., 2022). Jo et al. (2023) leveraged LLMs for a public health intervention in an open-domain chatbot to support socially isolated individuals (middle-aged adults) through check-up phone calls. Users perceived that the system helped mitigate loneliness and provided emotional support through empathetic questions about their health, hobbies, and interests. However, it was perceived as impersonal due to the lack of follow-up questions on past conversations.

While various foundation models are used in robotics for manipulation, navigation, planning, and reasoning (Xiao et al., 2023), only LLMs are used in the context of conversational robots. For instance, LLMs have been used for developing conversational robots with empathetic non-verbal cues (Lee et al., 2023), giving adaptive presentations (Axelsson and Skantze, 2023), functioning as a receptionist (Cherakara et al., 2023; Yamazaki et al., 2023), and supporting wellbeing of older adults (Khoo et al., 2023). Khoo et al. (2023) is the only study that integrated an LLM (fine-tuned GPT-3) into a companion robot for open-domain dialogue with (7) older adults, in addition to our prior work (Irfan et al., 2023). Most participants in that study found the interaction with the robot enjoyable, felt comfortable with it, and perceived it as friendly. However, the individual willingness to use the robot varied among participants, with some suggesting that it might be more suitable for older adults with dementia. However, the study did not incorporate older adults' perspectives on applying LLMs to companion robots through a co-design approach. In our prior study (Irfan et al., 2023), we investigated the challenges of applying LLMs to conversational robots, deriving from the one-on-one interactions of a robot with LLM with older adults, that were conducted after the discussions in the design scenarios. The challenges were found to be affected by the multi-modal context of conversations with robots that go beyond the textual linguistic capabilities of LLMs, leading to frequent interruptions, repetitive and superficial conversations, language barriers, and confusion due to outdated and incorrect information. In contrast, in this work, we investigate the expectations of older adults using thematic analysis of the focus groups, followed by design recommendations to apply these expectations to conversational companion robots with foundation models.

3 Data and methods

We conducted four participatory design workshops with 28 older adults, aged 65 and over, at the university premises. Each workshop involved 6-8 older adults and lasted 2 h. A Furhat (Al Moubayed et al., 2012) robot employing an LLM (GPT-3.5 text-davinci-003) in a zero-shot fashion, as described in our prior work (Irfan et al., 2023), was used to foster focus group discussions centered around design scenarios that represent situations from older adults' daily lives. Acapela[5] text-to-speech engine in Swedish (Emil22k_HQ) was used for the robot's voice, and the speech rate was decreased to 80% to facilitate understanding among older adults. In order to understand older adults' expectations and preferences for companion robots such that we can design robots that align with them, rather than them aligning with the technological limitations of current systems, the robot was only demonstrated autonomously for a brief period (2 min) by a researcher. In other words, the participants did not interact with the robot directly prior to or during the focus group discussions to prevent any biases due to technological limitations.

The study protocol consisted of introducing the study, demonstrating the robot's capabilities for open-domain dialogue, presenting conversational design scenarios with older adults through videos, and facilitating participants' expectations, needs, feedback, and shared understandings through focus group discussions to outline design recommendations for companion robots. All workshops were documented with video and audio recordings, and focus group discussions with participants were transcribed to text.

The participants were informed that the study aimed to acquire their feedback, insights, and opinions for developing a companion robot, and were encouraged to share both positive and negative perceptions of the robot for social and emotional support. The robot's capabilities were demonstrated by a researcher talking to the autonomous robot in an open-domain fashion for 2 min. While the robot's responses changed slightly due to the LLM (which can generate different responses at run time) in each workshop, the researcher led the conversation to the same topics: participatory design workshop with older adults for designing a companion robot, the robot's thoughts on robots, and their use in elderly care.

3.1 Design scenarios

We prepared six design scenarios that were demonstrated to participants with images and videos during the workshop[6]. Videos were adapted based on royalty-free stock video footage[7] that do not contain audio or text. In two of the scenarios (S1 and S6), a Furhat robot was integrated into the video[8], as shown in Figure 2, to provide better situational context on the robot interaction, whereas for the rest of the scenarios, the participants were asked to imagine talking to the robot after about the described event. Scenarios represented common situations that older adults could face in their everyday lives:

S1 An older woman returning home after family (children and grandchildren) visit and talking to the robot about it (Figure 2A).

S2 An older woman sitting in a kitchen alone and looking sad.

S3 An older woman talking on a phone and hearing bad news.

S4 An older woman finds out that her daughter is pregnant.

S5 An older man waking up from bed.

S6 Older adults (two women and a man) playing a card game around the table, where the robot was placed (Figure 2B).

After each scenario, participants were asked questions that were adapted from the Likert scale questions in the Almere model (Heerink et al., 2010) and privacy scale (Malhotra et al., 2004; de Graaf et al., 2019):

S1 Would your family members find the robot fascinating or boring? (*Social influence*).

S1 Would you like the robot to remember your conversation? (*Privacy concern*).

S2 Do you think the robot could help you reduce or strengthen the experience of loneliness? (*Usefulness*).

S3 Do you think the robot could personalize social conversation? (*Adaptiveness*).

S4 Do you think the robot could robot give you empathetic support? (*Usefulness*).

S5 Do you think the robot could be a nice conversation partner? (*Sociability*).

S6 Are you worried about your privacy with the robot? (*Privacy concern*).

In addition, the participants were asked, "What kind of conversation(s) would you like to have with the robot in this situation?" and "What would you like the robot to say/talk about?" for each scenario except for the final scenario involving interaction with friends, for which they were asked, "How would you like the robot to interact with you and your friends?". All questions were followed by "why/how/what" based on the participants' responses, aimed to initiate the discussions in a semi-structured format, leading to open-ended discussions.

Questions asked in the focus group discussions were centered on participants' perceptions and expectations of using the robot in envisioned social situations and for the provision of social and emotional support. There were no questions regarding whether or not the participants had experienced loneliness themselves. Therefore, the corresponding discussions represent participants' reflections about using the robot for loneliness prevention among healthy older adults, rather than investigating the effects of using the robot to reduce loneliness.

3.2 Focus group discussions

The presentation of each scenario resulted in vivid discussions in the group, where participants contemplated possible conversational scripts with the robot and shared their first impressions about the companionship function of the robot. Design scenarios were used as an elicitation tool for acquiring "tacit knowledge"' that often may remain hidden and unspoken in social situations (Van Braak et al., 2018). The researchers presented questions to understand the participants' preferences or self-identified needs and first

5 https://www.acapela-group.com/

6 Videos of the design scenarios: https://youtu.be/jAk92vm3oEk

7 https://www.pexels.com/ and https://www.videvo.net/

8 Based on Furhat Robotics footage: https://youtu.be/jJ2N4PvAMos

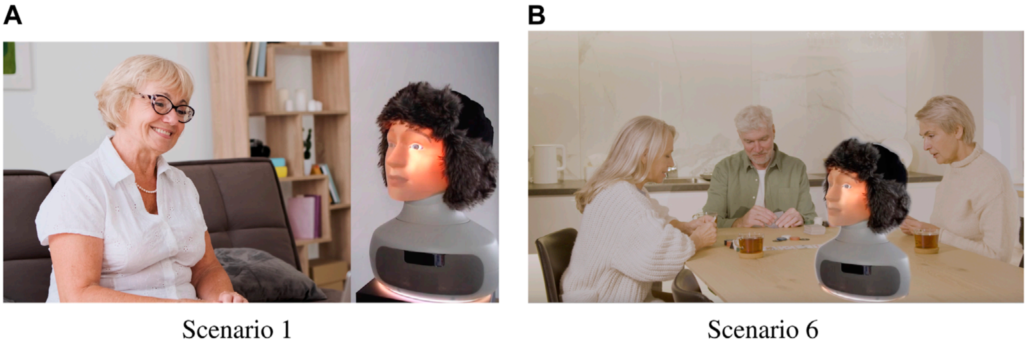

FIGURE 2
Examples of the design scenarios: **(A)** Coming home after a family visit, and **(B)** friends visiting.

impressions about the robot for providing social and emotional support in a particular social environment and context. The researchers only contributed to the group discussions when the participants asked them about the capabilities of the robot regarding their suggestions, in which case they responded affirmatively to avoid biasing them with the limitations of the current technology. Focus group discussions lasted approximately 60 min.

3.3 Participants

The participants were recruited through an invitation that described the goal of the project and the activities that will be part of the design workshops. Adults aged 65 or older were invited to participate in the invitation, without requiring prior knowledge of robots. The invitation was tailored towards recruiting participants interested in contributing to the development of a companion robot: "Your participation contributes to knowledge about the benefits of this technology for older adults, and you have the opportunity to influence future solutions." The invitation was distributed via our university's communication channels, social media, and platforms for gathering senior citizens.

Based on the recommended number (3-4 groups) and size (6-8 participants per group) of focus groups in the literature (Krueger and Casey, 2014), we recruited 28 participants (15 females, 13 males) from the age group 65 and over. All participants were Swedish speakers aged 66 to 86, with an average age of 74.5 (SD = 5.6). The majority (22) of the participants were living with a partner, and most (23) did not have prior experience with robots. Participants were offered a small compensation (100 SEK gift card) at the end of the study. The distributed invitation for the study mentioned that a gift card would be given as compensation, but did not specify the amount. The participants were divided into 4 groups, each involving 6-8 people, with an equal number of male and female participants to facilitate an equal presence of opinions from both genders. Since the participants' opinions or suggestions may influence the group's opinion as a whole in the focus groups, it is not possible to analyze gender effects. Before starting the study, all participants were given research subject information guided by the Ethical Review Authority, and they gave informed consent for participation in the study and publishing anonymized extractions from the data.

3.4 Analytical approach

All focus group discussions were transcribed to text and analyzed using a qualitative thematic analysis method (Hsieh and Shannon, 2005). In the first stage of the analysis, all transcriptions were read through by two researchers in order to form a holistic understanding of the data. In the second stage, one of the researchers used an inductive approach to form themes, iterating over the transcripts multiple times, allowing participants' self-identified statements to be the basis of the thematic categorization. In the final stage, all statements responding to the main themes were classified thematically, allowing both researchers to collaboratively validate the thematic categories developed in the second stage. The analysis focused on exploring the variance and richness of participants' insights and opinions.

4 Findings

Deriving from the thematic analysis of the focus group discussions, we investigate older adults' socially shared expectations regarding conversational companion robots, as summarized in Table 1.

4.1 Active listening

Discussions around all scenarios were centered around the robot's ability for 'active listening' when the user is alone. That is, the robot should be engaged in the conversation, understand its context, and ask follow-up questions to the user. Robots should be able to "elicit" interaction with users in a way that users feel comfortable with sharing possible concerns beyond just superficial small talk. This could occur in the form of follow-up questions:

> But it has to ask a lot of questions so that this lady in this case (referring to the loneliness scenario) gets to talk out her concerns and put everything into words and such. So that the robot becomes good at eliciting that story. *(G1, P2, male)*

Follow-up questions from the robot could inspire the user to think differently about their personal situation, and provide encouragement, by adding "something new, that I have not thought of to make it interesting" (*G3, P1, male*). The robot can also foster a fresh perspective and encourage users to self-reflect:

> If you say "I'm bored today", and then the robot says like this, "Yes, I understand, but yes, is there something funny you can think of?", or something like that. I do not know, but there will be a lot of follow-up questions and I do not think the robot itself can come up with that much input, but can ask more like this, "What do you mean then? Explain further.", something like that. Therapy call. *(G1, P2, male)*

4.2 Passive listening

On the other hand, when the robot is placed in a social environment, such as a part of a group discussion where people play cards together (scenario 6), the robot should listen "passively", that is, without reacting to the conversation. However, the robot should still comprehend the information in the conversations, and refer to shared history when the user is alone:

> Robot must be able to register, in order to then be able to talk about what he has experienced (–) But not that he should be part of the talks. *(G1, P1, male)*

> Then you can talk to (the robot) afterwards, "Was it fun yesterday?". *(G1, P1, male)*

The participants associated the robot to be a companion in one-on-one interactions, rather than in group interactions, because "When I have my friends at home, I think it should be quiet" (*G1, P5, male*). However, the robot's ability to provide information from these group settings was considered as appealing and a possibility for debriefing and reminiscence:

> You kind of want to talk a little about the evening. What was said, how did you react to it, and sort of reflect on what someone has told you and perhaps vent about jealousy or other things that may arise. So the point is also to be able to debrief in some way, I think. *(G1, P5, male)*

4.3 Personalization

Personalization was a recurrent theme in the discussions around all scenarios, brought about by the demonstration of the robot during the design workshop, which indicated that the robot could learn from previous interactions with the user and refer to them in conversation (Irfan et al., 2023). Participants associated this 'learning' with understanding their preferences and relationships, such as learning their needs and hobbies, remembering the names and ages of their family members, their residences, and occupations. Initially, the robot needs to learn these details actively through questions, and then refer to them over time:

> Either the robot knows a lot about your family or not, so what do you want him to say, if we are completely unknown to each other, do you want him to ask about the family, how it was, and how you feel, but another situation is if he knows all this. *(G3, P2, female)*

> If it is a family visit, then you probably want to be asked if there are grandchildren there, for example, how they are doing. Has anything funny happened to them in the forecourt? So that you kind of get a little curious about everyday life. *(G1, P5, male)*

> You can tell the (robot) I'm going to see my brother when he's in the hospital or something like that, and maybe he'll want to ask how is he? How was it there, how is he doing or something. If you are now going to teach it. *(G1, P5, male)*

Based on the learned information, the robot was expected to provide advice given the situational context:

> If the robot has learned about one's family, it can talk about how to deal with the grandchildren and little things like that. But that presupposes that one, it gets taught quite a lot about a specific situation. *(G1, P2, male)*

Because the robot is framed as a social companion, the participants expressed high expectations towards the robot, including the robot's ability to do user modeling to understand their personal taste and make recommendations (e.g., on movies), as well as being up-to-date on weather and political events:

> If it knows my taste and such, I would say "Can you suggest a good film" for example, it could suggest a good film, which one could see. *(G3, P4, male)*

> I have thought a lot about the fact that it says personal robot, do you mean that it should be someone who knows what I think and so on and should also be able to answer what the weather is like (..). It should be sort of up-to-date and it should still know perhaps what I have and think, and then it is personal to me. *(G3, P6, female)*

Participants described the process of 'personalization' of the robot in relation to human-human relationships that evolve over time through the mutual sharing of personal experiences and information with each other. If the robot is given a companionship role, it should be perceived as being "as good as any other human" (*G3, P5, male*), with a personality and own opinions, and should be "trained to catch important things" (*G4, P2, male*):

> But when you meet other people, it's not just a matter of talking about your interests and yourself, the interesting thing is just "Yes, but what do you say, do you think so?". That is to say, we will make very high demands on the robot, I think because, if we can choose to be able to replace it, it will be as good as another human. *(G3, P5, male)*

4.4 Privacy protection and data control

Security features, such as user identification, that prevent the robot from sharing the data with others might encourage users to feel more relaxed in the presence of the robot. Otherwise, the participants might feel the need to "censor yourself all the time" (*G3, P2, female*).

> If it is stolen, it must have a password or something like that. *(G1, P4, male)*

> (There needs to be) some certainty is that it senses who it is talking to. *(G1, P2, male)*

So that it can somehow identify. (*G1, P6, female*)

> You are in a retirement home there, and you say "You were with Karin and spoke to her just now, what did she say then?". *(G3, P4, male)*

> It will be very strange if you tell about your whole life and then someone else can access it. *(G3, P3, female)*

In addition, the confidentiality of personal data when cloud-based services are used is a valid concern among older adults, since their data can be used beyond their consent, in addition to being accessed by governmental entities for surveillance, or being open to hacker attacks. Thus, privacy-preserving frameworks should be used when using cloud-based systems. Otherwise, data storage, extraction, and dialogue generation systems should be embedded on the robot.

> But how is the robot connected externally, is there … does it have an external connection and different information channels and so on to be able to give feedback to when we talk to it? And then it can go the other way. *(G1, P1, male)*

> It can eventually lead to what? A closed society, surveillance, nobody says anything. *(G3, P5, male)*

> No, but it is connected. If it is connected to the internet, it can actually be hacked as well. *(G1, P4, male)*

Users should have the possibility to easily delete previous conversations with the robot to facilitate a sense of privacy, especially when there are "difficulties with family members, you may not have a good relationship at all" (*G2, P3, female*), in addition to self-provided (embarrassing or incorrect) information:

> If you say something stupid that you regret having said, you can say "Forget it, delete it". Yes, it is important. *(G2, P4, male)*

4.5 Information retrieval

Participants associated the companion robot with many practical informational needs, such as a reminder of the doctor's visit and daily agenda (for the fifth scenario): "I can tell him my agenda for all the next few weeks, and then he remembers, and then each morning: 'You have to do this and that today.'" (*G4, P2, male*). These kinds of conversations with the robot would fulfill both practical and social functions, because the users would receive personalized recommendations and reminders along with their daily schedules: "Don't forget you have to see the doctor at one o'clock" (*G1, P1, male*). Participants also expected the robot to take the initiative to provide information:

> "Good morning, today the weather is like this" and "Do you want to hear the latest news", and things like that. *(G3, P6, female)*

Companion robots can also provide information and explanations on situated contexts, rather than relying on search engines:

> If I got bad news (referring to the third scenario), then I would like the robot to tell me what it means, this bad news, it means that this person is going to die within a week, six months, a year. What can I do to help this person? *(G1, P3, female)*

> I think of my mother then, who is ninety-four, she has a lot of company from television (–). If (the robot) can answer questions, give factual answers, sort of like you do not have to go to Google but you get those answers from the robot. Then I think it would fulfill a function, like just because you talk about it snowing outside. *(G3, P1, male)*

Users already have many technologies available for information seeking (e.g., phones, computers, spoken dialogue systems), and a companion robot could complement traditional information seeking by providing personalized statements or opinions on the facts through natural language communication. Participants imagined 'double-checking facts' with the robot and acquiring its opinions: "You can use it if you disagree on some factual issue (referring to the sixth scenario for playing a game with friends) (–) 'Leo (robot), what do you say, what do you think?'" (*G3, P3, female*). This way, the robot could become handy because "you do not have to pick up your mobile phone" (*G3, P3, female*).

4.6 Social connectedness

During the discussions of scenarios 2 to 4 (loneliness, hearing bad and good news), participants appeared comfortable talking about their emotions with the robot. Expressing or sharing emotions with the robot was primarily associated with experiences of loneliness. Participants considered it beneficial to disclose their experiences of loneliness with the robot, for which the robot could provide advice on how to get in touch with other people. In these situations, sharing emotions was perceived as a necessity for receiving emotional support from the robot, as explained by a participant:

> Maybe if you are very lonely then you might want to talk about "I feel lonely, I do not know how to get in touch with someone, or I want someone to come and drink coffee with me". But I think you want to talk about feelings. *(G2, P5, female)*

However, participants were mostly critical of the robot's potential to reduce loneliness, because "it is a plastic thing" (*G3, P4, male*). They thought the robot could be beneficial to people who are completely alone, and may not have any other person to talk to, but not as something that other people would choose voluntarily:

> I have a hard time seeing that, if the choice is to either talk to you or talk to the robot, that you would choose the robot. *(G3, P7, male)*.

Similar to the findings by Deutsch et al. (2019), the participants associated the robot as a social companion for people in their 90s, such as their parents, who spend a lot of time listening to audiobooks or watching television, as well as for people with dementia who may have limited possibilities for social interaction, similar to the findings by Khoo et al. (2023). For people at risk of disabilities, talking with a robot could help maintain cognitive skills similar to watching television. "Then this is also better than nothing, not hearing a voice perhaps for large parts of the day, you fill this in a sensible way and modulate the voice, so it sounds happier, friendlier, in such a situation" (*G3, P7, female*). In these situations, the robot is not expected to provide social companionship, but rather facilitate speaking or maintenance of cognitive skills:

> I almost think it does not matter what (the robot) says, because if you're alone, you eventually lose the ability to speak (–) And if you have not said anything, then the voice even starts to fade, and then when the children call once every six months, you are sitting all alone, then it is very important that there is someone who carries on a conversation, regardless of what it is says then. *(G4, P7, male)*

The robot facilitating voice usage could be leveraged as a recreational practice, such as singing:

> In terms of voice, I would like to say that the most important thing you can do if you are alone is to walk around and hum and sing, so that your voice does not dry up again. And you might not think it's so fun to do it yourself, but if the robot wanted to say, for example, "Which nursery rhymes do you remember?" or "Can you sing something?" or just activate both memory and voice. *(G4, P5, female)*

On the other hand, the fifth scenario (waking up to a new day) stimulated discussions around the robot being part of everyday activities and engaging in conversations similar to those they would have with any other person. These types of situations included, for instance, watching television together, discussing favorite programs, visiting museums together through virtual reality glasses, discussing the news or personal hobbies, such as stamp collection:

> If you sit and watch a TV program, for example, and the robot sits along. Is it then able to hold a discussion about this program? (–) It can be something with more intellectual content. Is it then able to catch up and then be able to hold a discussion? *(G1, P8, female)*

4.7 Emotional expressiveness

In order to encourage older adults to share their feelings, the robot's ability to convey emotions through empathetic responses and facial expressions was considered to be crucial:

> It's a lot about simply sharing feelings, being able to (show) happy and sad feelings and then it should be able to be responsive in some way and ask a lot of questions so you can talk out everything you feel. *(G1, P2, male)*

> Is it possible (to share feelings with the robot)? Because I also thought about it if, for example, you come after a family visit and if someone has been ill, for example, and you are a little worried. Can the robot sort of show empathy and sort of give good advice like this, what to say if, well like this. something has happened. *(G1, P4, male)*

As such, the robot's current voice and face were mostly considered to be 'insensitive' and 'lacking emotions', due to the lack of functionality to "laugh and smile" (*G3, P4, male*) and low variance in vocal intonation or facial expressions:

> This voice that the robot has is very insensitive so it has no emotions in it, it just speaks very slowly. *(G2, P3, female)*

5 Design recommendations

Our prior work (Irfan et al., 2023) (among others described in Section 2.2) provides a starting point for using a foundation model (e.g., LLM) for a conversational companion robot for older adults. Deriving from the expectations of older adults outlined in the previous sections, and the challenges of LLMs encountered in our prior work based on the interactions with older adults, we offer actionable design recommendations for developing conversational companion robots that leverage foundation models, such as LLMs, vision-language models, and state-of-the-art architectures as their core, with potential relevance for other conversational robots and agents.

5.1 Passive and active listening

Passive listening, akin to a silent observer, would allow companion robots to discreetly gather invaluable insights from social events, creating a reservoir of knowledge to enhance future interactions of the user with their friends and family. On the other hand, active listening empowers the robot to actively engage in conversations with the user, asking relevant follow-up questions, and inspiring users to think critically about their perceptions and thoughts, in addition to improving trust in the robot (Anzabi and Umemuro, 2023). The key lies in the robot's ability to discern the conversation's context and choose the appropriate action–passive in social events and active when alone–ensuring a dynamic and meaningful dialogue that respects privacy and encourages thoughtful engagement.

For passive listening, relevant facts can be extracted from the dialogue during social events (e.g., friends gathering, family meetings) using LLMs through prompts, such as "summarize what we know about the user" (Irfan et al., 2023) and "How would you rephrase that in a few words?" (Scialom et al., 2022). In addition, retrieval-augmentation methods can be used for summarization (e.g., Xu et al., 2022). These facts can be stored in a knowledge base (e.g., user, friends, and family profiles) to use the learned information in conversation via paraphrasing, knowledge completion (Zhang et al., 2020), or construction (Kumar et al., 2020). Attention mechanisms can further improve the relevance of the extracted facts, especially when combined with multi-modal information, which is typically readily available in conversational robots (e.g., Janssens et al., 2022). These cues can help understand the situational context (social events or alone) to choose the appropriate listening strategy through activity, location, and event detection, which can be achieved through multi-modal foundation models (e.g., Afyouni et al., 2022; Fei et al., 2022), or more traditional methods, such as key-value, logic-based, or ontology-based approaches (Miranda et al., 2014).

Active listening can be achieved with LLMs through prompting, such as by describing the agent as an active listener that reflects on situations using shared history and follow-up questions (Irfan et al., 2023). In addition, LLMs can be combined with follow-up question generation mechanisms (S B et al., 2021; Ge et al., 2022). Fine-tuning on human-human interactions that contain follow-up questions, reflections, and inspirations to think positively can also increase the active listening capabilities of the agent (Khoo et al., 2023). These follow-up questions can be used to investigate the underlying aspects of the matters concerning the user's loneliness, to increase their awareness of the root cause, and correspondingly address the problem. If, for instance, the cause is the lack of contact with family and friends, the user can be encouraged to reach out to them, similar to the ElliQ robot (Broadbent et al., 2024). While it is challenging to pinpoint the LLMs into certain directions, such use cases (e.g., loneliness, negative thoughts) for older adults can be pre-set in the system, in addition to topic detection via LLMs (Cahyawijaya et al., 2023) or other traditional methods (Ibrahim et al., 2018). Fine-tuning can also be used to trigger corresponding responses that could lead the dialogue model in the 'right' direction. In addition to follow-up questions, backchanneling can be used while the user is speaking, such as verbal acknowledgment (e.g., "uh huh", "yeah") and non-verbal gestures (e.g., head nods, smiles) to convey to the user that the robot is listening attentively (Johansson et al., 2016; Anzabi and Umemuro, 2023).

5.2 Lifelong learning and personalization

Unlike generic short-term interactions, forming companionship in everyday life requires learning knowledge about the user, which can encompass their family members, memories, preferences, or daily routines, as emphasized by older adults. Yet, merely acquiring this information is insufficient; it must also be effectively employed within context. This includes inquiring about the wellbeing or shared activities of specific family members, offering tailored recommendations aligned with the user's preferences, referring to past conversations, and delivering timely reminders regarding the user's schedule. This learning and adaptation cycle should be done continually over time, requiring long-term memory that scales gradually, without forgetting previously learned information, known as 'catastrophic forgetting' (Delange et al., 2021). Preservation of past knowledge and incremental learning of new information and adaptation is termed 'lifelong (continual) learning' (Thrun and Mitchell, 1995; Parisi et al., 2019). In comparison to '(reinforcement) learning from human feedback' approaches, lifelong learning does not require explicit feedback in the dialogue and can be used to learn new facts from conversations, as well as update previously learned facts (Casper et al., 2023). While lifelong learning in foundation models showed benefits in various areas, such as question answering and empathetic dialogue generation (e.g., Scialom et al., 2022; Luo et al., 2023), open-domain dialogue is yet to be explored.

Learned facts in a conversation can be used to personalize the dialogue contextually, such as for providing reminders (similar to the ElliQ robot) and recommendations, adapting language style to be more personalized and suitable for older adults, and referring to a shared history. LLM prompts can be used to refer to these facts within the conversations (Irfan et al., 2023), in combination with retrieval augmentation and recommendation engines to provide personalized suggestions (see Chen J. et al. (2023) for a comprehensive survey on LLMs for personalization). Moreover, "in-context learning" and "chain of thought" (i.e., processing information step-by-step) reasoning (e.g., Wei et al., 2023) or planning can be used with conversation history for providing relevant recommendations (see Dong Q. et al. (2023) for a survey on in-context learning). LLMs can also be fine-tuned on a dataset of human-human interactions (e.g., older adults' interactions in Khoo et al. (2023)) or based on human feedback (e.g., Ouyang et al.,

2022) to improve the interaction style and personalize responses for long-term interactions.

Semantic understanding, i.e., the relations among entities within visual scenes through object, scene, or action recognition, can be achieved with foundation models to provide advice based on the situational context that extends beyond the capabilities of verbal context (Bommasani et al., 2022). For instance, the robot can suggest the user a recipe based on their preferences, and offer help with cooking verbally or potentially physically if integrated with manipulators, in which foundation models can be used for generating robot plans and actions, by referring to/using the learned locations of the equipment and ingredients (see Wang et al. (2024); Firoozi et al. (2023) for surveys of LLMs and foundation models in robotics for task planning and control).

In addition, the robot can be given a "persona" based on prompts that can evolve over time to maintain a believable and interesting character with its own preferences, opinions, and memories, which can help form the basis of a relationship with the user (e.g., Irfan et al., 2023; Landwehr et al., 2023).

5.3 Privacy preservation

Older adults often value their privacy and autonomy, and incorporating companion robots into their lives should be done with the utmost respect for these principles (Vandemeulebroucke et al., 2018). As these robots may gather and process personal information to enhance their interactions and functionality, ensuring robust privacy measures becomes imperative. Older adults may be more vulnerable to potential privacy breaches as they might not be aware of the span of information gathered in an interaction. Thus, companion robots should not compromise their sensitive data or personal preferences.

In order to prevent sharing personal information with others and to address the privacy concerns of older adults in a natural way (i.e., without requiring passwords or ID cards) in day-to-day interactions, a user recognition system can be employed on the companion robot. However, contrary to most approaches in face recognition, including foundation models, that require several images of users to be stored manually for pre-training (e.g., Yan et al., 2023), an architecture that can autonomously detect and gradually learn new users, known as 'open world learning', is necessary for real-world HRI (e.g., Irfan et al., 2021b; Belgiovine et al., 2022). Moreover, face recognition algorithms contain bias in identification (Irfan et al., 2021b; Buolamwini, 2023), and perform worse on older adults[9]. Thus, combining multi-modal information, such as age and gender, that decreases this bias is required to provide robust identification (Irfan et al., 2021b). Bias does not only affect user identification, but also appears in the form of misrepresentation (e.g., stereotypes), underrepresentation (e.g., lack of training data from a particular background), and overrepresentation (e.g., abundance of training data from a particular background that generates perspectives oriented towards them) in training data for foundation models, which can affect the performance between individuals from different backgrounds, lead to discrimination, and cause psychological harms (Bommasani et al., 2022; Weidinger et al., 2022).

Beyond the dangers of sharing information with other individuals, since foundation models require heavy computing, it is challenging to have embedded systems on robots, thus leading to cloud-based solutions, which carry the risk of sharing information with either the providers (e.g., OpenAI, Google) or cloud-services (e.g., Amazon Web Services) even when open-source models (e.g., LLaMA) are used. Thus, data should be anonymized when stored or passed to cloud services to prevent it from being used by third parties that train on user data or monitor it, by using privacy-preserving machine learning approaches (Xu et al. (2021) provide a review of such methods). In addition, cloud-based services open the floor for various types of hacker attacks that need to be addressed accordingly (Jia et al. (2023) review different types and suggestions to overcome them). Moreover, it should be made clear to older adults which data is stored and how, and who has access to it for transparency, which would improve trust in the robot (Berridge, 2015). Companion robots should not be used as surveillance systems by family members, care-takers, or governmental institutions, as that would break users' trust in the robot, thus, decreasing shared social information and invalidating their purpose for social support.

Additionally, it is important to provide older adults with control of their own data by enabling the deletion of information verbally and easily, referred to as machine or knowledge "unlearning" (Bourtoule et al., 2020; Jang et al., 2022). Other ethical concerns for robots in elderly care are given by Vandemeulebroucke et al. (2018), and the risks posed by foundation models on privacy and corresponding solutions are discussed in further detail by Bommasani et al. (2022), Weidinger et al. (2022), and Zhang et al. (2023).

5.4 Information credibility and recency

Providing correct and factual answers is important for ensuring the robot's credibility and dissipating concerns about deception (Berridge et al., 2023). A lack of correct information and awareness regarding news or political events renders the robot ineffective as a conversational partner. Moreover, users often combine their social and informational needs, making it convenient to engage the robot by posing practical yet informative questions about their daily schedule, weather updates, movie recommendations, fact-checking, or the latest news, similar to their use of spoken dialogue systems. More importantly, misinformation can be critical in health-related queries to the robot, especially for older adults who may be less inclined to independently fact-check such information, with medical foundation models yet to be sufficiently accurate (Yi et al., 2023). Providing explanations for contextual information inquired by the users require not only a correct understanding of the medical domain (Moor et al., 2023), but also explainable recommendations through prompting or fine-tuning (Zhao H. et al. (2023) provide a survey of explainability for LLMs).

The generation of text or responses that seem plausible but factually incorrect is referred to as "hallucination" in foundation models, which is a commonly recognized challenge (Weidinger et al., 2021; Irfan et al., 2023). Attention mechanisms, regularization techniques, retrieval-based methods, evaluating

9 https://nvlpubs.nist.gov/nistpubs/ir/2019/NIST.IR.8280.pdf

uncertainty in responses, memory augmentation, and rewards for increasing accuracy can help mitigate this challenge (see Ji et al. (2023) for detailed suggestions on these techniques). Additionally, anthropomorphism in foundation models can be deceptive for users (O'Neill and Connor, 2023), despite its benefits in likeability (Arora et al., 2021).

Furthermore, pre-trained models contain outdated information due to the limitations of their training data cut-off dates. This outdated information can be rectified by incorporating fact-checking mechanisms that use knowledge bases (e.g., Peng et al., 2023). Alongside lifelong learning for continuous fact updates, relevant facts can also be sourced from the internet, including real-time data like weather forecasts and news as requested by older adults, similar to spoken dialogue agents (e.g., Amazon Echo) and ElliQ robot, by utilizing LLMs with web browsing capabilities, such as Gemini[10] and ChatGPT-4[11].

It is also imperative to include strategies that mitigate adversarial behavior in users, in addition to the engraved toxic behavior in foundation models, such as the spread of misinformation and the generation of toxic, offensive, or undesirable responses. Such strategies include filtering (e.g., Dinan et al., 2019; Zellers et al., 2019; Schick et al., 2021), fine-tuning (e.g., Si et al., 2022), and user-based removal methods (Ju et al., 2022)). These measures are essential to safeguard the model's factual accuracy and its adherence to the intended persona, thereby avoiding instances like Microsoft's Tay when learning from users (Davis, 2016).

5.5 Social engagement

To alleviate loneliness among older adults, companion robots can provide users with the opportunity to reconnect with friends and family, thereby, mitigating the risks of over-reliance on interaction with technology. Foundation models capable of utilizing tools for social media, phones, and various devices (see Wang et al. (2024) for a survey) that leverage edge computing can enable this functionality (e.g., Dong L. et al., 2023; Shen et al., 2023). Additionally, robots can facilitate new online connections for users by harnessing their social media networks with the assistance of other deep learning architectures (e.g., Ding et al. (2017); Chen et al. (2020).

Conversational companion robots can enrich the communication and cognitive skills of older adults with dementia and at later stages of life (Cruz-Sandoval and Favela, 2019; Lima et al., 2022). LLMs can be prompted to encourage conversations in certain contexts and times of the day. In addition, cognitive games can be incorporated into the conversations or via tool use (e.g., phones). Fine-tuning on therapists' interactions with such older adults can also shape the conversations toward incorporating these elements further into their daily lives. Furthermore, LLMs can be used to detect language impairment, which can help early diagnosis of dementia (Agbavor and Liang, 2022).

To maintain user engagement and interaction in daily life, conversations with companion robots should involve topics beyond the superficial small talk employed in current companion robots, such as ElliQ. The conversations should evolve around shared daily activities, hobbies, family, news, politics, and advice about situations. In contrast, the majority of conversations with LLMs tend to revolve around small talk, arising from a short number of turns and "let's chat" approach used to obtain training data, which evidently results in small talk between humans (Doğruöz and Skantze, 2021; Irfan et al., 2023), which can be addressed through fine-tuning with real-world interactions. Moreover, they lack the ability to adapt to the dialogue context and maintain coherency with their limited memory, which can be overcome by memory augmentation. In addition, companion robots may be endowed with visual feedback in order to participate in the preferred leisure activities of the user that involve other media, such as watching television together and discussing programs or news. To enable such interactions, multi-modal foundation models (e.g., vision-language models) can be used to understand the content from images (e.g., Dai et al., 2023; Liu et al., 2023; Zhu et al., 2023), videos (e.g., Li K. et al., 2023; Maaz et al., 2023; Reid et al., 2024), and real-time interactions (e.g., Driess et al., 2023), which can be used in conversation.

5.6 Reflection of congruent emotions

Expressing empathetic responses in congruence with the emotional state of the users facilitates trust (Cramer et al., 2010), sustains long-term relationships with users (Bickmore and Picard, 2005), and improves likeability, especially for older adults (de Graaf et al., 2015), as supported by the perceptions of the older adults in our study. Empathy in dialogue can be conveyed through appreciation, agreement, and sharing of personal experiences (Lee et al., 2022), which can be achieved in LLMs that are shown to have high emotional awareness (Elyoseph et al., 2023). Prompting the model to be empathetic helps tailor its responses accordingly (e.g., Chen S. et al., 2023; Irfan et al., 2023). In addition, LLMs can be combined with supervised emotion recognition architectures (e.g. (Song et al., 2022)). Fine-tuning on empathetic dialogues between humans can guide the model toward providing appropriate responses (see Sorin et al. (2023) for a review of empathy in LLMs). Multi-modal affect recognition can also be used to dynamically adapt the emotion of the agent's dialogue responses based on the emotions of users (e.g., Irfan et al., 2020; Hong et al., 2021).

In human-to-human communication, emotional prosody plays a more significant role than spoken words (Mehrabian and Wiener, 1967). In order for robots to sound emotionally expressive, as noted by the older adults in our study, "emotional voice conversion" (i.e., changing the emotion of the utterance) can be applied in text-to-speech (TTS) synthesis that allows variability in vocal intonation (see (Zhou et al., 2022) for a recent review). Recent methods have also incorporated LLMs into speech synthesis with emotional adaptation (Kang et al., 2023; Leng et al., 2023). Furthermore, Voicebox (Le et al., 2023) and ElevenLabs[12] offer cross-lingual zero-shot TTS synthesis with emotionally appropriate vocal intonations.

10 https://gemini.google.com/

11 https://chat.openai.com/

12 https://elevenlabs.io/text-to-speech

Mimicking user expressions and behaviors, such as smiling and laughing with the user, can improve interpersonal coordination, boost interaction smoothness, and increase the likeability of the robot (Vicaria and Dickens, 2016). In addition, generating social signals that match the robot's utterances can improve the believability, perceived friendliness, and politeness of the robot, and increase user interest in interacting with the robot (Sakai et al., 2012; Fischer et al., 2019). LLMs have also been incorporated into generating contextual facial expressions and gestures in virtual agents and robots via prompting (Alnuhait et al., 2023; Lee et al., 2023). Paiva et al. (2017) and Li and Deng (2022) give an overview of other methodologies for understanding, generating, and expressing emotions and empathy with robots and virtual agents.

5.7 Loneliness and social isolation

Design recommendations provided above were formulated by synthesizing older adults' self-perceived expectations towards companion robots with the technical capabilities of foundation models. This study did not investigate whether or not these technical capabilities could fulfill older adults' social needs or mitigate the experience of loneliness. Loneliness and social isolation are complex individual and societal phenomena, which are connected to other health-related issues and demographic changes in society. Loneliness is a subjective perception of a lack of social connectedness with social and personal relationships, communities and society (Newall and Menec, 2019), and it can be experienced regardless of the quality and quantity of social relationships (Kuoppamäki and Östlund, 2020). Therefore, not all older adults experiencing social isolation or lack of social contact necessarily consider themselves as lonely, and loneliness can be experienced regardless of the amount of social contact (Beneito-Montagut et al., 2018).

To investigate the association between open-domain dialogue with a conversational companion robot and experiences of loneliness in later life, future studies should explore older adults' experiences with conversational companion robots outside the laboratory environment with a scale for measuring subjective perception of loneliness before and after interacting with the robot over time, such as UCLA Loneliness Scale (Russell, 1996) or Companion Robot Impact Scale (Broadbent et al., 2024). Loneliness and social isolation should be recognized as phenomena related to social and personal relationships and connectedness with the community, networks, and society. In this regard, the robot could function as a mediator between the user and their social networks to strengthen interpersonal ties between human-human relationships. By incorporating the technical capabilities presented above, conversational companion robots could be leveraged for social conversations that go beyond information retrieval towards more adaptive and personalized social conversations. These dialogues could proactively recognize the user's perception of loneliness and guide the user with conversational exercises to increase user awareness of strategies to mitigate loneliness.

5.8 Study limitations

Our study has developed recommendations for designing conversational companion robots that leverage foundation models, focusing on LLMs for their dialogue capabilities, where we integrated older adults' insights based on a co-design approach into tangible design recommendations. Rather than having the participants directly interact with the robot prior to discussions, we elicited participants' expectations towards conversations based on visual design scenarios displaying the robot in diverse social contexts. Even though insights retrieved from this study represent participants' shared expectations without having a direct interaction with the robot, this approach was a necessary step in order to learn about their needs and preferences, overcome current technological limitations, and be able to design more appropriate, inclusive, and accessible companion robots and dialogue models.

The participants' cultural backgrounds may have influenced their views and expectations regarding the role and utility of robots in their daily routines, potentially differing from perspectives in other nations (Haring et al., 2014). Moreover, our thematic findings were based on the expectations of healthy older adults aged 66–86 years old, as such, these findings may not generalize to older adults beyond this age range or to individuals with cognitive impairments. While the chosen design scenarios captured common aspects of older adults' daily lives, they did not encompass all possible scenarios, leaving room for diverse viewpoints that other situations may offer that can be discovered by deploying conversational companion robots at homes in long-term contexts. The focus group discussions elicited participants' expectations of using the robot for social and emotional support, with a possibility to reduce loneliness among older adults. Therefore, the actual effects of whether or not the robot could mitigate the experience of loneliness remained unexplored in this study.

6 Conclusion

This study underscores the significance of aligning conversational companion robots with the distinct expectations and needs of older adults, aiming to provide social and emotional support in their daily lives. By involving older adults in the design process, we have gleaned invaluable insights into their desires for conversational companionship, ranging from active engagement during isolation to passive companionship in social settings, while prioritizing features like memory, personalization, privacy, information retrieval, social connectedness, empathy, and expressivity. Drawing from these findings, we provided recommendations on integrating foundation models, such as LLMs and vision-language models, and other state-of-the-art technology into conversational companion robots spanning key areas such as listening capabilities, lifelong learning, privacy safeguards, information credibility, social engagement, and congruent emotional expression generation through voice and facial cues. These insights offer a pivotal foundation not only for conversational companion robots, but also for the broader landscape of conversational agents that build upon foundation models.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Ethical Review Authority in Sweden (reference number 2022-09-21). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

BI: Conceptualization, Funding acquisition, Investigation, Methodology, Software, Validation, Visualization, Writing–original draft, Writing–review and editing. SK: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Supervision, Writing–original draft, Writing–review and editing. GS: Writing–review and editing, Conceptualization, Methodology, Project administration, Resources, Software, Supervision, Writing–original draft.

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Conflict of interest

GS is co-affiliated with Furhat Robotics, as its Co-founder and Chief Scientist.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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How did COVID-19 pandemic affect the older adults' needs for robot technologies in Japan?: comparison of participatory design workshops during *versus* after the COVID-19 pandemic

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Social technology can improve the quality of social lives of older adults (OAs) and mitigate negative mental and physical health outcomes. When people engage with technology, they can do so to stimulate social interaction (stimulation hypothesis) or disengage from their real world (disengagement hypothesis), according to Nowland et al.'s model of the relationship between social Internet use and loneliness. External events, such as large periods of social isolation like during the COVID-19 pandemic, can also affect whether people use technology in line with the stimulation or disengagement hypothesis. We examined how the COVID-19 pandemic affected the social challenges OAs faced and their expectations for robot technology to solve their challenges. We conducted two participatory design (PD) workshops with OAs during and after the COVID-19 pandemic. During the pandemic, OAs' primary concern was distanced communication with family members, with a prevalent desire to assist them through technology. They also wanted to share experiences socially, as such OA's attitude toward technology could be explained mostly by the stimulation hypothesis. However, after COVID-19 the pandemic, their focus shifted towards their own wellbeing. Social isolation and loneliness were already significant issues for OAs, and these were exacerbated by the COVID-19 pandemic. Therefore, such OAs' attitudes toward technology after the pandemic could be explained mostly by the disengagement hypothesis. This clearly reflect the OA's current situation that they have been getting further digitally excluded due to rapid technological development during the pandemic. Both during and after the pandemic, OAs found it important to have technologies that were easy to use, which would reduce their digital exclusion. After the pandemic, we found this especially in relation to newly developed technologies meant to help people keep at a distance. To effectively integrate these technologies and avoid excluding large parts of the population, society must address the social challenges faced by OAs.

KEYWORDS

social robots, participatory design, co-design, older adults, social challenges

1 Introduction

The COVID-19 pandemic brought drastic changes to humanity's way of daily life. Because of the extremely high infectivity of COVID-19 virus, people were required to maintain social distance, and refrain from activities normally taken for granted, like going to school or work, eating or drinking out, traveling, and gathering with close relatives. This resulted in the loss of opportunities to meet new people and maintain old friendships, a loss of social mobility, fragmentation of intergroup interaction and extreme social isolation (Buecker and Horstmann, 2021; Donizzetti and Lagacé, 2022; Rodrigues et al., 2022; Murayama et al., 2023). Especially, the COVID-19 had a higher mortality rate in older adults (age 50+; OAs) (Morrell et al., 2000; Sum et al., 2008; Gao et al., 2015; Itoh et al., 2021) compared to the other age groups. To save lives, health professionals recommended that OAs avoid contact, even with close friends and family members. Thus, OAs were overexposed to the risk of adverse mental health outcomes, including a complete loss of opportunities for daily and traditional social interaction. Such strong restrictions of in-person activities made OAs being socially isolated or feel loneliness (Armitage and Nellums, 2020; Tyrrell and Williams, 2020).

The digital technology revolution coincided with the COVID-19 pandemic (Almaiah et al., 2020; Papagiannidis et al., 2020; Waizenegger et al., 2020; Abu Talib et al., 2021; Kniffin et al., 2021; Ben-Zvi and Luftman, 2022). Various information technologies were introduced at a rapid pace into people's everyday lives in order to maintain normal life as much as possible, such as remote learning and employment. This included videoconferencing for online teaching and working, electronic money for non-contact money exchange, self-checkouts and home delivery services for shopping without human contact are typical examples. Thus, viewing the COVID-19 pandemic from a social perspective, it caused a breakdown everywhere in society by forcing individuals to live with extremely restricted behavior; however, viewing it from a technological perspective, it enabled the rapid introduction of digital transformation. In terms of the relationship between social isolation and information technology use, Nowland et al. (2018) proposed the stimulation and disengagement hypotheses; that is, the former one is that people use information technology to enhance social relationships which decrease loneliness, the latter is that people use information technology to escape from their own lives, which increase loneliness. Therefore, to clarify how the large periods of social isolation like during the COVID-19 pandemic affect whether the OAs use technology in line with the stimulation or disengagement hypothesis is quite meaningful to understand the social challenges faced by OAs.

To comprehend the OA's attitude toward the technologies, we utilized the participatory design (PD), which is a design methodology in which end-users are involved in the design process to ensure that the final product meets the needs of them (Lee et al., 2017). In our PD, the participants were required to consider what social problems they are facing and what kinds of robotic technology would resolve these problems. This procedure can allow participants to effectively reflect their issues specific to the pandemic and accurately grasp their current situation. We then conducted the PD workshops in June 2023 when the COVID-19 pandemic has ceased (about 1 month after the US declared that the COVID-19 pandemic has ceased[1]) so people were returning to their pre-pandemic lifestyle. We then compared the results of our last August 2021 workshop (during the pandemic) (Fraune et al., 2022) and this June 2023 workshop (after the pandemic), and then examined how the COVID-19 pandemic affected the social challenges OAs faced and their expectations for robot technology to solve their challenges changed from during to after the pandemic. We finally considered how the results of PD workshops during and after the pandemic can be explained by the Nowland's stimulation or disengagement hypotheses.

Here, the following two research questions would be a guide of this paper.

- RQ1: How did OAs' needs for robot technology change from during to after the pandemic?
- RQ2: How were OAs' attitudes toward such technology during and after the pandemic explained by the stimulation and/or disengagement hypothesis?

2 Related works

2.1 Social isolation and loneliness

Social isolation, defined as low quantity and quality of social and emotional connections (Shankar et al., 2011), increases loneliness and decreases physical and mental health (Weiss, 1973; Van Baarsen et al., 2001; Wang et al., 2003; Tomaka et al., 2006). Loneliness, a negative emotional state due to a discrepancy between the social relationships people wish to have and the ones they perceive they actually have (Heinrich and Gullone, 2006), relates to increased social anxiety, risk of depression, suicidal ideation, and reduced cognitive functioning (Heinrich and Gullone, 2006; Hawkley and Cacioppo, 2010). Loneliness also closely relates to negative health conditions like cardiovascular disease (e.g., high blood pressure, high cholesterol) and risky life-threatening habits (e.g., smoking, lack of exercise) (Hawkley and Cacioppo, 2010; Shankar et al., 2011).

1 https://www.cdc.gov/coronavirus/2019-ncov/your-health/end-of-phe.html

Social isolation and loneliness are especially concerns for OAs and are also prominent issues in Japan, which is categorized as a super-aged society (Yasunaga et al., 2017; Mitsutake et al., 2018)[2]. Muramatsu and Akiyama reports that the OAs in Japan are more socially isolated than those in France, Germany, South Korea and the US (Muramatsu and Akiyama, 2011). The mental and physical impacts of social isolation and loneliness in OAs is strongly associated with more frequent medical visits, earlier onset of cognitive decline and Alzheimer's disease, and risk of all-cause mortality (Wilson et al., 2007; Gerst-Emerson and Jayawardhana, 2015; Boss et al., 2016; Beller and Wagner, 2018).

2.2 COVID-19 and societies

COVID-19 (Coronavirus disease 2019) was an epidemic disease caused by the virus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which originated in Wuhan, China in December 2019 and subsequently spread globally. By September 2023, more than 690 million people had been infected (Worldometer, 2022). In response to the rapid spread of the virus, governments around the world ordered their citizens to observe various degrees of physical distancing (i.e., maintaining physical distance between an individual and people not living in the same household), from restrictions on international travel to mandatory stay-at-home orders (Giallonardo et al., 2020; González-Rodríguez and Labad, 2020; Moreland et al., 2020). Such strong restrictions of in-person activities increased the worldwide prevalence of mental health conditions like anxiety and depression (Lytridis et al., 2020; Saladino et al., 2020; Sikali, 2020) and especially loneliness in OAs (Buecker and Horstmann, 2021; Donizzetti and Lagacé, 2022; Rodrigues et al., 2022; Murayama et al., 2023). By September 2023, the COVID-19 pandemic had subsided in many countries, but there are currently limited studies reporting how the end of the COVID-19 pandemic affect the OAs.

Researchers have conducted studies on the impact of COVID-19 on various aspects of society in Japan (Handler and Kawaminami, 2023; Kobayashi, 2023; Tanikaga et al., 2023). One study investigated how and to what extent pandemic-induced novel telecommuting affected employees' travel, activities, and residence locations and explored their expectations of post-pandemic life (Liang et al., 2023). Another (Arai et al., 2023) showed that opportunities to participate in society were disproportionately reduced for people with disabilities during the COVID-19 pandemic. Tani et al. (2023) found that the flourishing, which is conceptualized as "a state in which all aspects of a person's life are good," declined during the pandemic, especially for men and lower-educated people.

The COVID-19 pandemic led to the rapid introduction of information technologies into everyday life to maintain normal life as much as possible, like education and employment (Papagiannidis et al., 2020; Ben-Zvi and Luftman, 2022). Many studies investigating technology use during the pandemic focused on educational aspects, like how online learning was constructed and how it benefited learning styles (Almaiah et al., 2020; Abu Talib et al., 2021), and on employment aspects, like how online employment facilitates team work performance (Waizenegger et al., 2020; Kniffin et al., 2021). A meta-analysis of nearly 300 articles about the relationship between humans and information technologies during the COVID-19 pandemic found that information technologies were mainly used in specific domains like education and employment, and also used in healthcare and daily use (Vargo et al., 2021). A few articles report how OAs have used these technologies for healthcare and family interactions (Elbaz et al., 2021; Racin et al., 2023; Tang et al., 2023).

2.3 Technology and people

When technology develops, especially quickly, it is important to ask who the technology is being developed for and how well it meets their needs. As scholars of design justice point out, people create technology based on existing biases, which tends to favor groups in the majority (Costanza-Chock, 2020). This, and other situational factors, create digital exclusion of certain groups of people. Digital exclusion (Age UK, 2018) occurs when people do not have access to technology, the skills to use technology, or cannot benefit from the outcomes of the technology (Blank and Groselj, 2014; Government Digital Service, 2014; van Deursen and Helsper, 2015; Scheerder et al., 2017). People were typically considered digitally excluded include those who are people in a minority ethnic group, people with disabilities, and OAs, the last of which we study in this paper. Thus, with new technology developing especially rapidly, it can place heavier burdens on people who are already digitally excluded because they not only need to adapt to a new technology like everyone else, but they need to adapt to a technology that does not suit them.

Using technology to one's social benefit is not only a matter of feeling comfortable with the technology, but using it in a way that leads to more social connection. In Noland et al.'s model (Nowland et al., 2018) of the relationship between social Internet use is loneliness, they propose to hypotheses that are not mutually exclusive: Evidence for the stimulation hypothesis shows that people can use information technology to enhance social relationships, which decreases loneliness (Sum et al., 2008; Elliot et al., 2013; Lee et al., 2020). Evidence for the disengagement hypothesis shows that people can also use information technology to escape from their own lives, which leads to increased loneliness (Kraut et al., 1998; Nie, 2001; Nie et al., 2002; Kato et al., 2019). Likewise, if people have access to technology, but cannot use it well, they do not benefit from its use (Chen and Schulz, 2016; Chopik, 2016). Research on OAs tends to support the stimulation hypothesis. Social technologies can assist them in maintaining contact, especially with existing social networks (Cotten et al., 2012; Wilson et al., 2021). Social technology can also reduce social isolation in OAs (Bruck, 2002; Clark, 2002). More frequent social technology use related to fewer mental and physical health problems and higher self-perceptions of wellbeing in OAs (Chopik, 2016). During the pandemic, OAs had the possibility of connecting with others through social technology, but they only gained these benefits if they had high affinity for technology

2 The World Health Organization (WHO) and the United Nations define an "aging society" as one in which more than 7% of the population is 65 years or older, an "aged society" as a society in which more than 14% of the population is 65 years or older, and a "super-aged society" as a society in which more than 21% of the population is 65 years or older (Tahara, 2016).

(Fraune et al., 2023a). Recent work shows that digital exclusion acts as a barrier to obtaining benefits from stimulation via social technology (Ling et al., 2023).

2.4 Participatory design

Participatory design (PD, or co-design) is a design methodology in which end-users and people other than traditional researchers and designers are involved in the design process to ensure that the final product meets the needs of users (Lee et al., 2017). Through PD, participants first identify their own needs and desires, and then co-design a technical solution to meet those needs. PD workshops are qualitative research and tend to have small numbers of participants because of the long time required for conducting workshops (Gliner et al., 2002; Mason, 2010; Amrhein et al., 2019), however PD is valuable for helping researchers to understand perspectives of diverse users and stakeholders in different contexts (DiSalvo et al., 2008; Šabanović et al., 2015; Georgiou et al., 2020).

OAs are often stereotyped as less willing to use new technologies, so they have not been recognized as end-users of many previous technology developments. However, PD workshops are particularly valuable and empowering for OAs (Lee and Šabanović, 2014; Laura Ramírez Galleguillos and Coşkun, 2020; Fraune et al., 2022). Therefore, this methodology has attracted a lot of attentions in a research area of human-robot interaction especially how to design the social robots for OAs (Eftring and Frennert, 2016; Thunberg and Ziemke, 2021; Ostrowski et al., 2021a; b, 2022; Fraune et al., 2022; Alhouli et al., 2023; Stegner et al., 2023). For example, Ostrowski et al. (2021a) proposed a year-long co-design methodology leveraging convergent and divergent design activities to empower OAs in the technology design process with researchers based on seven sessions in a co-design project of home social robots with 28 OAs. This long-term co-design principle was deliberately and carefully proposed so this strongly supports and calls for respectful and responsible co-design with communities who may, in the future, interact and live with robots. Fraune et al. (2022) proposed an approach to participatory design of future technologies that spends 2/3 of the PD sessions asking participants about their own life experiences as a foundation. This grounds the conversation in reality, creates rapport among the participants, and engages them in creative critical thinking. We already conducted the PD workshops during the COVID-19 pandemic (August 2021) by means of the above Fraune's methodology (Fraune et al., 2022), so we also utilized this in PD workshops after the pandemic (June 2023).

3 Methods

3.1 Design teams

We recruited in 12 participants who satisfied the following requirements; (1) 50+ years of age, (2) able to use video conferencing software, (3) a resident of Japan and spoke Japanese, and (4) no prior experience participating in PD activities beforehand. Participants (N = 12; age M = 57.9, range = 50–65, five men and 7 women) were recruited through a human resource dispatching company and compensated 7,000 JPY per participant. There was no participation overlap between our PD workshops in August 2021 and June 2023. The term "older adult" is typically used to describe people age 65 years or older, which is the ideal target population of our research. Some previous work using participatory design in the HRI literature has also used older adults aged below 60 (Šabanović et al., 2015) and similarly, there is evidence of wider age bands regarding research on smartphones (Gao et al., 2015), internet use (Morrell et al., 2000; Sum et al., 2008), and care technologies for activities of daily living (Itoh et al., 2021). These papers used the term "Older adults" as over 40–55, so our criteria "OA is 50+" is quite reasonable.

The PD sessions remained virtual (Feil-Seifer et al., 2020). Each workshop included two facilitators and three participants. Facilitators had a background in information technology and research, and participants did not. During sessions, one facilitator led the discussion, posed all questions and brainstorming prompts, and moderated the discussion. One note-taker paraphrased participant comments and themes of the discussion on a shared screen throughout the workshop.

3.2 Procedure

The PD workshops took place on June 17 and 18, 2023. Sessions occurred via Zoom online video chat and were video recorded. Researchers mailed participants study supplies (post-it notes, markers) and printed ethics consent form, and they mailed the signed form to us before the workshop. Session lasted approximately 75 min, consisting of three rounds, each focused on a different main theme. Rounds began with a 5-min brainstorming phase, then used a 'round-robin' discussion format, with the facilitator allowing each participant the opportunity to share an initial idea one at a time before opening the floor to a more free-form discussion. This ensured that each participant contributed their ideas during the early stages of each round, so that the following discussion was informed by the opinions of all present. Through all rounds, the note-taker paraphrased participant comments and main ideas on Google Slides, using it as a shared 'digital whiteboard' to provide a common reference point for continued discussion.

Before the round 1, participants viewed a video of current commercial robots to ensure all participants had some understanding of current robotic technology's capability, as opposed to drawing from movies (Sundar et al., 2016).

Round 1: Participants discussed the technologies they currently use to communicate with others. The facilitator asked both what they liked about social experiences facilitated by technology, and what aspects of their technology-mediated interaction were missing or altered when compared to in-person interactions.

Round 2: Participants reviewed social challenges they currently faced, such as keeping up with old friends, making new connections, or socializing at large gatherings. The facilitator welcomed participants to share both new challenges specific to the unique social circumstances of the time and general challenges that existed before social distancing norms of COVID-19 pandemic.

Round 3: Participants brainstormed ideas for robots to help solve one of the social challenges discussed in Round 2. The facilitator encouraged participants to focus on ideas for a robot they would personally want to own and use and would be technically feasible within the next 3 years. After initial brainstorming and discussing their individual ideas, participants engaged in iterative design by picking one idea discussed (either their own or another participant's) to improve upon, or add to, in a subsequent 3-min brainstorm session. Another round-robin discussion followed this second brainstorming session. When appropriate, the facilitator re-focused the discussion or posed high-level questions, such as "What problem is the robot solving?" and "What might be some challenges of that idea?" Finally, the facilitator asked participants to create a list of their five favorite robot features discussed in this round.

3.3 Analysis

We transcribed video-recordings of each workshop session. Researchers then analyzed and coded these transcripts along common themes. Themes were derived from open and axial coding (Glaser et al., 1968) which was translated in Japanese. Specifically, two experimenters independently worked to check the participants' statements and to select the appropriate coding categories for each statement. Interrater agreement between these two experimenters in all four PD sessions ranged from moderate to strong (IRRs > 0.65) (Miles and Huberman, 1994). Note that the previous workshops in 2021 mainly focused on the comparisons between Japan and the US, whereas this workshop was conducted only in Japan, so we compared the Japanese data during and after the pandemic.

3.4 Results of PD study during the COVID-19 pandemic

In order to compare the results of the PD workshops during and after COVID-19 pandemic, we summarize below the results of PD studies conducted in August 2021, in Japan (during COVID-19 pandemic). Participants ($N = 12$; age $M = 54.42$, range = 50–63, 6 men and 6 women) were recruited through a human resource dispatching company and compensated 7,000 JPY per participant. For the detailed results, see Fraune et al. (2022).

3.4.1 Round 1: current technology use

LINE[3] was the most frequently used technology. While the participants felt that communicating with others through the technology without worrying about location or time was an advantage, they also thought that the lack of the information they could obtain through the technology was a disadvantage compared to face-to-face communication.

3.4.2 Round 2: current social challenges

Regarding existing social relationships, OAs lost most opportunities to anyone outside their households, including family members who live apart. Therefore, their most significant difficulties were with keeping in contact with these family members, especially their parents who were not good at using current technologies.

Regarding connecting with new people, participants found it difficult to create new connections with the others via only online technology, due to difficulties discussed in Round 1, about the limited information available via online technology.

3.4.3 Round 3: robot design concepts

Participants' final robot design concepts followed three themes: (1) pet robot, (2) sharing experiences, and (3) easy operation. Pet robot: Many participants wanted to place a pet robot in their parents' house to provide them with a social companion when they were unavailable to visit. Participants expected pet robots to be useful in relieving loneliness of parents who are apart and in communicating and dealing with problems when they occur. Sharing experience: Although there were no concrete discussions about how the robots can resolve these issues, half of the participants said that they felt huge challenges of sharing experiences (e.g., sharing pictures from a recent trip). Easy operation: Many participants required help from tech-savvy people when facing new devices or applications. They wanted robots with easy operation because they wanted to place these robots at the parents' house on the behalf of the participants.

To wrap up the PD workshop during the COVID-19 pandemic, participants' most significant social difficulties were in maintaining existing relationships, such as with family members, including their parents who live apart. They wanted to use robotic technologies to resolve this issue; specifically, they wanted to place an easily-operated pet robot that could mitigate their parents' loneliness and could watch them on the behalf of the participants in case they have a problem (e.g., falling down due to unexpected injury or illness).

4 Results

4.1 Round 1: current technology use

In Round 1, the participants discussed the technologies they currently use to communicate with others, and the advantages and disadvantages of those technologies. The most common application was LINE, followed by videoconferencing applications like Zoom[4] and Microsoft Teams[5]. Several participants used ChatGPT[6] to communicate with AI systems. They mainly used these applications on smartphones rather than PCs[7].

4.1.1 Benefits of current technology

Participants enjoyed that they could communicate with others regardless of where they were. "I don't need to travel all the way to meetings and conferences, so I can use my time more effectively (P3)." "Since these technologies are portable, I can take them with

3 https://line.me/en

4 https://zoom.us

5 https://www.microsoft.com/en-us/microsoft-teams/group-chat-software

6 https://chat.openai.com

7 Visualizations of four PD sessions (Supplemetary Figures S1–4) were shown in appendix as Supplemetary Material.

me when I go out and immediately get contact the other person wherever and whenever I want (P10). "They enjoyed using one device or application for multiple purposes: "These applications are in my smartphone, so I can carry these with me easily (P2)," "(LINE) can be used not only for text chatting but also for video and voice calls (P1)."

They also enjoyed elements of the technology that made social interaction via it more seamless. "(Text chatting) is easier and smoother than e-mail (P7)," " (LINE) shows already read remark when the other person reads my message, so their responses are quick (P1)." Some also enjoyed that it was not a financial burden, liking the "Free video calling (P10)."

4.1.2 Drawbacks of current technology

The main drawback participants discussed was uncertainty about nuance and communication due to the limited information they could gain from the technology. For example, P1 said, "In video calls such as Zoom, I don't feel like I am looking at the other person eye-to-eye, so I worry about whether my facial expressions are properly conveyed to the other person." Similarly, P11 said, "Online video call cannot convey detailed nuances to the others," and P3 said, "I cannot understand the mood of the situation because I cannot see the other person's facial expressions in detail." P12 pointed out the disadvantages of text communication, like "I am worried that I cannot convey my feelings well using only text or letters, which can lead to miscommunication and misunderstanding from the others."

Overall Round 1, while most participants mentioned that the current technologies communicating with others have advantages that can beyond their constraints of place and time, they also mentioned that these have some disadvantage in that the amount of information they could obtain was less than in face-to-face communication.

4.2 Round 2: Current social challenges

In Round 2, participants discussed social issues about human relationships that they themselves face, especially about maintaining existing social relationships and connecting with new people.

4.2.1 Challenges maintaining existing social relationships

Participants discussed the difficulties and problems they experience in maintaining existing social relationships. Regarding technology for communication, which was the focus of the previous Round 1, P7 and P9 responded, "when I want a reply from the other person, but I don't get a reply, I get frustrated or anxious," and P9 responded, "I can easily join some groups on the Internet, but it is difficult to get out of them." P11 indicated that she worried about problems caused by miscommunication or misunderstanding of the contents of e-mails.

As general difficulties not related to technology, P2 and P3 were careful in their interactions with people younger than themselves, and P1 and P10 said that it was important to maintain appropriate distance from others (e.g., switching between public and private) was important for maintaining appropriate relationships with them.

4.2.2 Challenges connecting with new people

Participants discussed perceived difficulties and problems in connecting with new people, related to the lack of information compared to in face-to-face environments, as discussed in Round 1. P6 responded, "When communicating with people I am meeting for the first time, it is more difficult to convey my personality and atmosphere via online than in person."

In addition, although it has become easier to exchange contact information such as via SMS, some participants had general anxiety about relationship-building. P7 worried about how to build relationships from there, and P9 was concerned about what the other person thinks about them. P11 usually feels nervous because he believes he is not good at interacting with others, and P12 wondered how much information about himself he should disclose to others to avoid oversharing them.

4.3 Round 3: robot design concepts

In Round 3, participants discussed ideas for designing a robot that can solve problems discussed in Rounds 1 and 2 and they picked the top five features they would want for a robot. Participants' final robot design concepts surrounded three themes: 1) Interactive robot, 2) Proxy robot, and 3) Assistant robot.

4.3.1 Interactive robot

The most frequently mentioned robot concept was the interactive function. In all sessions, participants discussed interactions and conversations with the robot, with 10 out of 12 participants speaking on this topic. Many participants indicated that they themselves would like to be able to interact with these robots to relieve their loneliness, to feel comfort, or to have someone to talk to. For example, P10 said, "I would like to have the robot that can talk to me. This robot would be a beloved friend if this robot shows the personalized behavior based on my input data, my own preference and personality." P5 also stated, "I think it would be good in the future to have a robot that has a function like ChatGPT: that the robot can answer various kinds of questions we have,"

4.3.2 Proxy robot

There were also active ideas for robot concept that the robot performs various tasks on behalf of the participants. For example, P7 focused on complicated procedures of on-line application for government offices, saying, "When I search on the Internet, I could find contact information and phone numbers of the government office, but after a while, I could not find the phone numbers and only can inquire by e-mail, so I am wondering where to contact exactly … " P10 was also concerned about the replacement of technology in all aspects of daily life, saying, "At the unmanned checkouts in supermarket, it is a bit difficult for elderly people to use this. If possible, I want to use the in-person checkouts. If there is a question, I know that people can ask questions via the monitor at this checkout, but I often see some people having trouble at there." P8, who felt that he was not able to make good use of the functions implemented in smartphones, added, "Even though I look at map apps, I often get lost on my way, especially when I am in a bit of a hurry and have a fixed time. It would be nice if there was an alternative that could guide me in such situations."

4.3.3 Assistant robot

There was also active discussion about a robot that does not take over all the works like a proxy robot but that assists users. For example, P1 remarked, "If there is a robot that manages schedules and appointments and tells me what to do, I think we can maintain a good relationship because it will not bother other people if I accidentally forget my schedule or something." Other opinions were also expressed, such as a robot that can think about the text of e-mails together with us (P10, P12), and a robot that can subtitle the audio of video calls (P9).

4.4 Common features of PD sessions during and after pandemic

Across the two PD studies in August 2021 (during the pandemic) and in June 2023 (after the pandemic), we found similarities in responses in Rounds 1 about current technology use and Round 2 about connecting with new people.

4.4.1 Round 1

Both during and after the pandemic, Round 1 was very similar. The most commonly-used technology was LINE. Participants appreciated the advantage of social technology was that there were no restrictions on time and place. The main drawback they felt was that they could not obtain a lot of information that face-to-face communication can easily (e.g., body posture).

4.4.2 Round 2

Both during and after the pandemic, Round 2 included similar discussions about the challenges of connecting with new people. Because of difficulties discussed in Round 1 about the lack of information during online interaction, they had trouble connecting new people online.

While technology that connects people online is effective for OAs in maintaining the existing relationships, it is not well suited for them in connecting with new people. Indeed, higher levels of affinity for technology during the pandemic related to higher perceived group cohesion with new groups, but not existing groups (Fraune et al., 2023b). Conversely, younger generations are very active building new relationships through the use of online technology, such as dating apps, so this may cause a generation gap in the adoption of such technology (Gibson, 2021; Joyce et al., 2022).

4.5 Different features of PD sessions during and after pandemic

Although Round 1 and challenges of connecting with new people in Round 2 were similar during and after the pandemic, there were the completely different discussions about challenges of maintaining the existing relationship (Round 2) and about preferred robot design concepts (Round 3).

4.5.1 Round 2

In Round 2, participants had different experiences with challenges of maintaining the existing relationship during and after the pandemic. During the pandemic, because of restrictions against meeting others face-to-face, participants had difficulty interacting and communicating with family members, especially those who lived far from them. Therefore, in the PD workshops during the pandemic, interaction and communication with elderly parents who live apart was a particularly serious problem. Conversely, after the pandemic, with the restrictions removed, only a few participants had concerns about communicating with family members. Few participants used the terms "COVID-19" or "parents who live apart" in the workshops after the pandemic. Instead, participants' current challenges were general anxieties about ordinary social life that probably existed before the pandemic related to socially integrating OAs (Muramatsu and Akiyama, 2011), like "how to interact with or how to keep comfortable distance to younger generations in their office," or "My SMS message was already read by the others, but still there is no response."

4.5.2 Round 3

In Round 3, there was a vast difference in robot concepts that might resolve present social challenges. The final three robot design concepts in the PD workshops during the pandemic were *Pet robot, Sharing experience,* and *Easy operation,* while in the workshops after the pandemic, they were *Interaction robot, Proxy robot,* and *Assistant robot.* Thus, participants in both PD workshops suggested robot solutions from different perspectives.

5 Discussion

5.1 Stimulation/disengagement hypotheses and PD workshops

Here, we focused on the different features in "Round 3" of PD sessions during and after the pandemic, and discussed these in more depth in terms of the stimulation and disengagement hypotheses Nowland et al. (2018). Specifically, we considered which robot concepts can be explained by stimulation or disengagement hypotheses. Table 1 showed that the top three concepts of robots in round 3 and the following hypotheses (stimulation or disengagement) during and after pandemic.

In PD during the pandemic, most participants had serious concerns and difficulties communicating with family members or elderly parents, especially those who live apart from them. Perhaps in reaction to this new distance, participants' responses during the pandemic relate most strongly to the stimulation hypothesis and reducing digital exclusion. The theme of wanting to *share experiences* relates strongly to the stimulation hypothesis, helping people connect socially with others. *Ease of operation* relates to wanting to reduce digital exclusion for themselves and their family members. This suggests that during the pandemic, OAs were trying to maintain social connection, following the stimulation hypothesis. The desire for *pet robots* for parents, however, links to both the stimulation and disengagement hypotheses. It relates to the stimulation hypothesis because people wanted the robot to create a social connection with their parents. However, it relates to the disengagement hypothesis because this robot would engage in social interactions, rather than participants engaging in them. The theme of *pet robot,* in which these two hypotheses of different nature are compatible, may reflect the uniqueness of robot technology in Japanese society, because it was

TABLE 1 Top three concepts of robots in round 3 and following hypotheses of PD workshops during and after the pandemic.

During-pandemic		After-pandemic	
Top 3 concepts	Hypotheses	Top 3 concepts	Hypotheses
Pet robot	Stimulation/Disengagement	Interactive robot	Disengagement
Sharing Experience	Stimulation	Proxy robot	Disengagement
Easy operation	Stimulation	Assistant robot	Stimulation/Disengagement

not observed in PD sessions conducted at the same time in the US (Fraune et al., 2022).

In PD after the pandemic, participants had concerns not about family members who live apart but about themselves, and their responses relate mostly to the disengagement hypothesis and increasing digital exclusion. Although we instructed them "to brainstorm ideas for robots to help solve one of the social challenges discussed in Round 2," their discussions shifted from the challenges about the communication between persons to the one about the relationship between themselves and societies, reflecting their concerns about their position or status in their societies. For example, in PD after the pandemic, participants discussed *interactive robots*. However, the reason they needed these robots was not for other people (like *pet robots* for their parents), but for relieving the OA participants' own loneliness. This relates to the disengagement hypothesis because they want to interact with the robot rather than with other people through the robots. The themes of the *proxy robots* and *assistant robots* were to dispel or resolve their own anxiety about the latest technologies such as online applications at government offices or self-checkouts, which are rapidly increasing (Duarte et al., 2022). We speculate that the rapid digital transformation made the OAs uneasy and anxious for these useful technologies. Therefore, this would be the reason why they need the proxy robots facing to these technologies on their behalf. These themes (*proxy robots* and *assistant robots*) are similar to the *ease of use* theme from the during-pandemic PD sessions; however, the participants after the pandemic wanted ease of use from themselves, whereas during-pandemic participants wanted "ease of use" for their parents. This relates to the disengagement hypothesis because they wanted the robot to work in their society instead of them. However, in case of *assistant robot*, the participants wanted the robot to help with their social activities (e.g., organizing the participants' schedule, or checking the incoming messages). This also relates to the stimulation hypothesis because this facilitates their engagement to their society. Here, the theme of *assistant robot* was explained by both stimulation and disengagement hypotheses, like *pet robot* was during the pandemic, so the required functions for *assistant robot* and *pet robot* seems to be similar–that is, not only taking care of or helping somebody (elder parents or themselves) but also connecting to the others (children or their society).

Overall, although the COVID-19 pandemic led to the rapid adoption of various kinds of useful systems that can allow the same functional processing as before the pandemic without human contact, such rapid shift to digital transformation (DX) seemed to made OAs uncomfortable. Our two PD workshops during and after the pandemic captured the OA's concerns and difficulties with current social challenges. Analyzing their difficulties from the viewpoint of the stimulation and disengagement hypotheses allowed us to extract their current situation. Specifically, the OAs were using technologies following the stimulation hypothesis during the pandemic because they wanted technologies to connect them with people who live apart, while they were using technologies following the disengagement hypothesis after the pandemic because they wanted to help themselves (Table 1). This is the strong evidence that the OAs are becoming in an increasingly "digital excluded" (Age UK, 2018) situation.

As described by the stimulation and disengagement hypothesis, technology can be designed and used to disengage people from others or stimulate social interaction. For example, one participatory design study investigated a virtual-reality artifact to help OAs reminisce. This technology promoted OAs' wellbeing (Veldmeijer et al., 2020) and could be used either for disengagement (if the OAs talk only to the machine) or stimulation (if the OAs use the machine to help them reminisce to family or friends). To help OAs connect with others, it is important to develop technology that promotes the latter. Prior work shows that OAs can be socially connected in three ways: to other people, to a neighborhood, and to a society (ten Bruggencate et al., 2019). That study recommended ways technology can connect OAs such as by helping them find ways to volunteer (ten Bruggencate et al., 2019). We recommend that researchers bring these themes of disengagement and stimulation to the forefront when conducting PD workshops to help understand the situation of socially vulnerable peoples like OAs and to motivate the research community in developing the appropriate technology to help them and stimulate social connection.

5.2 Limitations

There are some limitations in this study. The first limitation was about the assignments of the participants; that is, no participants experienced both workshops during and after the COVID-19 pandemic. We compared the results of the PD workshops between during and after the pandemic, but there were no overlaps in the participants. This study is not a rigidly prepared longitudinal study to observe the participants' attitudes change. The second one is the average age of the participants, being middle to older adults, rather than older adults. The average age in the PD workshops in 2021 was 55.4 years old (SD. = 4.17) while the one in 2023 was 57.6 (SD. = 5.12). Even though the 2023 study participants are older, the typical retirement age in Japan is 65–70 years old (70 becoming more normal), so the participants in these PD workshops are active not in their retirement. The third one is the lack of the participants' detailed information such as academic background or experiences with technologies. These information can be an analysis factor to deeply understand the participants' answers or justifications, so our consecutive studies should be designed to correct these information.

We ran these studies on one group of participants: OAs in Japan. Of course, other populations will be different and are important to study. We encourage researchers to perform similar PD workshops in other countries and with other age groups; we will therefore share all our materials in detail including the coding rubric, to increase our community's understanding of how needs of various populations are similar and how they differ.

Someone will point out that the COVID-19 pandemic is not the only differences between the PD workshops in 2021 and in 2023 or that this seems to be confusing correlation with causation and implying that COVID-19 is causing some of the changes or a digital technology revolution. However, the effects of the pandemic on our lives are tremendous, and it facilitated the rapid introduction of various kinds of technologies including the generative AIs, or telecommunication tools. So we would like to argue that the other factors that seems to be independent from the pandemic should not be considered independently but be a part of side-effects of the pandemic. Actually some studies (Grinin et al., 2022; Tarhini et al., 2022) supported these arguments, so we believe that the results of the two PD workshops might reflect the participants' understanding of the COVID situation "during" and "after" the pandemic.

6 Conclusion and future work

By means of the participatory design (PD) workshops during and after the pandemic, we were able to clarify what social issues and difficulties the Older Adults (OAs) faced during and after the pandemic and what they wanted for robot technology to resolve those issue. Specifically, during the pandemic, their most serious issues were communicating with distant family members, and they had dominant altruistic opinions such as wanting to help their distant family members via technology; this follows Nowland et al.'s stimulation hypothesis in their model of the relationship between social Internet use and loneliness (Nowland et al., 2018). However, after the pandemic, their issues shifted from the others to themselves; they wanted technology to take care of themselves in anxious and lonely situations. Social isolation and loneliness have been the major social issues of OAs before the pandemic. After the special circumstances of the pandemic had passed, many people felt that society was returning to the way it was before the pandemic in both positive and negative ways. A new development was the rapid introduction of technology in the midst of the pandemic (digital transformation), which made the OAs more anxious and uneasy, and may increase their social isolation and loneliness more. Therefore, this follows the disengagement hypothesis.

At the beginning of the paper, the following two research questions were presented:

- RQ1: How did OAs' needs for robot technology change from during to after the pandemic?
- RQ2: How were OAs' attitudes toward such technology during and after the pandemic explained by the stimulation and/or disengagement hypothesis?

Now we could answer the two research questions as follows:

- Answer to RQ1: OAs changed their needs for robot technology from "helping the others who live apart" to "helping themselves."
- Answer to RQ2: OAs' attitudes toward such technology during the pandemic could be explained mostly by the stimulation hypothesis, while these after the pandemic could be explained mostly by the disengagement hypothesis. This analysis clearly reflects the current OAs' situation that the OAs are becoming digital excluded after the pandemic.

For older adults to make effective use of these effective technologies, it is important for society as a whole to confront the social issues faced by OAs by learning about and designing technology to meet their needs, such as through future PD workshops like our own and participatory sessions related to specific technologies like self-checkouts. We then argue that conducting these PD workshops routinely not only in Japan and US but also in the other countries or conducting the longitudinal PD workshops with recruiting the same participants will help the research community to understand the situation of socially vulnerable peoples like OAs and to motivate the community in developing the appropriate technology to help them.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee on Human Research of Meiji University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

TK: Conceptualization, Investigation, Writing–original draft, Writing–review and editing. MF: Conceptualization, Writing–review and editing. KT: Conceptualization, Funding acquisition, Writing–review and editing. SS: Investigation, Visualization, Writing–review and editing. MK: Investigation, Writing–review and editing.

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Conflict of interest

Author KT was employed by the company Toyota Research Insitute.

Author KT receives a nominal financial award for publishing academic papers.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frobt.2024.1363243/full#supplementary-material

Supplementary Figures S1-S4 are visualizations of the PD sessions. These figures provide an overview of flow during the PD sessions. The red, green, and blue shading in the figures call out the top 3 concepts (Interactive robot, Proxy robot, and Assistant robot) across 4 PD sessions, and arrows show how the concept evolved. The black arrows indicate concepts that participants created and then carried forward their idea for development. The gray arrows indicate that another participant either further developed the concept or had a similar concept.

SUPPLEMENTARY FIGURE S1
The first PD session was held on June 17, 2023 and had 3 participants.

SUPPLEMENTARY FIGURE S2
The second PD session was held on June 17, 2023 and had 3 participants.

SUPPLEMENTARY FIGURE S3
The third PD session was held on June 18, 2023 and had 3 participants.

SUPPLEMENTARY FIGURE S4
The fourth PD session was held on June 18, 2023 and had 3 participants.

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Do you wanna dance? Tales of trust and driving trust factors in robot medication counseling in the pharmacy context

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Introduction: The sustainable implementation of socially assistive robots in a pharmacy setting requires that customers trust the robot. Our aim was to explore young adults' anticipations of and motives for trusting robot medication counseling in a high-stakes scenario.

Methods: Through a co-creation approach, we co-designed a prototype application for the Furhat platform together with young adults. In-lab testing of a pharmacy scenario, where the robot provides medication counseling related to emergency contraceptive pills, was conducted to deepen our understanding of some factors driving young adults' initial trust establishment and anticipations of interacting with a robot in a high-stakes scenario. Qualitative data from interviews with six study participants were analyzed using inductive, reflexive thematic analysis and are presented through a narrative approach.

Results: We outline five tales of trust characterized by personas. A continuum of different anticipations for consulting a robot in medication counseling is presented, ranging from low to high expectations of use. Driving factors in the initial trust establishment process are position, autonomy, boundaries, shame, gaze, and alignment.

Discussion: The article adds to the understanding of the dimensions of the multifaceted trust concept, of driving trust factors, and of the subsequent anticipation to trust robots in a high-stakes pharmacy context.

KEYWORDS

trust, medication counseling, human–robot interaction, socially assistive robots, pharmacy and medicine, medication safety

1 Introduction

Advanced emerging technologies such as robots are becoming more common in the workplace, including healthcare (Hosseini et al., 2023). Socially assistive robotics (SAR) is the field of researching robots that assist users by way of social interaction (Trost et al., 2019). It has been suggested that the COVID-19 outbreak could herald an era of greater integration of robots in healthcare, as socially assistive robots could strengthen security by reducing human contact, thereby minimizing the spread of viruses (Yang et al., 2020;

Zeng et al., 2020; Giansanti, 2021). Apart from the many benefits their introduction entails, ethical challenges such as privacy rights and the responsible use of technology arise. Concerns have been voiced that advanced robots may create responsibility gaps through a lack of clarity about who is responsible for the performance and result of a task, should a task that was previously performed by a human being be handed over to a robot, for example (Hosseini et al., 2023). Recently, calls have been made for caution and regulation of artificial intelligence (AI)-supported health technology (European Commission, 2023; Federspiel et al., 2023).

Simultaneously, the pharmaceutical field struggles with challenges. Prior research points to global shortages of care professionals, including pharmacists (Ikhile et al., 2018), and heavy workloads in pharmacies (Ljungberg Persson et al., 2023). This is reflected in downstream effects in medication processes, for example, medication errors occurring in 10%–20% of medication orders (Gates et al., 2019), poor quality of medication counseling (Alastalo et al., 2023), and poor handling of medication errors (World Health Organization, 2017; Ministry of Social Affairs and Health, 2022). Research is scarce on the topic of the pharmaceutical use of socially assistive robots, but a scoping review by Andtfolk and colleagues (in preparation, 2024) proposes that socially assistive robots may be considered suitable for use in medication processes. For example, socially assistive robot interventions such as medication advice have had positive results in prior research (Broadbent et al., 2018; Robinson et al., 2020), and Alahmari et al. (2022) state the need for robotic-assisted pharmacies to distribute drugs to eradicate or substantially reduce human error. However, pharmacies and medication counseling are strictly regulated fields. Regulation acts as a safeguard to prevent severe health risks due to medication errors, but these occur occasionally, nonetheless. The scoping review (Andtfolk et al., 2024a) indicates that using safe and trustworthy socially assistive robots in medication processes might have potential.

As socially assistive robots may be expected to perform more tasks in healthcare, understanding human trust in robots to carry out tasks is an essential research topic (Archibald and Barnard, 2018; Lyons and Nam, 2021; Schneider and Kummert, 2021). Trust is a critical element in human–robot interaction (HRI) scenarios, where humans rely on the robot to meet their goals in vulnerable and potentially high-risk contexts (Pinto et al., 2022; Saßmannshausen et al., 2022; Kumar et al., 2023). Moreover, as AI-based decision-making systems are being implemented, a requirement for trustworthy AI systems is that users accept and are willing to use and trust them (Kaur et al., 2022). Trust has a significant effect on the anticipation of using AI applications in the future and, thus, acceptance of AI technology (Hyesun et al., 2022). Moving beyond causality and effect, trust has been defined as being an anticipatory, continually emerging feeling that resides in the liminal space between the present and what we think will happen in the future (Pink, 2021). We approach this call for more research on trust in AI-enhanced technology such as robots by exploring Finnish community pharmacy (henceforth referred to as pharmacy) customers' establishment of initial trust in robot medication counseling in the high-stakes scenario of purchasing emergency contraceptive pills (ECPs) through user testing of a prototype robot application, co-designed with end users and pharmacists.

Emergency contraception may prevent unplanned pregnancy after unprotected sexual intercourse if used correctly (Atkins et al., 2022). The mechanism of action is inhibition of ovulation to prevent fertilization (Rosato et al., 2016; Endler et al., 2022). In Finland, emergency contraception is often given in the form of pills and is available at pharmacies without age limit restrictions or a prescription (FSHS, 2023). However, some women have reported that buying ECPs has been uncomfortable. In-depth interviews with young women in London report experiences of pharmacy staff as judgmental, unsympathetic, and unsupportive (Turnbull et al., 2021). A survey (The Pharmaceutical Journal, 2018) found that some women would rather travel to another city to purchase ECPs to avoid meeting acquaintances at the pharmacy. In addition, the women said they waited until the pharmacy was empty of customers before asking about ECPs. This is consistent with the finding of Turnbull et al. (2021) that transactions in a pharmacy are not discrete and can jeopardize client confidentiality and privacy. Against this backdrop, this article serves as an exploration of customer experiences in a potentially vulnerable, uncertain, and awkward scenario where a socially assistive robot performs the tasks of medication counseling for ECPs.

The aim of our research was to explore some of the factors driving young adults' choice decisions when establishing initial trust in a robot, and our work was guided by two research questions. The first one targeted choices that a young pharmacy customer might make regarding robot medication counseling for ECPs. To explore this first research question, we examined whether customers anticipated trusting medication counseling to the robot (RQ1). The second research question focused on motives driving the choice to trust or not trust the robot. We aimed to explore how young adults perceived the robot, indicating factors that either drive or impede trust in robot medication counseling (RQ2). The aim of the article is to contribute new knowledge to the field of human initial trust establishment in the context of trust in robot medication counseling in pharmacies.

2 Theoretical background

2.1 Trust in a human–robot interaction context

Currently, there is no widely accepted definition of trust and its conceptualization, nor is there a methodological paradigm for its evaluation (Law and Scheutz, 2021; Saßmannshausen et al., 2022). In previous HRI studies, the trust process has been related to the attitude or belief of the trustor in the sense that the trustee—the robot—will help achieve the goals of a trustor—for example, a pharmacy customer—in an uncertain and vulnerable situation (Lewis et al., 2018; Rossi et al., 2018). Trust has also been explored as the subsequent behavior of this belief or the extent to which one chooses to rely upon recommendations or actions of the agent (Lewis et al., 2018; Schneider and Kummert, 2021). Falcone et al. (2023), on the other hand, argue that trust can simultaneously be a mental attitude toward an agent, a decision to trust it—rendering the trustor vulnerable—and a behavior, an intentional act to trust the robot. Hancock and colleagues have defined trust as "an individual's calculated exposure to the risk of harm from the actions of an influential other (2023)," whereas Lee and See (2004) suggest the following definition: "the attitude that an agent will help achieve an individual's goals in a situation characterized by uncertainty and vulnerability." This study adheres to the latter definition, as the scenario includes ECP purchases that are most likely characterized by uncertainty and vulnerability. We have operationalized initial trust establishment as attitudes toward the robot and its task in this vulnerable situation. The attitudes and reasoning regarding trusting the robot and the medication counseling are explored through individual semi-structured interviews post human–robot interaction.

Several factors may influence a human trustor's belief in the robot trustee's benevolence and capability to act in a risk-mitigating manner (Hancock et al., 2023). Recently, trust in HRI was conceptualized as a quadratic model where humans, robots, the environment, and interaction/communication function as antecedents of trust (Saßmannshausen et al., 2022). Trust is a multifaceted concept encompassing many dimensions (Pinto et al., 2022), and thus, its assessment in HRI is challenging, partly because trust is multidimensional and context and culture dependent. Trust is also impermanent and fluid, as it is continuously recalibrated over time as prior experiences of HRI are complemented with new knowledge and experiences (Pinto et al., 2022; Saßmannshausen et al., 2022).

2.2 Trust in healthcare

Trust is a care value manifested by actions and tasks in care practice (van Wynsberghe, 2017). Its importance in healthcare is well-documented and remains a mediating factor in the effectiveness of healthcare provision (Douglass and Calnan, 2016). General social trust levels are very high in Finland, being part of "Nordic exceptionalism" (Lundåsen, 2022), and trust levels in Finnish healthcare are relatively high (Keskimäki et al., 2019). Healthcare in Finland performs well in terms of trust as it ranked second in trustworthiness ratings in the EU in the spring of 2021 (Eurofound, 2020).

Only 18% of Finns aged 25–34 stated that they trust AI-powered services in general, and only 35% of that age cohort feel they have been informed about the safe use of AI-powered services, with 59% wishing to be better informed on the topic (Finnish Digital and Population Data Services Agency, 2023). The rationale of our study is that despite, and precisely because of, the complexity and volatility of trust dimensions at play, it is worthwhile exploring driving factors motivating choices when discussing the potential introduction of socially assistive robots in vulnerable scenarios such as purchasing emergency contraceptives. Understanding drivers and manifestations of trust in HRI may determine the implementation of sustainable and ethical robot applications in social systems such as pharmacies.

2.3 Mediation

Several theories posit that there are complex, casual, and multidirectional relationships at play within a social system (Norman, 2023). Some theories that have been applied in a care setting are theories of action with an explanatory focus on how new technologies, ways of acting, and ways of working become implemented in everyday practice (such as normalization process theory; see May et al., 2022), whereas others focus on individual users' ascribed attributes and characteristics of a technology (diffusion of innovations theory, see Rogers, 1995). Other theories take a more descriptive and ethnographic approach to human agency. For example, the sociotechnical systems (STS) framework argues that technology is shaped by the social and cultural context in which it is implemented. Hence, it emphasizes a need to examine this interplay between the social and the technical and how technological developments are shaped by broader social structures and, in turn, shape themselves. From a sociotechnical perspective, successful implementation of technology within an organization is dependent upon the joint optimization of social components, like peoples' needs, attitudes, knowledge, and skills, and the (emerging) technology in question (Winter et al., 2014; Norman, 2023).

Another theory that focuses on the interplay and the mutual shaping of the technical and the social is the technological mediation theory (TM). Building on post-phenomenological studies, the theory emphasizes an empirical focus and takes the design and development of technology as its starting point for analyzing relationships between humans and technical objects. Technologies are viewed not as instrumental objects but as mediators of human experiences and practices, thus actively shaping relationships between humans and the world (Verbeek, 2016; Nyholm, 2023).

TM does not recognize sharp distinctions between humans and the technologies that they use and favors a blurring of the boundaries between them, much in line with actor-network theory (ANT) (Verbeek, 2013). In contrast to ANT, however, TM addresses the hermeneutic dimension of mediation as it explores ways in which technological artifacts actively participate in shaping humans' interpretations of the world while humans interact with them. Technologies participate in changing humans' perceptions, experiences, values, and actions and thus also mediate morality (Verbeek, 2016; Kudina and Verbeek, 2018). This theory's advocates stress that the dynamics of the interaction between human values and technology is best explored empirically and "in the making," that is, grounded in micro-level practices of design and actual use, rather than being speculated about and assessed through ethical frameworks (Verbeek, 2016; Kudina and Verbeek, 2018).

Thus, a technological mediation approach proposes a way to understand how people anticipate their engagement with and normative implications of experimental technologies not yet implemented on a large scale as a part of a learning process (Kudina and Verbeek, 2018). Accordingly, TM has the ambition (Verbeek, 2015; Verbeek, 2013) to inform interaction designers in their work adhering to design thinking or value-sensitive design (see, for instance, integrative social robotics (Seibt et al., 2020) and care-centered, value-sensitive design (van Wynsberghe, 2017).

There are several pitfalls in HRI design to be aware of. Robots are often designed as either a thing or a being. However, they are often perceived by humans as both, and as neither of these but as an Other with psychological and social superpowers that offers the possibility to design a new hybrid, ambiguous entity (Dörrenbächer et al., 2023a) that mediates with assistive functions in social settings (Kaerlein, 2023). Another pitfall is, according to Dörrenbächer et al. (2023a), the urge to imitate human–human interaction in the design of robots. Such an approach fails to acknowledge that robots act as our counterparts instead of tools that extend human abilities.

The authors argue that robots and humans constitute each other through diverse otherware relationships that depend on the mode of the interactivity involved (Dörrenbächer, 2023b, 31). Participatory design methods may assist robot designers in understanding how people anticipate coexisting with robots and in shaping the coexistence of humans and robots (Dörrenbächer, 2023b).

Knowledge about human social interactions with robots has been described as "still dimensionally incomplete" (Seibt et al., 2020), as research in the field of SAR has not sufficiently explored ethical, cultural, or existential aspects of peoples' experiences of interacting with a socially assistive robot. Seibt et al. (2020) call for using items in the humanities research toolbox, such as phenomenological analysis and narrative analysis, to address the need for more knowledge on human social interactions with robots.

In our analysis, we draw upon technological mediation theory and a value-sensitive design approach to further knowledge of the interrelationship between customers and socially assistive robots in a pharmacy context. We present observations of anticipatory concepts of robot futures through five personas that may inform and guide design and research in the field. We chose a narrative approach to address the call for multidimensional descriptions of HRI. Seibt et al. (2020) suggest narrative analysis methods to counteract what they call the description problem in social robotics, where humans' social relationships with robots are explored too narrowly. De Pagter (2022) recommends a more explicit inclusion of a narrative focus to come to grips with how trust building between humans and social robots can be further developed. Given the small sample size of the study, a narrative approach may capture the nuances of the initial trust establishment phenomenon and ultimately contribute to the understanding of what the trust-building process may look like. We hope that our analysis of the six shared informant experiences as five personas may contribute to this. As noted above, trust has been identified as one important driver of successful interactions between humans and robots, but more in-depth studies are called for on the topic of antecedents of trust and human interaction with robots (Saßmannshausen et al., 2022). Therefore, as a step in a humanity-centered design process (Norman, 2023), we aim to contribute new knowledge on initial trust establishment in robot medication counseling in pharmacies.

3 Methods and materials

The study is part of a multi-disciplinary PharmAInteraction project exploring whether socially assistive robots at pharmacies may strengthen patient and medication safety (cf. Andtfolk et al., 2022; Andtfolk et al., 2024b). The article draws on data from the first stages of a design process where we iteratively co-design, develop, and test a prototype robot application with potential end users and pharmacists.

3.1 Study stimuli

In Finland, ECPs are over-the-counter medication, but they require medication counseling concerning side effects, function, use, and individual needs. In our study scenario, the socially assistive robot Furhat was assigned the role of a standalone Sweden-Swedish-speaking ECP counselor with no pharmacist in the immediate loop (cf. Hagglund et al., 2023 for a video of the interaction flow of the application).

As medication counseling is strictly regulated, we designed a controlled system based on rules instead of an adaptive decision system. The application presents different options based on speech input from the customer concerning the following variables: hours since unprotected sexual intercourse, allergies, underlying diseases, and regular medication. The manuscript for this interaction flow was created together with pharmacists (Using role play and Hierarchical Task Analysis, 2023). Based on the user input to these queries, Furhat presents available options for medication and informs the customer on the function, use, and potential side effects of these options. Lastly, the customer is given the opportunity to choose between several available options. The robot provides the study participant with information about the range of available substitutable alternatives and pricing; communication of this information is mandatory according to national legislation (Finlex, 1987).

3.2 Participants and data collection

Purposeful sampling (Palinkas et al., 2015) was the chosen technique for recruiting participants who met the following criteria: being Finland-Swedish speakers, within the age range of 20–40 years, identifying as female, and having some experience using technology. Prior experience of or attitudes toward ECPs was not a criterion for inclusion and was not explored. Six study participants (all identifying as female) agreed to participate in the role-playing study evaluating the prototype robot application created as study stimuli. The research was carried out in a laboratory setting in Ostrobothnia, Finland, with participants from the area, having Finland-Swedish as their primary language, aged between 29 and 37 (mean age 30.5) and being somewhat experienced with technology (mean 3.83 on a scale of 1–5, where 1 corresponds to the least and 5 the most), though none had previously met Furhat. Study design rather than achieved data saturation governed the extent of the data collection phase. All six study participants had previously, approximately 2 months earlier, role-played the same scenario in the same laboratory setting with a pharmacist serving them as customers. Thus, the study participants reported here also participated in the previous scenario with a pharmacist. Therefore, playing the role of a customer buying ECPs was familiar to them, as was the multi-disciplinary research team and laboratory setting. This article, however, reports the experiences of the condition where Furhat provided medication counseling instead of a pharmacist.

Study participants met Furhat individually in a simulated in-lab pharmacy (see Figure 1). First, we went through the consent to participate forms and privacy notices. Then, we assigned the participant a role as a customer (see Supplementary Appendix S1 for task and scenario description). Next, the participant entered a room for robot medication counseling. A member of the research team was present in a rear section of the room in the event of technical challenges. The human–robot interaction was video recorded for analysis and will be reported elsewhere, as this article focuses on qualitative interview data. After

FIGURE 1
Study participants individually role-played a scenario with Furhat in a simulated pharmacy. Staged photograph by Marie Lillhannus.

interacting with Furhat, the participant exited the simulated pharmacy. Lastly, qualitative data were collected through six individual semi-structured post-test interviews, ranging from 24 min to 46 min (mean length 32:27 min), and recorded for analysis (see Supplementary Appendix S2 for interview guide). As the study participants had now role-played the scenario with both Furhat and a pharmacist, the interview guide focuses on the experiences of the two occasions.

3.3 Analysis

Data were analyzed using a process of inductive, reflexive thematic analysis (Braun and Clarke, 2022), with a focus on broad thematic patterning across all data. Analysis was conducted from a constructivist perspective. Reflexive thematic analysis is a method that integrates well into co-creation studies due to its flexibility and accessibility (Braun and Clarke, 2022, p 261).

Our reflexive thematic analytic approach began with familiarizing ourselves with the data by reading through the interviews multiple times. Three of the authors (SH, MA, LN) worked together to increase the validity and reliability of the analysis. A reflexive and iterative strategy was used during the coding process, where our preunderstanding, reflections, and interpretations were discussed within the group. This approach enabled a deeper understanding of the participants' experiences and the underlying thematic structures. The coding was adjusted in multiple iterations, resulting in over one hundred codes of potential analytic interest. Subsequently, codes were organized into broad themes, which related to what a robot is, the interaction with the robot, the experience of non-judgment, and the importance of autonomy.

After reviewing the codes and the whole dataset, we became most interested in the latent idea underpinning articulations related to trust, as we noted that all patterns somehow related to varying degrees of trust. We identified factors in the codes that are driving motives when establishing and calibrating one's trust in the robot and its use case. These trust factors or motives act as subthemes and address the second research question. The anticipation to trust the robot or not became a set of five distinct themes, ranging from low to high levels of trust, that address the first research question. Each theme—articulated as a song title—captures a different expression about trust in relation to robot medication counseling, and we treat these metaphors (Lakoff and Johnson, 1980) as personas (Lewrick et al., 2018). We chose song titles for the themes as the process of establishing initial trust in a novel robot appears to resemble a dance. We interpret the dynamic interaction between the robot and study participants and the subsequent interview stories regarding anticipations to trust the robot with providing medication counseling as motion and continuous calibration. The organized codes revolved around finding space, a shared rhythm, appropriate forms, and quality performance, among other things, which steered our thoughts to elements of dancing. The themes are illustrated through personas, which is a common concept in interaction design (Lewrick et al., 2018).

The findings are presented with illustrative quotes from the participants that capture the driving motives for intentions to interact with the robot.

3.4 Ethical considerations

The procedures used in this study adhere to the tenets of the World Medical Association's Declaration of Helsinki (2022). Ethical research practices (TENK, 2023) were applied, participants provided their written informed consent to participate in this study, and data were pseudonymized. Participation was voluntary, and all study participants were informed of the possibility of withdrawing from the study without providing any further explanation. According to the Finnish National Board on Research Integrity TENK (2019), the study design does not warrant an ethical review statement from a human sciences ethics committee. The study participants were not real pharmacy customers in actual need of emergency contraception in the role-playing study, but they represented their sociodemographic group of young women aged roughly 18–40. They were not at risk of physiological health injuries as they role-played a scenario in a laboratory without any medication present.

Furthermore, our work relates to ethics in a methodological way. The practice of designing with and by, instead of *for*, users is well-established in today's design field (Norman, 2023) and increasingly so in HRI technology development (Ostrowski et al., 2020). The method of co-designing is an ethical orientation, with its focus on inclusion and equality (van der Velden and Mörtberg, 2014; Carros et al., 2023). Technological mediation theory defines technology design as experimental ethics and argues that ethics benefits from exploring actual practices of design, use, and implementation of technology. Instead of "merely" assessing technology from the outside, Verbeek (2013) argues that ethics should come up with new ways of doing ethics of technology empirically and from "within." Applying design thinking methods

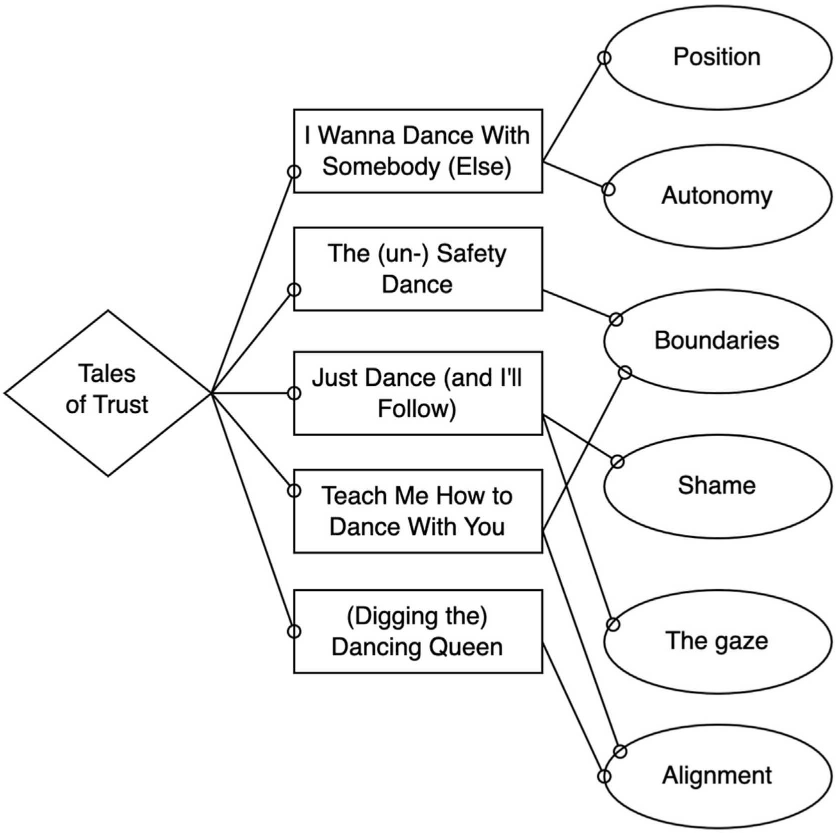

FIGURE 2
From left to right: Main theme, themes, and subthemes. The links between subthemes and themes indicate the main driver(s) in the persona's trust process.

has also been suggested to provide insights into whether and how technology and the social practices it affords lead to ethically desirable or virtuous practices (Misselhorn et al., 2023).

4 Findings—tales of trust and driving factors

In the two research questions, we explored whether the study participants anticipated trusting medication counseling to the robot and how the young adults perceived the robot, indicating factors that either drive or impede trust in robot counseling. The main theme of the analysis is Tales of Trust, illustrating the varying outcomes of the dynamic HRI (see Figure 2).

The findings in this study show that the study participants' anticipations of using socially assistive robots as a source of information within the pharmacy context vary considerably. Some participants expressed low acceptance of the use of robots as a source of information as they mistrusted the robot, while others saw great potential. Trust, in turn, shaped behavior in the robot simulation. Song titles with meaningful content are used as metaphors to illustrate our tales of trust and strengthen the five themes of the analysis. Each theme exemplifies the acceptance of the participants, progressing from the more skeptical to the predominantly positive perceptions. The six study participants are clustered into five personas or fictional yet realistic characterizations. The persona Just Dance (and I'll Follow) merges two similar tales of trust and thus represents two study participants.

The subthemes (see Figure 2) illustrate important factors driving trust in this particular robot behavior and use case, as raised by the participants. The figure contains links between some subthemes and themes, illustrating what we found to be the salient main driver(s) of the personas' narratives. For example, the persona The (un-)Safety Dance did discuss the gaze behavior of the robot as an example of anthropomorphic robot cues. However, we interpret her total experience as being more about the boundaries of humans and robots and whether the robot is a tool or an agent than about being observed by a robot's gaze. Thus, although several subthemes may have been expressed by a persona, we choose to highlight the one or two we interpret as most predominant in the analysis.

4.1 I wanna dance with somebody (else)

Neither the robot itself nor the use of it as a source of information is of particular interest for this persona. She values being independent and, therefore, seeks necessary information about medication on her own. As she does not trust the information the robot gives her, she would like to verify it with a pharmacist: *I would have gone to a pharmacist and asked, "Did I get this right?"* She appreciates the freedom to choose and wants to decide for herself with whom she wants to interact. She does not see the robot as an agent but rather as a tool that should be controlled: *I can imagine that this could be a bit like self-checkout at the grocery store, where you can choose to take the fast route: go to the robot, get the information, and go home.* She is also very skeptical of the environment the robot is in, as the location affects her trust in the robot. In her opinion, only healthy people could benefit from robots. Furthermore, she does not trust that the robot recognizes her intentions, as people can lie to it: *Perhaps one might give the robot an answer that may not be entirely truthful because one just wants to move on to the next question.* If she still must interact with a robot to get the medication, she wants to choose the robot's attributes, such as appearance.

This persona dismisses interacting with the robot and hurries away from the robot dance floor toward another disco.

4.2 The (un-)safety dance

This persona is interested in the robot but is uncertain about its competence. According to her, the robot did not respond adequately to her questions, which diminished her trust in the robot's competence. She wishes the robot were more responsive and capable of handling emotionally charged situations. According to her, the robot looked pleasant but did not behave like humans do. The non-human facial expressions and gestures further weakened her trust: *I think it wandered with its gaze, which made me feel a bit, you know, not on guard but rather uncertain.* Therefore, she is not convinced that she can rely on the medication information provided by the robot. She suggests that this could perhaps be alleviated through additional information, such as written or displayed content. If she is going to speak with the robot, she calls for clear instructions on how to communicate with it: *How can I convey this information in a way that the robot picks up what I mean; how can I be clearer?*

This woman prefers to be served by a human rather than a robot. Trusting a robot requires more of her than trusting a human being does. She suggests that the robot would function better by working as a team with a pharmacist. She would feel more secure if a pharmacist were present in the background, ready to intervene if something goes wrong: *It would also be good if there was a button to call for staff to come and assist.* The woman needs a human to verify that the medication is suitable and safe, specifically for her.

This persona cautiously dances one dance with the robot and then chooses to stand against the wall, attempting to gauge the reactions of others on the dance floor. She wonders if the robot is a tool or an agent.

4.3 Just dance (and I'll follow)

This persona emphasizes that the robot has certain advantages over a human, the main one being that one does not need to feel ashamed in front of a robot. The robot does not judge, even though the matter is sensitive in nature. *You might not want to see a pharmacist because you know you shouldn't be in that situation in the first place.* Especially in a small community, she prefers avoiding being seen. For her, interacting with a robot grants invisibility. This means she does not have to expose herself to a human, and the robot protects her privacy. *With the robot, I felt more at ease because I can answer anything.* However, she wishes the robot would communicate more quietly so that the people nearby cannot overhear the nature of her errand. She suggests that perhaps it could be placed in a secluded area to ensure her privacy.

After interacting with the robot, she spends a long time contemplating its gaze. She perceives the robot's gaze as neutral and non-judgmental, which increases her trust. Its gaze does not carry the same weight as that of a human. *While the robot also maintains eye contact, it feels different than when a human does so.* The woman suggests that she can let go of her façade and relax when being served by a robot. It feels good not to have to wonder what the robot is thinking because, well, it does not think. The rules of social interaction are thus set aside. Additionally, the robot is always equally agreeable to all customers, unlike humans. This woman emphasizes that there is no risk of being offended by a robot.

This persona enjoys dancing with the robot as it allows her to avoid dancing with a human. By doing so, she avoids the risk of being judged.

4.4 Teach me how to dance with you

It is exciting to interact with a robot, according to the persona in this tale, and she is eager to try it out. It feels a bit challenging because it is her first time speaking with a robot. *And it was also nerve-wracking, but I believe that over time, I might become more comfortable with it*. When she notices that the robot does not recognize what she wants to say, she becomes uncertain and feels insecure, rejected, and frustrated. She questions her own way of interacting due to these communication failures. She wants to learn how to interact with a robot in the best way possible, and she wonders how she can adapt to the robot. *I noticed that I improved my language with the robot, but maybe, yes, I wanted it to understand me, so I started to articulate a little more and speak using complete words so that it would understand.* She wishes for clear instructions on how to communicate with a robot.

It is important that the robot does not interrupt her; she wants to convey her message without haste. The robot should be as responsive as humans, as that would enhance her perception that the robot's responses are tailored specifically to her. The choppiness in the dialog flow negatively affects her sense of trust in the robot. The robot should not speak too quickly, and it is beneficial to repeat information about the medication when necessary … *because I didn't quite understand all the information the robot provided, so I would have liked it to repeat its message.* She also wishes for a clear confirmation, affirming that the robot has processed her message. She calls for such a confirmation in the form of a repetition of her message by the robot.

The persona in this tale wants to learn how to dance with a robot. She tries to adapt to the robot's steps but becomes disappointed when the dance does not turn out the way she envisioned. She wonders if the robot is a friend or foe.

4.5 (Digging the) dancing queen

This persona is enthusiastic after interacting with the robot, and she sees great potential for robots offering medication counseling in the future. She has many questions about the robot's performance. She trusts the information she receives from the robot, and she feels that the information provided is consistent: *It feels very reassuring that I'm getting all the information I need, that I can trust the information I receive.* She expects to be heard by the robot and to be taken seriously. However, she wishes that the robot were more flexible, would ask additional follow-up questions, provide spontaneous information, and wait for her replies instead of moving along without considering her input. In this story, the woman seeks a dialog on ontological questions and wonders how robots and humans actually differ.

The woman appreciates the robot's human-like appearance, and she is surprised by how important the robot's appearance is to her. She appreciates the opportunity to interpret the robot's gender role: …*and very androgynous, not directly a woman or a man, but you can interpret it as you need.* The woman longs for an even more human-like interaction with the robot: *It could be more nuanced in the language, not always responding with "oh, so you said … " but varying, for example, with an "mm," just like we do "mmm."* The voice could also be more human-like, according to her. She also calls for robot confirmation and acknowledgment of what she has said, much like when drive-thru clerks repeat her order, for validation and to avoid misinterpretations. She feels it is her fault if the robot does not acknowledge what she says and alters her way of speaking to it.

In this last tale, the persona thoroughly enjoys being on the dance floor with the robot. She does not miss dancing with humans, and she hopes that the robot can become an even better dance partner.

5 Discussion

The findings outline study participants' drivers of trust and subsequent choices to trust medication counseling to a robot. Five themes are summarized in the tales of choices, ranging from low to high levels of trust and acceptance, and underlying motives are presented as six subthemes. In the following, we will discuss the factors driving young adults' choice decisions when calibrating trust in a robot and the interplay between the motives and succeeding choices to trust the robot with medication counseling.

5.1 Position

The persona I Wanna Dance With Somebody (Else) is quite reluctant to interact with the robot. The tale highlights the importance of position, both in terms of physical and/or structural environment and medical circumstances. Regarding the former, protecting the *integrity and privacy* of the customers interacting with the robot is required. Careful planning of the physical placement, the establishment of interaction safe zones, and multipurpose labeling of the robot help to minimize the risk of other customers learning the nature and details of sensitive errands. The concerns also extend to the digital realm. The uncertainty of personal data governance breeds insecurity, as voiced by the third persona. This concern is in line with recent study results reported by the Finnish Digital and Population Data Services Agency (2023), showing that only 21% of young Finns aged 25–34 trust safe data privacy management in AI-empowered services. Earlier studies have showcased the importance of data and integrity protection for emergency contraceptive customers (Turnbull et al., 2021), as these data suggest as well. Protection of privacy and (data) integrity is one of the make-or-break drivers of trust expressed in our study, echoing the findings of frameworks (Kaur et al., 2022) and earlier studies, where integrity is a suggested component of moral trust (Malle and Ullman, 2021) and organizational trust (Pearson et al., 2016).

As a complement to the physical environment, the study participants discuss their position in terms of medical circumstances. The analysis shows how the *complexity* of the situation affects the willingness to consult a robot for medical counseling. Examples include whether the medication is new to the customer, whether the customer has complex health issues they wish to discuss with a care professional, the level of confidence that the robot has correctly received and processed their message, and the perceived accuracy of the robot's reply. Data include opinions that only healthy people benefit from HRI and a need to verify the robot's advice with a pharmacist, who is more trusted than the robot, to be reassured that the medication is suitable and safe. If the medication is familiar, and there is no need for consultation or answers to questions, then the robot has the potential to serve as a trustworthy, smooth, and quick self-service technology. As complexity increases, study participants' trust in the competence of a robot providing medication counseling—a high-stakes use case—is challenged. Thus, the participants perceived risks, fueling mistrust in the robot and greater confidence in pharmacists. Trust is partly explained by risk perception (Malle and Ullman, 2021; Pinto et al., 2022), and risk assessment lies at the very heart of the concept of trust.

5.2 Autonomy

The five tales highlight two aspects of autonomy that the study participants value in the interaction: *empowerment and independence, as well as freedom of choice* regarding the form of service. Both the least and the most interested persona in the HRI in this scenario value being able to search for information about the medication themselves. This implies an empowered role as a customer, shifting the task from the pharmacist to the customer. Robots are not necessarily trusted with retrieving this information, as the tales illustrate. One participant shared how disempowered she felt when the robot advanced in the dialog without taking her input about allergies into account. This challenges her ability to control and play an active part in health-related issues, which may result in severe consequences.

Another side to the empowerment coin is being independent as a customer. The ability to treat the robot as a quick self-checkout that limits time spent at the pharmacy could be valuable, should the situation allow for it, for example, when the medication is already familiar, and there are no health changes to consider. Lastly, the value of choosing the agent or counterpart to interact with each time is highlighted in the tales. Depending on the situation, a robot may be trusted to inform, whereas at other times, a human is preferred, and the ability to choose is valued.

These findings point to interesting shifts in perceptions of agency in the medication counseling process and pharmacy setting in general. The robot in the study scenario changes how medication processes could be carried out at pharmacies, dividing the tasks and responsibilities between a pharmacist and a robot. This shift has implications for customers' behavior in and experiences of the pharmacy. The robot thus carries the potential to shape the practices of interacting with pharmacists and buying over-the-counter products. As the five main themes described above illustrate, a robot is likely to shape the anticipated actions differently, as some participants were more interested than others in consulting the robot, should it be available for ECP counseling. The participants want to make informed decisions and see themselves as active agents that co-create the experience and service instead of a customer entering the pharmacy and receiving a product from a care professional. The call for the ability to choose between human and robot assistance when entering the pharmacy informs the design of the service and localities and is likely to shape social norms impacting agents at the pharmacy as well. Batalden et al. (2016) note that, over the years, healthcare has transformed into a service cocreated by healthcare professionals together with people seeking help to restore or maintain health for themselves and their families. Trusting a robot to play a role in the co-productive partnership at a pharmacy should address the value of an empowered role of the customer cocreating the experience and service while carefully mitigating the risks of responsibility gaps following a lack of clarity about who is responsible for the performance and result of a task (Nyholm, 2023).

5.3 Boundaries

The tales reflect a continuum of experiences where, at one end, the robot is perceived as a tool to control, allowing for little acceptance of a robot in such a high-risk use case. In these tales, the professional team acting out the role of pharmacists (Goffman, 1959) does not include a robot for anything other than merely instrumental tasks, at best. At the other end, the robot is perceived as an agent on par with pharmacists, with clear benefits over humans; a robot never has a bad day or offends or shames the customer. In between, The (un-)Safety Dance persona expresses a trust default in humans, as she says that engaging in a risk evaluation of a robot requires much effort on behalf of the trustor. Calls are made for more emotional intelligence and responsivity in the robot, allowing for more human-like behavior. Here, a more "human interplay" and an ability to handle distress in the client serve as drivers of trust. However, human participation through *human-in-and-over-the-loop* (Kaur et al., 2022; Shneiderman, 2022) is considered a benefit by all but one persona. The presence of pharmacists is a requirement, albeit with potentially different tasks in the workflow and with limited proximity to the customer. This is in line with the findings of Alahmari et al. (2022), which stated that pharmacy robots are unable to entirely replace human duties.

Taken together, those study participants who are least accepting of robots tend to consider the robot as a tool, and the ones the most accepting consider it to a greater extent as an agent. All personas engage in an assessment of who the interlocutors in the dialog are, ontologically and socially, in relation to each other and their boundaries. Notably, the persona Teach Me How to Dance With You struggles with boundaries and how she should adapt for the dialog to run smoothly. Therefore, our analysis suggests that knowing who and what the robot is, ontologically, as well as in relation to the person interacting with it, is involved in driving trust. Knowing what the robot can do for the human without risking harm is another cofactor that drives trust. Consequently, lacking that piece of information fosters feelings of uncertainty and risk aversion.

Emerging drivers of trust also include explainability and accountability. The former concerns clarity regarding what the robot is, how it works, and *transparency of its competence.* The latter concerns a shared responsibility between the robot and the customer to avoid harm. The participants say that a crucial dimension of trust for them is accurate information or knowledge in this high-stakes scenario so that they can make an informed decision. Therefore, the robot must be competent to appear trustworthy, and currently, few feel it does so fully. In addition to the requirement for greater capability in medication counseling and answering questions, some participants suggest mitigation mechanisms to avoid harm and decrease uncertainty. Seeing the information on another non-robot interface is suggested, perhaps on a touchscreen where clients can see the packet of the suitable ECP or the list of its side effects. Our data are thus not in line with findings (e.g., Schneider and Kummert, 2021) that robots are trusted more and considered to be more competent the more autonomous they are. The calls for shared responsibility and increased user control to make informed decisions are interesting and may reflect the high-risk scenario where misunderstandings could lead to dangerous risks.

Our analysis thus identifies both relation-based and performance-based trust factors, and this is in line with earlier research on what constitutes trust. Law and Scheutz (2021) identify performance-based as well as relation-based dimensions of trust. The reliability, competence, and capability of the robot to successfully carry out tasks lie at the heart of performance-based trust. A vulnerable human being trusting a robot to be a social agent constitutes the moral/relational dimension. Our analysis showcases the suggested dimensions of performance, as well as relationship, in the initial establishment and calibration of trust and extends the notion to include an ontological dimension as well. A simple one-dimensional continuum between humanness and robot-ness does not mirror how humans reflect on robots and their differences from human beings (Ullrich et al., 2020). In that conceptualization, clashes may occur between new ontological categories, such as non-living and animate technologies much like robots, and the human moral-cognitive system (Laakasuo et al., 2021). The negotiation of humanness and robot-ness expressed by the study participants is in line with the observation that people find robots to be their counterparts, an Other or Otherware, rather than extensions of themselves (Dörrenbächer et al., 2023a).

5.4 Shame

The data show the value of *not having to feel ashamed or judged* while purchasing ECPs. Interacting with a robot for medication counseling might enable young customers to maintain a sense of self-respect and not feel ashamed about their situation, as illustrated by the persona Just Dance (and I'll Follow). According to self-determination theory, human behaviors are both intrinsically and extrinsically motivated. Extrinsic motivation drives behaviors carried out for reasons other than inherent satisfaction, but these are still partially internalized through an avoidance of anxiety, shame, or guilt. The avoidance of shame functions as an internal reward of self-esteem (Ryan and Deci, 2020). Moreover, humans run the risk of shame and stigma (Goffman, 1963) in everyday interactions as we present ourselves to others on a social stage, influenced by social norms and values (Goffman, 1959). The finding of this study suggests the possibility of the robot acting as a mediator, offering the customer a chance to maintain a sense of self-esteem and to avoid having to search for approval from oneself or feel ashamed about their situation. The robot could be an example of a mediating technology (Verbeek, 2016) that may change the experience of an interaction to a less shameful or embarrassing one. Using Goffman's dramaturgical metaphor of the theater (1959), the customer may find it beneficial to present themselves to a robot instead of a pharmacist on the pharmacy stage to maintain a sense of self-esteem. The robot in this particular scenario might help the young customer shape the experience and situation in a more positive way, diminishing the negative emotion of shame. Previous research has found that humanoid robots can elicit feelings of shame in human interlocutors (Menne, 2017; Schneeberger et al., 2019). In contrast, Pitardi et al. (2022) argue that service robots reduce potential customer shame to a higher degree than service employees. For some customers, robots could be the preferred means of service delivery in potentially embarrassing service encounters, including healthcare contexts. As the body of literature on shame in HRI is still small and points to complex interplays (Menne, 2017), our finding on the robot's potential to alleviate feelings of shame and judgment contributes to the discussion.

5.5 The gaze

Interestingly, gaze is a concept that was found to both diminish and increase trust in our study. However, gaze is a broad concept. Two of its dimensions were discussed by the study participants, yielding opposing findings. On the one hand, gaze is a crucial mechanism in HRI that affects interaction through the process of joint attention, where the human and the robot share attention to reach a goal, and gaze aversion is a social cue in the interaction (Koller et al., 2022; Irfan et al., 2023). This dimension of gaze is expressed in this dataset. On the other hand, *gaze embodies values and opinions* between an observer and the observed. The personas refer to pharmacists' judging of young customers through non-approving gazes, mirrored in the robotic gaze that is not perceived to contain such a moral judgment of the customer.

When the robot gaze behavior was perceived by study participants as being non-aligned with the expected and interpreted anthropomorphically, the sense of trust diminished, and feelings of insecurity as to whether the medication counseling was accurate and reliable arose. Earlier studies have found that robot gaze behavior matters in HRI (Skantze, 2021) and is a determinant of human trust (Babel et al., 2021). A recent study carried out on Furhat found that it is important that the gaze behavior is aligned with and grounded in the ongoing dialog and other parallel cues for HRI to be successful (Irfan et al., 2023). Our study extends this finding as it links robot gaze behavior to trust and echoes the importance of consistent robot gaze behavior for a successful interaction.

Concerning the content or the message of the robot gaze, we share findings that the study participants perceive it as neutral, non-judgmental, and inoffensive. Talking to the robot instead of a pharmacist allows the customer *to avoid being seen* and is a means of protecting one's privacy and integrity. As the persona Just Dance (and I'll Follow) highlights, HRI offers a chance to avoid being judged by the staff and other customers in the pharmacy. Many aspects of relief are expressed as strengths of HRI, such as the absence of prejudice by staff and exposure to the approval of staff and other customers. Other examples include the absence of human-to-human contact, which removes the need to maintain a social façade and to expose oneself by sharing private and sensitive matters with strangers and potential acquaintances. The robot is entrusted with private health issues, and non-judgmental treatment of the customer is expected. The quotes suggest that the robotic gaze does not convey as much meaning as the human gaze does, which is experienced as a positive thing in this particular case. Similar to the previous discussion on shame, the robot could help a young customer shape the experience to become more comfortable. This could be a means of maintaining face and managing one's social impression or image, which is an activity that most individuals engage in Goffman (1959), Goffman (1955). The extrinsic motivation of avoiding being punished or judged (Ryan and Deci, 2020) drives study participants' anticipated choice of engaging in HRI.

The relief of interacting with a non-judgmental robot with non-observant, meaning-laden eyes in a care setting has been previously acknowledged. The superpower of being non-judgmental is suggested to be a social power that allows for new, meaningful practices between machine-beings and humans and should serve as a starting point for designing HRI (Dörrenbächer et al., 2023a). Our study reports a sense of relief in the robot being non-judgmental and echoes the call for drawing on this power of the robot in design.

5.6 Alignment

We find that lexical and behavioral alignment, as well as *reciprocity*, is a powerful driver for study participants' establishment of initial trust in the robot. The importance of *robot confirmation and acknowledgment* of human (lexical) input is a crucial requirement, as expressed by personas (Digging the) Dancing Queen and Teach Me How to Dance With You. Otherwise, feelings of insecurity and mistrust in the accuracy of the robot output arise, and coping mechanisms may kick in, such as changing one's message to mitigate communication breakdowns. Adapting the way one talks to the robot impacts the experience of the dialog, which is in line with the claim of technological mediation theory that technology shapes how we behave (Verbeek, 2016). Earlier research has found that advanced linguistic dialog behaviors, such as lexical alignment (repeating what the user said), are, in fact, preferred and trusted more (Chiesurin et al., 2023). Our data hold many calls for echoing the input, functioning as a receipt of being understood. The persona in the tale of The (un-)Safety Dance showcases behavioral misalignment as she feels the robot does not behave as a human would, and therefore leads to feelings of uncertainty.

Another aspect of alignment is reciprocity in the dialog between the human and the robot, where both interlocutors give and take in communication characterized by adaptability and flexibility rather than in an indelicate, tactless dialog with interruptions and inconsideration. This finding is in line with earlier research, suggesting a positive relationship between reciprocity and trust in human–technology interactions (Gulati et al., 2019; Pinto et al., 2022).

6 Conclusion and future work

The socially assistive robot behavior in the study scenario disrupts how medication counseling processes could be carried out at pharmacies, dividing the task and responsibility between a pharmacist and a robot. Such a shift would bring about implications for customer behavior in and experience of the pharmacy. The findings illustrate the claim of technological mediation theory that technology organizes and shapes how we behave, our relationships, and how we experience the world. As the five themes in the form of song titles described above illustrate, the human–robot interaction shaped study participants' experiences differently. Some study participants do not anticipate consulting a robot, should it be available for counseling about ECPs, due to mistrust and a preference for human-to-human interaction. Others might consult a robot, provided that several requirements are met. For them, the robot thus carries the potential to shape current practices of interacting with pharmacists, provided that the robot is trustworthy and safe to entrust with health data without harm or high cost to personal health. The six subthemes illustrate some of these requirements, reflecting the drivers of trust in this particular high-stakes scenario. In line with the idea that technology mediates how we experience things, the data show how Furhat is anticipated to shape the situation that informants role-played, for example, in terms of experiences of not being judged, more individual autonomy, more strain on how to speak and express oneself, increased feelings of uncertainty due to lexical and behavioral misalignment, and increased vulnerability as the robot's physical position may signal to other customers what business the customer has.

The subthemes may, at first glance, seem disparate, but the data suggest that they are interlinked in a web of interdependencies. Factors serving as antecedents of trust do not only concern the robot or the human interacting with it but also the environment and the interaction between the robot and the human (Saßmannshausen et al., 2022). Our data seem to fall within all these four as the subthemes Shame and Autonomy relate to the human trustor, the subtheme Gaze to the robot trustee, Position to the pharmacy, and lastly, Alignment and Boundaries to the interaction between the interlocutors. We find interrelatedness, for example, in the link between how the gaze of the robot is perceived and experiences of shame in the medication counseling, as well as between informants' calls for secure environments for the HRI (both physical and digital) and transparent, easy-to-understand communication of how the robot functions and behaves. Our analysis suggests that these determinants, in concert with many other factors, may then act as barriers or facilitators when establishing and calibrating trust in a robot in a similar use case, depending on their valence. A sustainable and ethical implementation of socially assistive robots in a pharmacy context must address these key aspects and requirements.

Our ambition is that the findings contribute to deepening the knowledge of trust factors at play in the interplay of HRI in the social context of a pharmacy and may inform future human-centered design work of socially assistive robot behavior and applications in pharmacy settings.

6.1 Study limitations

Several factors may be considered to limit the validity of the study findings. An inductive approach to data analysis risks being redundant and limited to surface descriptions and general summaries (Graneheim et al., 2017). Furthermore, the speculative approach may limit validity as we do not know whether the study participants have already purchased or may consider purchasing ECPs and, therefore, how they might relate to the scenario. The study participants merely speculate as to how they would behave; thus, they express attitudes and anticipations rather than reporting actions. Although intentions are considered a major determinant of behavior, the intention-behavior gap illustrates that future plans may not always be realized (Cheng and Cheng, 2023). Although the presence of a researcher at the rear of the room may have induced feelings of safety, should the robot malfunction, it may also limit or hamper the interaction and communication on a sensitive topic. The researcher was careful to stay in the background to balance this risk.

Additionally, the laboratory setting and a live interaction with an embodied, co-present robot might evoke different levels of trust than would studies in the wild or with a virtual or telepresent robot. Thus, our findings are not transferrable to other kinds of robots. Generalizability and transferability may be further hindered by the non-static, complex nature of the trust process. The experiences of a trustor are likely to change as a result of subjective factors, such as prior experience with robots, personality, individual and societal attitudes, and the context of the interaction, as well as robot behavior and levels of autonomy. Because trust is continuously recalibrated in time-/context-/people-sensitive circumstances, replications of the study may result in new and different findings. The transient state of the concept of trust in a socially assistive robot's ability to meet human goals is one of many good reasons to advance the knowledge in the field. The aim of the study is not to obtain transferable insights into other populations but to explore anticipations, attitudes, and factors driving young adults' decisions when establishing initial trust in a socially assistive robot providing medication counseling for ECPs. A limited sample size and the narrative approach through reflexive thematic analysis impede generalizability to all potential purchasers of ECPs in Finnish pharmacies. Nonetheless, portraying the study participants' anticipations of and motives for trusting robot medication counseling offers insights into some of the trust dimensions at play.

Notwithstanding these limits, the merit of the study is found in a deeper understanding of the dimensions of the trust concept in the initial establishment or calibration phase, of driving trust factors, and of the subsequent anticipation to trust robots or not in a pharmacy context.

Data availability statement

The datasets presented in this article are not readily available because they contain non-anonymized data that may reveal participant identifiable data. Requests to access the datasets should be directed to SH, susanne.hagglund@abo.fi.

Ethics statement

Ethical approval was not required for the studies involving humans because according to the Finnish National Board on Research Integrity TENK (2019), the study design does not warrant an ethical review statement from a human sciences ethics committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

SH: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, validation, writing–original draft, writing–review and editing, and visualization. MA: formal analysis, funding acquisition, investigation, methodology, writing–original draft, writing–review and editing, conceptualization, project administration, and data curation. SR: conceptualization, funding acquisition, investigation, and writing–review and editing. MW: conceptualization, investigation, writing–review and editing, funding acquisition, and software. SA: conceptualization, funding acquisition, software, and writing–review and editing. LN: funding acquisition, writing–original draft, writing–review and editing, formal analysis, investigation, methodology, project administration, supervision, and writing–original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frobt.2024.1332110/full#supplementary-material

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From care practices to speculative vignettes–design considerations for robots in good care

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The care sector has become one of the test beds for developing robotic technologies, which have been promised to mitigate problems with aging populations and labor shortages. Despite these promises, the practical application of such technologies have been met with limited success. Apart from technical limitations, other challenges exist in the way we approach designing these technologies. Critical to the development in the care sector is understanding the complexity of the contexts, the needs and goals of diverse actors, and how these are socio-materially scaffolded. This paper presents a study conducted at the intersection of a value sensitive design and speculative design to understand these sensitivities. Based on the data collected in interviews (n = 6) and card workshops (n = 6) from care workers and residents in mobile care and care home contexts in Austria, we developed five themes capturing situated practices and understandings of good care as built on trust-developing routines, negotiations between different actors, affective and reciprocal dimension of care, care worker self-care, and material mediations. Subsequently, we created six speculative vignettes which serve as rhetorical devices to emphasize the tensions that arise with any technological intervention entering and reshaping existing care practices and relations. We argue that our approach can support robot designers to develop a rich understanding of the values and tensions in the specific context under study from the before design and development begin.

KEYWORDS

good care, robots, field studies, care-centered value sensitive design, reflexive thematic analysis, vignettes, speculative design, design considerations

1 Introduction

Older adult care in countries of the Global North faces two interrelated challenges. First, the number and proportion of older adults in societies worldwide are increasing due to increasing life expectancy and improved medical treatment. This development is especially prevalent in countries in Europe and Northern America, where the percentage of people over 65 years of age is projected to increase from 18.7% in 2022 to 26.9%

in 2050 (United Nations Department of Economic and Social AffairsPopulation Division, 2022). Aging is accompanied by various individual changes in intrinsic, i.e., physical and mental, capacities. To prevent a decline in functional abilities (e.g., mobility, meeting basic needs), older adults require supportive environments that help maintain intrinsic capacities or compensate for their loss (World Health Organization, 2020). One measure to support older adults with changes and challenges is providing professional care by care institutions. However, as a second challenge, while the number of older adults is increasing, the number of care workers (CWs) is decreasing due to the forthcoming retirement of cohorts with high birthrates. Predictions indicate a substantial shortage of professional carers in the coming decade (European Commission, 2022).

Together, the developments discussed above threaten the provision of good care. In response, policymakers and NGOs have identified digital technologies as one lever to provide qualitative care in the future. Among many technological interventions in development to this call are robots (World Health Organization, 2020; European Commission, 2022). Robots are envisioned to provide a variety of functionalities: lifting and mobilizing care recipients (CRs) (Mukai et al., 2010)), engaging in physical exercise (Martín Rico et al., 2013; Martinez-Martin and Cazorla, 2019), as affective companions (Hung et al., 2019), or to support people with dementia (Ghafurian et al., 2021).

Despite the potential as a helpful tool in care, the adoption rates of existing products and platforms remain lower than expected (Ienca et al., 2016; Östlund et al., 2023). Among the reasons for low acceptance are that existing technologies are far from resembling agile and versatile robots depicted in futuristic visions (Weiss and Spiel, 2022). Additionally, a lack of training (Melkas et al., 2020) and neglect of contextual circumstances in the design and development process (Östlund et al., 2023) contribute to low acceptance.

With this work, we address a neglect of contextual circumstances and follow calls in HRI for more direct stakeholder involvement and mutual learning between stakeholders and researchers to create meaningful robotic technologies for everyday life (e.g., Weiss and Spiel, 2022). Our study is embedded in a trans-disciplinary research project centered on a collaboration between research institutions and a care practice partner, a non-profit care provider in Austria. What we present here is a first step to an ongoing effort to develop novel robots for care. As such, this work aligns itself with a Participatory Design (PD) approach (Lee et al., 2017; Bødker et al., 2022) and takes inspiration from Value Sensitive Design (VSD) (Friedman and Hendry, 2019), in particular the care-centered value sensitive design (CCVSD) methodology (van Wynsberghe, 2013) to consider values - as the lived experiences of what is meaningful to care stakeholders - in the design of robotic technologies. Our studies were conducted in care homes and mobile care contexts operated by our partner institute.

Two research questions guide the approach of this study. Research Question 1 (RQ1) asks *"What does good care mean for care workers and care recipients in contexts of mobile care and care homes?"* To explore RQ1, as a phase of research-for-creation (Chapman and Sawchuk, 2012), we first conducted interviews and card workshops with CWs and CRs in mobile care and a care home. Based on the collected data, we developed five themes (*Building a trustful care relationship through time and routines*, *Negotiations of care between care stakeholders*, *Emotional care and reciprocity*, *Self-Care of Care Workers*, and *Socio-material Mediation of Care*) following a reflexive thematic analysis (RTA) (Braun and Clarke, 2022). The results are presented in Section 4.

Research Question 2 (RQ2) asks *"What should we consider in the design of robots based on identified meanings of good care?"* In response to RQ2, we performed a creation-as-research phase (Chapman and Sawchuk, 2012) and generated speculative vignettes of robotic technologies in care. We use the format of speculative vignettes as a method to illustrate how robots in care scenarios inevitably exert influence to tensions and themes of good care and articulated considerations by juxtaposing the vignettes with themes of good care in Section 5.

This article contributes to the ongoing efforts to design meaningful and desired care robots in two ways. First, we flesh out understandings of good care based on situated practices and values of care workers. Second, grounded in our speculative vignettes, we exemplify potential tensions but also spaces of possibilities for robot-mediated care.

The article is structured as follows: first, we present related work on socially assistive robots in healthcare, and value sensitive design and speculative design approaches. Then, the methodology of field studies, data analysis, and the process of writing speculative vignettes are presented. In Section 4, we present the themes developed in our reflexive thematic analysis. This is followed by speculative vignettes and related discussions 5. We conclude with limitations of our approach and opportunities for future work.

2 Related work

2.1 Socially assistive robots in health and care

Robot platforms such as NAO, Pepper, Moxi, ROBEAR and others have been applied for tasks ranging from therapy to delivery services, patient lifting, disinfection, rehabilitation, (Kyrarini et al., 2021), for therapeutic assistence and engagement of people with dementia (Ghafurian et al., 2021), and as companions for exercising, games, playing music, or walking (Yuan et al., 2023). Acceptability of these technologies remains an open challenge, for instance due to replacement fears Kyrarini et al. (2021). Further reasons for limited success are the highly individual nature of (dementia) care (Ghafurian et al., 2021), or accessibility issues, additional burdens to care workers, and reduced caregivers' autonomy (Yuan et al., 2023).

To overcome outlined shortcomings, robot designers and developers are encouraged to become aware and directly implement the needs, expectations, resources and values of care workers and care recipients in design processes (Yuan et al., 2023). Participatory design approaches (Lee et al., 2017), and value sensitive design approaches (van Wynsberghe, 2013; Cheon and Su, 2016) considering the life-worlds of potential users in the design process are potential paths to achieve these sensitivities (Ghafurian et al., 2021).

2.2 Value sensitive design and care-centered value sensitive design

Value sensitive design is a methodology well established in Human-Computer Interaction aiming to consider people's values in the design of technologies. Part of the VSD methodology is to empirically investigate the values of stakeholders (van Wynsberghe, 2013; Friedman and Hendry, 2019) developed the care-centered framework (CCF) and care-centered value sensitive design (CCVSD) methodology to explicitly address the design of robotic technologies in consideration of values. The CCVSD methodology builds on an investigation of the components context, care practice, actors, type of robot, and four values of care (attentiveness, responsibility, competence, and reciprocity, based on a care ethics theory by (Tronto, 1993)). The author suggests a prospective application aiming *"[…] to illuminate the relationship between the technical content of a care robot and the resulting expression of care values within a care practice."* (van Wynsberghe, 2013, p. 410).

Despite being a widely acclaimed work, no empirical study following the CCVSD methodology exists to our knowledge. Related work either extended the CCVSD framework (e.g., by adding the dimension of touch (Grobbel et al., 2019)) or considered it in developing an alternative framework for healthcare technologies (e.g., (Poulsen and Burmeister, 2019; Jacobs, 2020)). Applied design processes of robotic technologies refer to it only as related work (e.g., (Casey et al., 2016)) but do not follow the proposed CCVSD methodology. A recent literature review (Yuan et al., 2023) draws on Tronto's ethics of care framework (Tronto, 1993) and the CCF framework (van Wynsberghe, 2013) to analyze qualitative data from user studies with humanoid robots in residential care. Yuan et al. (2023) outline design principles on the basis of the reviewed projects. In contrast to approaches that involve adding an additional reflective layer on top of principles that are already abstract, we argue that it is important for robot designers to have a rich understanding of the specific context under study.

To address this research gap, our work directly applied the CCVSD methodology in empirical field studies with stakeholders as an attempt to understand their lived and embodied experiences of values of care. As noted in the introduction, we position field studies as a phase of research-for-creation in the wider research-creation approach (Chapman and Sawchuk, 2012). Research-for-creation involves gathering materials to inspire generation. Gathering can take many shapes, including scientific research activities such as qualitative and ethnographic methods. In field studies (see Section 3.1, we have focused on the expression of the CCVSD components context, care practice, actors (care workers and care recipients), and values of care, and have developed semi-structured interviews and card workshops based on these components. Instead of following the care ethic's theory (Tronto, 1993) underlying the CCVSD, we adopt an inductive approach to gather values of good care from participants, acknowledging their lived experiences might differ from pre-conceptualized categories.

2.3 Speculative design approaches

As a second step to the research-creation approach, we have conducted a creation-for-research phase (Chapman and Sawchuk, 2012). Creation-as-research builds upon the inspirations gathered in research-for-creation phases–in our case the results from empirical studies following the CCVSD methodology–and follows a process of creative production aiming to communicate and reveal new forms of knowledge produced outcomes.

Methods from similar traditions are well established in HCI (Forlano and Halpern, 2023) and are starting to be more frequently used in HRI (Luria et al., 2021). According to Blythe (2014), design fictions can express novel perspectives or conflicts through speculation. The format remains ambiguous to solving the conflicts, while an emerging discussion of the fiction can lead to potential answers (Blythe, 2014).

Several studies in HRI have implemented speculative and fictional work as part of their inquiry (Auger, 2014; Cheon and Su, 2018; Dörrenbächer et al., 2020; Luria et al., 2020; Albers et al., 2022). Dörrenbächer et al. (2020) worked with student-created video design fictions of social robots as starting points for a secondary analysis. As an outcome, the authors discussed a variety of imagined application scenarios, social roles, and the benefits and challenges of social robots entering everyday life situations. Designing for informal care, Albers et al. (2022) initially interviewed informal caregivers and care recipients. Based on identified practices and a concept of "robotic superpowers", the researchers developed speculative video prototypes of robots as means to explore fictional everyday situations together with participants.

In an interview study with roboticists, (Cheon and Su, 2018), co-developed "fictional autobiographies" of robotic concepts. The aim was to elicit the values of participants from created narratives. (Auger, 2014). investigated why robotic technologies did not yet become part of everyday life. He argues that approaches such as speculative design can help developers to focus on the everyday lives of people and less on technology-driven solutions. Similar to these approaches, our application of speculative design is grounded in analysis of the care context (Albers et al., 2022), without aiming to provide technological design solutions (Blythe, 2014), but to initiate discussion about values in care (Cheon and Su, 2018) and think through the influence robots exert on these in everyday care (Auger, 2014).

3 Methodology and methods

We frame the activities and outcomes of our studies as a research-creation (Chapman and Sawchuk, 2012) practice. As research-for-creation we conducted field studies (ethnographic observations, interviews, workshops) to understand the everyday lived experiences, circumstances, and desires in care. Following the CCVSD methodology (van Wynsberghe, 2013) we aimed to understand embodied meanings of good care and how values structure everyday care practices. As a practice of creation-as-research (Chapman and Sawchuk, 2012) we have written a set of speculative vignettes. They function as a rhetorical tool to express context complexities and tensions arising when we introduce hypothetical robotic technologies in care situations.

We approach our work from a constructivist epistemological paradigm, employing qualitative methods. Knowledge from this standpoint is actively constructed and contingent of knower and the circumstances. As researchers, we are actively involved in the construction of knowledge and strive to produce more informed understandings of the world (Guba and Lincoln, 1994).

All research activities and the informed consent procedure were submitted to and peer-reviewed by the research ethics committee of one of the involved universities and the ethics committee of the care organization. All participants received and signed informed consent forms and data processing agreements prior to participation.

3.1 Field studies

The first step of our research process was divided in two phases. First, we conducted observations and interviews, which is a common approach in PD and VSD and useful to explore and understand the context a robot is designed for (Moharana et al., 2019; Ostrowski et al., 2021). In a second phase, we developed a card tool along the CCVSD methodology (van Wynsberghe, 2013) to discuss practices of good care and conducted three card workshops. We conducted six interviews with three care workers in the care home and three care workers in mobile care, and conducted 3 card workshops that each involved one care recipient (n = 3) and one care worker (n = 3). In total, 10 unique individuals participated in our study, since two care workers participated in both an interview and a card workshops.

To acknowledge the co-constructive nature of knowledge production in our approach, we provide accounts of positionality, or information on the participants and researchers involved in this study (Reich, 2021) to promote the transferability (Korstjens and Moser, 2017) of results. Studies took place in a mobile care context and a long-term care home in Austria, both services offered by our research partner institution. Card workshops were exclusively conducted in the care home due to organizational constraints. In Austria, mobile care involves delivering care services to individuals in their own homes, with care workers traveling between locations. In contrast, a long-term care home is an institution where residents permanently reside. As explained by our practice partners and participants, in mobile care a broader range of people receives care, while in care homes the main group of care recipients are older adults and people with dementia. Care in both contexts includes support for Activities of Daily Living (ADL) (Katz, 1983), such as wound care, medication administration, or bathing, as well as Instrumental Activities of Daily Living (IADL) (Katz, 1983), such as meal preparation and household tasks. In Austrian healthcare, care professionals are differentiated by their level of competences and responsibilities, based on the underlying training. Participants covered the whole range of care qualification levels: i) qualified nurse (Bachelor degree level); ii) qualified care assistant (2 years training), iii) care assistant (1 year training), and iv) home assistant (1 year training). In Austrian healthcare, large numbers of care workers have immigrated from another country. All participating CWs had an immigration history, mostly from countries Southeast Europe, which is representative for both care contexts.

The authors are a group of interdisciplinary researchers collaborating on a project of designing robotic technologies for good care in participatory design approaches. Our scientific backgrounds are varied and include Human-Computer Interaction, Human-Robot Interaction, Cognitive Sciences and Science and Technology Studies, Sociology, and Media Design, hence none of us has experience of directly working in healthcare contexts. We were aware of our unfamiliarity and foreignness to care contexts ahead of the empirical work, which reflected our choice to first develop a nuanced understanding of the practices, actors and values.

3.1.1 Observations and interviews

Seven observation rounds were conducted directly prior to the interviews by the first (3 observations; care home), third (1; care home), and fourth (3; mobile care) author. We accompanied 7 CWs on their working day, each for 4–8 h. Researchers followed an observer-as-participant (Flick, 2009) approach, as they were overt in the field but did not actively participate in the practices. Observers took field notes on actors, time, spaces, care practices, artifacts, and interactions. Based on immediately these notes, we wrote textual observation protocols, however, we did not analyze observation data. Our motivation to conduct observations was: a) To establish trust and familiarity between participants and interviewing researchers (6 of the CW participated in following interviews) and increase the likelihood of high information power (Malterud et al., 2016), b) to use observed situations of care as specific examples and discussion points in interviews, c) to gather concrete actors, spaces, and practices of care and adjust the card workshops to the actual circumstances of participants, d) to observe the procedure of care practices over a full day to inform the creation of varying speculative vignettes.

We conducted six semi-structured interviews (50–90 min) with CWs to explore their subjective understandings of good care. The interviews covered CWs' experiences, opinions, thoughts, and feelings of care workers regarding the challenges of providing good care. All interviews were audio recorded and transcribed. Participants were care workers working in mobile care (n = 3, all female) and a care home (n = 3, all female). Interviews were conducted in German, the primary language of the interviewers and the secondary or tertiary language of the interviewees.

3.1.2 Card workshops

Following the interviews, we noticed that CWs would often initially define good care as dependent on the person receiving care, and on the particular practice in question. Given this bi-directional, relational nature of care practices (Bjornsdottir, 2018) we recognized a need to discuss interpretations of good care with CRs and CWs together. For this purpose, we developed a card workshop method. Card workshops are a versatile method used in PD (e.g., (Beck et al., 2008)) and VSD (e.g., (Friedman and Hendry, 2012)) as they are an accessible material to facilitate stakeholder participation (Beck et al., 2008) and discussion on abstract issues related to places and practices (Schwaninger et al., 2021))such as good care. We operationalized the care-centred framework (van Wynsberghe, 2013) as a card tool to discuss good care with CWs and CRs. Given the scope of this paper, we do not offer a detailed description of the development and application of the card tool here.

We held three workshops at the care home where we had conducted our field studies, each lasting 57–78 min. Each workshop involved a CW and a CR. CWs (aged 24–55 years, all female) with varying levels of qualification participated. Two of them took part in the observations and interviews beforehand. Our practice partner facilitated recruitment of CRs (all above 65 years, all female) station leads consulted available Mini-Mental State Test (Folstein et al.,

1975) scores, for residents and their personal assessment, as the workshop was not designed to accommodate people with moderate or severe dementia.

3.2 Data analysis field studies

We performed a reflexive thematic analysis (RTA) according to guidelines by Braun and Clarke (2022) to analyze the data from the interviews and workshops. They emphasize that RTA aims to generate rich, contextualized meanings based on the researcher's deep, iterative, and interpretative engagement with the data (Braun and Clarke, 2022). With our goal to develop themes as everyday meanings of good care, RTA was a suitable method for data analysis.

The concept of information power as an indicator for the richness of a dataset guided the composition and size of our sample (Malterud et al., 2016; Braun and Clarke, 2022). We continuously reflected on our dataset and adjusted the data collection accordingly. We strove for a high specificity and variability (Malterud et al., 2016) in our sample to develop rich and diverse interpretations of good care. Our sample included seven unique CWs with varying professional expertise (assistant to leading positions; medical to social care foci) and experience (a few years to multiple decades) and 3 CRs with diverse reasons for being in care (sarcopenia, terminal illness and depression, and stroke-induced hemiplegia). Given the composition of our sample, however, we acknowledge that the interpretations of good care developed in our analysis capture primarily CWs' perspectives. Additionally, after each workshop and interview, we reflected on the quality of dialogues and observed a relaxed atmosphere between researchers and participants, participants as open to talk about sensitive and personal aspects of care and comfortable to be challenged about these notions. Our reflections indicated a high quality of dialogue, which is an indicator for high information power, and thus justifies a smaller sample (Malterud et al., 2016).

The first author performed the RTA in regular conversations with the other authors. Particularly, the first and second authors had daily calls throughout the process of analysis to reflect on the progress, discuss challenges and reflect on the developed codes. Following Braun and Clarke (2022), a first step involved familiarization with the data, which the first author did by marking relevant sections in transcripts while listening to audio recordings in MAXQDA[1]. In the second step, the first author revisited marked sections and iteratively coded them. The analytic focus of the coding was on how participants constructed interpretations of good care, and which aspects were involved in these interpretations. After multiple rounds of coding, he examined codes with a larger number of instances for granularity of meanings and split them into multiple new codes if necessary. The first author presented these later versions of codes and underlying data extracts to all authors towards the end of the coding process. The first author developed multiple versions of themes during these discussions, which were drawn in a paper notebook. Clusters of codes were then replicated on an online whiteboard. By revisiting the codes and data extracts, the first author developed organizing concepts for the themes and explored the structure of and relationship between themes by creating multiple versions of slightly altered clusters of codes. A final theme had to be organized around one single coherent concept of good care of considerable depth and diversity, and simultaneously be distinctive from other themes. We wrote up our final themes based on the clustered codes, and searched and added illustrative transcript excerpts. We translated excerpts from German to English, with attention to making as few edits as possible for readability while staying true to the intended meaning of participants.

3.3 Speculative vignettes

The second part of our study resembles a practice of creation-as-research (Chapman and Sawchuk, 2012). Our goal was to create formats of design fiction, opening a space for discourse and consideration without proposing design solutions (Blythe, 2014) in response to RQ2 (""What should we consider in the design of robots based on identified meanings of good care?"). With this, we mean that our paper mainly contributes to HRI research by opening the discourse around the introduction of robotic technologies in care. By placing a hypothetical, yet not impossible, robot in such moments, and articulating the possible consequences on care values and tensions, we contribute to the questions what we should consider when introducing robotic technologies. To this end, we collaboratively developed six speculative vignettes addressing some of the tensions that surfaced in our analysis.

Primarily used in sociological and anthropological research, vignettes have two applications. First, as representing a snapshot of lived experiences gathered in field studies. Second, as a short fictional scenario introducing characters and situations to elicit responses from participants (Spalding and Phillips, 2007; Jenkins et al., 2016). As a speculative format, they can explore how everyday conditions might be affected by introduction of technologies (Frauenberger, 2021). We identified vignettes as a promising format for design fictions articulating speculative scenarios of robotic technologies in care based on actual field study data.

All authors were involved in drafting or iterating these vignettes. We followed a step-by-step guide for generating vignettes, starting with reading the themes of our RTA. As part of our field studies, the first, third, and fourth author have conducted observer-as-participant observations (Flick, 2009) in both care contexts. Observation notes were made available to all authors in the vignette creation process. This ensured vignettes would consider sensitivities to the practices, procedures and actors in care situations, crafting scenes close to those in real-life. Following reading themes and observation notes, each author chose one robotic concept from a selection conceived at an internal brainstorming workshop. Authors first individually wrote vignettes, which were later refined in a collaborative and iterative writing process, ensuring that illustrated scenarios and envisioned technologies remained open for interpretation and expressed a tension observed in our analysis. The first author made final edits, such as placing all vignettes in the course of a day in a care home, given he was most familiar with this context, and to aid the reader in imagining the vignette scenarios through recurring locations and actors.

1 Version 2022.0.0, https://www.maxqda.com/products/maxqda

TABLE 1 Overview of themes and organizing concepts.

	Theme	Summary
(1)	*Building a Trustful Care Relationship through Time and Routines*	Trusted care relations are built in processes considerate of time and consistency in care routines
(2)	*Negotiations of Care between Care Stakeholders*	Ongoing negotiations of care stakeholders (CWs, CRs, relatives) shape the performance of care practices and require balancing of multiple perspectives what good care entails
(3)	*Emotional Care and Reciprocity*	Performing care practices well involves creating spaces for CRs to express physical and emotional vulnerabilities. CWs in turn draw emotional validation from attending to these vulnerabilities
(4)	*Self-Care of Care Workers*	In order to provide good care, CWs work in self-caring practices and attitudes
(5)	*Socio-Material Mediation of Care*	The socio-material circumstances of care mediate performance of good care, illustrated in information exchanges, care planning and lifting practices

4 Results

In response to RQ1, we present five themes as results of our RTA process. In Table 1 we provide an overview of the themes with the corresponding core organizing concepts.

4.1 Theme 1: Building a trustful care relationship through time and routines

The first theme is organized around the processes of building a care worker-care recipient relationship. Two facets illustrate how a trusted care relation is established through the performance of a consistent care routine, with consideration of the time required to build routines and relations.

4.1.1 Consistent care routines and relations

The consistent execution and collaborative development of care routines are crucial for providing good care, as they foster trust and familiarity. Ideally, the CR-CW relation is maintained by having only a small group of care workers performing care with a group of care recipients. Both CW and CR can form expectations for the performance of care. *"Well, we are doing patient-centered nursing, that is, we try as much as possible that the same care workers always go to the same clients, so their relationship is better established." (Mobile Care Worker 1 = MCW1)* This is especially important for people with dementia. Any disruption in established routines or unfamiliarity with a CW could cause confusion and resistance against performing care practices. *"Especially with clients with dementia, patient-centered care would be important, where you know the processes are in place." (MCW2)*.

In essence, a consistent care worker-care recipient relationship and repeated performance of a routine transforms the whole care process from initial novelty into one characterized by familiarity, supporting the expectations and trust of CR in CW. *"And then they are happy when I come, because they already know me. And then I also do not have to always repeat, you do that, you do that. Because they already know and they trust us." (Care Home Care Worker 1 = CHCW1)* Consistency eliminates the need for a continuous explanation of the practices, which CWs in turn, interpreted as signs of trust and familiarity. A CR supported that familiarity with CWs and experiences of consistent, proficient, and repeated performance of care practices reduces their fear and, in this sense, expresses a form of trust. *"Actually, my fear is taken away, when I see there is a care worker and another one, anyway two that I know and I know I can rely on them." (Care Recipient 1 = CR1)*.

4.1.2 Taking time to build routines and relations

Particularly in unfamiliar care circumstances, developing care routines requires time. Time is needed to allow for a collaborative development of routines involving identification of and adaption to preferences and habits of CRs. For instance, this might involve performing the same care routine at a specific time each morning. *"Customers are accustomed every day, almost at the same time, that someone comes, washes her, dresses her, prepares breakfast, prepares medication." (MCW1)* CWs acknowledged making only minor changes at first to ease the transition into new routines and being understanding of the time it takes for a CR to become used to them. As indicated in the first facet, new routines but also new CW-CR relations require a period of acclimatization. *"Time plays the big role, yes. To learn how to interact with the person. They also learn (to interact) with us." (CHCW2) "I am there more often. She (the CR) probably will not find it so difficult when she cannot do it anymore and we decide I will wash her back or something. Doing the little things first. And when (a) completely new (CW) comes people need a settling-in period." (MCW2)* As the care routine slowly becomes established through small changes, the interpersonal space and trust between CW and CR start to grow, allowing for conducting increasingly intimate physical care practices and more emotional care, as will be explored in theme 3. *"She knows me, so it probably will not be so difficult if she cannot do what she can now. Where I then said, well, I can wash your back or so. First allowing little things. And when someone completely new [comes] the people need a period of acclimatization." (MCW2)*.

It is essential to mention that continuity in care relations, consistent routines, time for routine development, and building trust through routines are interconnected, forming a holistic process in developing care relationships.

4.2 Theme 2: Negotiations of care between care stakeholders

Our second theme delves into the collective nature of shaping care. Our data included the ongoing negotiations of CWs, CRs, and relatives shaping the specific performance of care practices. While other actors undoubtedly contribute to these negotiations, our reporting focuses on negotiations between CWs and CRs, and CWs and relatives.

4.2.1 Care worker - Care recipient negotiations

In the first facet, we report aspects of the negotiations between CWs and CRs. The interplay between the autonomy and independence of CRs and the imperative for CWs to nurture their wellbeing requires a delicate balance. One way of CWs to preserve the independence is by sustaining their existing abilities without further diminishing them. To illustrate, in mobile care this could entail dividing household tasks in a manner that accommodates a CR's capabilities on a given day. They may participate in washing the dishes, drying them, or doing both, or walking as far as they are able and being pushed in a wheelchair for the remaining distance. As the capabilities and preferences of CRs change over time, the distribution of participation requires continued and repeated negotiation.

The autonomy of CRs extends beyond deciding the performance of physical activities, as it encompasses a general freedom of choice. CWs expressed a commitment to acknowledging the wishes of CRs and the individuality coloring these preferences, as illustrated in an extract on the duration of staying in the garden for tea time: *"Some people do not want to stay out that long. But that's also something. Fifteen minutes, half an hour. It's very individual. Everybody is different." (CHCW3)*.

In this sense, eliciting articulations of immediate needs was pivotal in practices. CWs reported constantly addressing CRs to express their needs, preferences, or choices. Conversely, CRs highly value the capacity to make choices and have them respected by CWs. *"You know what is very good? The care workers come and if I do not have pain I go with them (to the garden) and if I have pain I stay in my room. And that's okay. They say it is good, it is okay. And I think it is right that you're not forced to come along." (CHCW3)*.

Challenges arise when CRs lose the ability to effectively express themselves, such as in advanced stages of dementia. CWs face difficulties in interpreting observations instead of relying on verbal expressions. This can introduce tensions, as the interpretations may be inaccurate. In such situations, a close relationship, a deep understanding and collaboratively established routines become valuable for providing good care along (assumed) preferences of CRs. *"We do not know anything about the residents and then we do what we suspect is best, but maybe that is not right." (CHCW1) "If I know who likes what, and who dislikes what, then it is easier. If not, then I have to guess. And that all comes from experience, from that you get to know the people." (CHCW2)*.

CWs work from a care plan that prescribes the care practices that should be performed for a CR. Another tension arises when there is a mismatch between the preferences of CRs and CWs' aspiration to perform "all" care practices of the plan. *"And it is important to me that I do all my professional, caring measures. That they get the treatment which meets all their needs. I'm happy when I get my work done. From A to Z, yes." (CHCW2)* CWs perceived it was their responsibility to balance caring according to the care plan while continuing to consider the autonomy of CRs in making choices for their care. Finding this balance becomes increasingly difficult if CRs cannot express themselves directly, and it becomes unclear what their choices are. One approach to handle such situations was for CWs to motivate CRs for a care practice, even if it might contradict their initial expression of preference, such as in the following excerpt referring to a person with dementia who refused to eat. *"And she says: Well, I do not want to eat. You can motivate. Try at least a spoon or two, or at least something to drink." (MCW3)*.

4.2.2 Care worker negotiations with relatives

The second facet of this theme related to the dynamics and tensions between CWs and relatives of CRs. On the one hand, CWs build and maintain relationships with relatives, especially those living with CRs in mobile care. Care includes the needs of relatives, such as temporary relief from the burdens of care, or offering emotionally loaded care, such as end-of-life care. When CRs cannot express themselves, relatives become a crucial and often only source of information. *"If the resident is in a palliative stage, then we as care staff - we also care for relatives, so they help us at the beginning and then we help them." (CHCW4)*.

On the other hand, reliance on relatives can lead to ambiguities in performing good care, for example, when relatives lack up-to-date knowledge of the CR's (current) preferences, habits, and needs or project their assumptions on the CR's situation. Not only are the voices of CRs diminished in such moments, but CWs find their approaches to care challenged. Relatives set unattainable expectations of the quality, immediacy, availability, and "correct" care performance. CWs must navigate these circumstances by working from their expertise and capacities while prioritizing the needs of CRs and, simultaneously, avoiding conflicts with relatives that could threaten their care partnership. *"Often the ideas of the relatives, are different, to what the client wants." (MCW2)* One example of a CW navigating their available capacities with the unattainable expectations of relatives is illustrated in the following excerpt. *"I'm trying to change something. If several times it is not okay, then it is no longer my problem. I can not do it on the millimeter, it is not possible in care to make everything perfect. If they complain I try to talk back nice. (I tell them) I will try to change it." (CHCW4)* The CW initially showed readiness to adapt the care practice according to the suggestions of relatives but would stop with repeated and increasingly meticulous demands. Despite a lack of understanding of the CWs' capacities, CWs remained amicable to avoid strains in the care partnership.

4.3 Theme 3: Emotional care and reciprocity

The third theme depicts how performing care practices involves creating space for and attending to the physical and emotional vulnerability of CRs and how CWs draw emotional validation from attending to these vulnerabilities in acts of reciprocity.

4.3.1 Opening spaces to allow vulnerabilities in care

In developing a trusting, routine-based relationship (as discussed in theme 1), more spaces for disclosure of vulnerabilities open up. In an illustrative example, a CW described how a CR would only accept one particular CW for wound care. *"Then we have a customer, where only I go. Because she just has the trust in me. She's ashamed of the wound that she has. And she does not want a change of staff." (MCW1)* This example illustrates an (accelerated) process of building a trusted relationship through a care routine, which allowed the CR to accept and CWs to attend to their vulnerabilities. Further, the example reveals an interconnectedness of attending to bodily and emotional care.

In the example above, emotional vulnerabilities are cared for implicitly as part of a bodily care practice. However, at other times, CWs explicitly address the emotional care needs of CRs. This may involve actively inquiring about the emotional wellbeing of CRs and fostering opportunities for them to share their feelings as part of their trusted relationship. Many CRs would rarely have the chance to do so, e.g., due to reduced social contacts, and would take the opportunity to discuss sensitive concerns such as end-of-life thoughts or feelings of depression. *"She was really sad and when I was there, but usually she always tries to be cheerful. And then I asked her, 'What's wrong with you today, tell me.' And then I gave her time and asked, do you want to talk about it. And then she said but what I tell you, please keep it between us." (MCW3*).

Directly inquiring about emotions was viewed as a unique care practice, a pivotal opportunity to build and strengthen care relationships. In these one-on-one conversations, care workers function as listeners and active participants, offering personal advice and emotional support. Despite their significance, these practices are often undervalued in care planning and discussions about quality care, according to CWs.

Engaging in such practices allowed CWs to develop a heightened ability to recognize and interpret expressions (speech, gestures, mimic) as signifiers in care interactions. This becomes important again for CRs who may have limited or impaired verbal communication, such as people with dementia. *"Some tell you, but some do not. For some it is not clear what they want. We can not understand, but we must watch closely. And after a longer time we know better what they want and what they do not want. How is the facial expression, you can also know from that." (CHCW1*).

Through interactions depicted above, closer bonds develop between particular CRs and CWs, often ending in CRs favoring certain CWs. The factors influencing these preferences are unclear, with CWs attributing them to a distinct interpersonal chemistry. *"And there is always one person who the resident fixates on. And that does not mean that others cannot do the care. But just that this person has the most trust from the resident." (CHCW2*).

4.3.2 Care workers experiencing emotional reciprocity

While the first facet of the theme was centered on the emotional experiences of CRs and how CWs attend to them, the second facet concerns what CWs experience regarding emotions, support, gratitude, and fulfillment for their care efforts. Care workers described emotional capabilities as a central quality of their professional role, most often depicted as having an open heart and working from a stance of compassion. As illustrated in the following extract, working from compassion allows CWs to help other people, starting with identifying and understanding care needs. *"You need to have a heart in this profession. Heart, patience, love, being there. We do not work just for money. We help and support other people as much as we can." (MCW3*).

On the one hand, CWs reported experiencing increasing the wellbeing of CRs as a form of validation for themselves. *"And that makes me really happy when I can help, when I can do everything well then I go home with a good feeling. The resident is satisfied, we are satisfied and then everything is fine." (CHCW2)* On the other hand, perceiving the thankfulness of CRs and their relatives was another confirmation that CWs are performing care well. *"A certain gratitude helps me to I realize through my work I can actually make people happier." (MCW2)* We can identify a reciprocal quality of good care in that the act of providing care itself is valuable, but what CWs receive back in terms of emotional validation from CR is a contribution to a picture of good care. Overall, responsiveness to the correct performance of care was essential for CWs to perceive work satisfaction and self-identification with their profession.

The responsiveness from CRs to the care practice has a dual function for CWs. On the one hand, it confirms to CWs the 'correct' (in the sense of fulfilling needs and increasing wellbeing) execution of care practices. On the other hand, receiving confirmation for a central aspect of their professional identity positively contributes to the self-identification of CWs with their profession, and confirms their choice of profession. *"That gives me the confirmation that I'm doing the right thing that I'm trained for and that I'm in the right profession. It gives me pleasure, yes. Yes, when someone confirms that you're doing well, it is a great joy." (CHCW2*).

4.4 Theme 4: Self-care of care workers

While the first themes deal with the relational, collaborative and reciprocal elements of care, the fourth theme concerns an intra-personal dimension of good care. CWs described a number of practices and attitudes that we subsume under the notion of self-care. They report performing self-care practices as a means to provide good care for others.

In general, practices of self-care concern finding a balance between the responsibility of caregiving and related physical and emotional burdens and the responsibility for one's own health and wellbeing. Care workers expressed awareness that qualitative care is only possible when they care for themselves. *"Trying to do a lot for yourself, take time for yourself. So that we have more energy, because for this profession you really need a lot of [mental/emotional] strength." (CHCW3*).

Some self-care practices pertain to the direct performance of care: taking time, working with patience, and being in the present moment. On the one hand, being present in the moment was aligned with a self-image of good care and providing care according to the expectations of good care. *"For me it is really important that I have time for a customer, I'm present with the customer. This time belongs to them. They pay for it and I do not have to be mentally somewhere else." (MCW3) "If you take time it is great for you and it is also great for residents." (CHCW1)* CRs reported sensing when a CW was working under time pressure, connecting to elements of responsiveness and reciprocity, and pointing to the importance of having and taking time as a CW to perform good care. *"I can sense when a staff member is stressed, because then they're quick. Then I know, then I already say, ah today you have a lot to do again." (CR2)*.

Certainly, in the face of staff shortages and underfunding of care services, working with patience is not always possible. Nonetheless, CWs indicated they own a share in ensuring they work from a stance of patience. *"If I do not have patience, if I'm constantly stressed, I'd better go and find something else (to work)." (CHCW3)*.

Another facet of care worker self-care concerns a separation of private life and professional life. While affective care, as presented in the third theme, involved CWs establishing spaces of vulnerabilities for CRs, CWs, on purpose, withdraw their personal vulnerabilities from such spaces. Therefore, care is not fully reciprocal, as it embodies an inherently asymmetric relationship in which CWs do not expect care for their vulnerabilities. From a point of view, this can even be desirable for CWs, as it allows them to find distance to their personal burdens. *"Most of the time I come to work without thinking of my problems. Although I have a thousand problems outside I come here and everything is gone." (CHCW4)*.

CWs simultaneously created a boundary between professional concerns and their private life. This separation involved ending the sense of responsibility at the end of the working shift. As highlighted in the following excerpt, mastering this self-care measure is a professional competence that requires practice. *"I have somehow managed, when I go home, I just leave everything. I am completely somewhere else and I never call and ask what happened. Only when I'm [at the care home], I get all the information, but I do not take that home. It is easy to say and everybody thinks that's so easy, but it is very hard to accomplish." (CHCW3)* Our data only provided a narrative account of these practices, leaving us to speculate on how far the separation of private and professional life succeeded.

Last, self-care practices involve setting boundaries within the care work. CWs would reflect on their capacities and capabilities and refrain from performing care beyond these self-established boundaries. *"For me, I actually have my (…) limits. So I'm not the one who (…) does a lot beyond my limits." (MCW2)*.

Moreover, communicational boundaries for CRs aimed to maintain the CWs' emotional/mental wellbeing. Care workers reported setting boundaries for CRs regarding communication style, for example, not accepting being sworn at. *"Even if we have screaming or hysterical clients now. I say in a calm tone, please, voice down. I will not let them yell at me otherwise I'll terminate the visit." (MCW2)*.

4.5 Theme 5: Socio-material mediation of care

The final theme from our analysis makes the socio-materiality of care explicit, showing how materials-technologies, social structures, and care practices are mutually dependent and collectively contribute to a practice of good care. This became evident in three facets: information sharing, mediation of flexibility in caregiving, and safety-inducing materials for caring.

4.5.1 Information exchange and documentation

Regarding information exchange, CWs described several practices for sharing information with each other. Two main types can be differentiated into verbal communication and transmission via digital systems. Technologies actively contribute to the exchange of information. Particularly in mobile care, CWs would share information via phone calls or group chats. For example, when a CR received a device, CWs would share photos and instructions with their colleagues. *"When I come to a customer and I see that she has a new [device], then I take a photo, send it to everyone." (MCW3)*.

Care workers reported a stronger emphasis on verbal transmission of information for care homes. In each shift, one CW would be on "main duty", and collect all care-relevant information from other care workers in intermediary exchanges. *"The person on main duty must always be informed." (CHCW1)* Verbal transmission was an immediate practice and relevant during shifts and at shift handovers. On the other hand, written reports were relevant as a legal obligation and from a future-oriented perspective. *"If you have not much time or someone forgets … then when you come back after a few days, you cannot remember. That's why it is important to always document." (CHCW2)* CWs need to make informed predictions and decisions anticipating potential future needs of care. This can include end-of-life care considerations or transitions between care contexts; hence, documenting this type of information in long-lasting storage, such as a care documentation system, has become important. *"Medical activities like life-prolonging measures such as resuscitation or artificial nutrition. Everything is written down so you can stick to it." (MCW1)*.

4.5.2 Mediating flexibility of providing care

A second facet addresses how a digital time recording application mediates the flexibility of work practices. Writing documentation, including time recording of care visits, is a legal responsibility and is thus considered part of working hours. In mobile care, a digital time-keeping application is in use. In the following excerpt, a CW refers to a moment when they ended the care visit in the application before actually ending the visit. They continued to write the documentation as part of their travel time. *"But I still had the documentation to do. So I finished the visit [in the time recording application] but I continued. Because I did not want to exceed. Because when I start another 5 minutes then 15 minutes are counted. The customer pays 15 min. And then I realized that I do not even need 2 minutes to finish. And these 2 minutes I write as travel time." (MCW3)*. Restrictions on time granularity and regulations for hourly fees drove the CW's decision. Billing occurred only in quarters of an hour. The mediation of the application becomes evident when we imagine a different form of calculation and recording of care visits. Care workers generally desired greater flexibility in care planning within mobile care beyond the constraints imposed by current scheduling and regulations. *"That's the disadvantage (…) I have 2 hours of visiting scheduled today. The weather is bad, so I would say I do half an hour today and tomorrow, when the weather is better, I'll add the time and we go for a walk. Now the program wants to know why my visit was ended early today. I have to write it, but the assignment will be billed for 2 hours still. Even if I'm only there for half an hour. And the next day the client has to pay extra."(MCW2)* Care workers reported feeling restricted in adapting the care planning to the immediate needs of CR and the daily circumstances, which stands in contrast with the desire to adapt care to the immediate needs of CR as reported in theme 2.

4.5.3 Feeling safe through use of material infrastructure

The final facet of theme five revolves around care materials contributing to feeling safe while performing a care practice. For CWs in both care contexts two material infrastructures - hospital beds and semi-automatic lifting devices - contributed to their perception of performing care practices in safe manner. In mobile care, hospital beds (which are not available at every CR) allow CWs to work from health-sustaining ergonomic positions. *"Everyone should have a hospital bed. There are some people who do not have a hospital bed and some things are extremely strenuous, for example, when someone sleeps on the sofa. Imagine you have to do care there, bending down and so on. Your back will be worn out." (MCW3)*.

In a similar fashion, a lifting device was regarded as a contribution to a safe performance of lifting in the care home. Moreover, it would enable performance of a care practice, such as lifting a heavier person out of bed, in the first place. *"We're lucky that we have a lifter at all, because without a lifter they (the CRs) can hurt themselves and we can hurt ourselves too. And you always have to mobilize when you are at work." (CHCW4) "This lifter is really good, because some CR are impossible to mobilize even with fifty people. We absolutely need this lifter." (CHCW2)* Both material infrastructures mediated essential care practices of lifting and turning. Having a technology mediate the practices to be safe and sustainable can be assumed to have a positive impact on the intention and perception of performing the practices.

5 Contributing design considerations through speculative vignettes

Contributing to RQ2 ("*What should we consider in the design of robots based on identified meanings of good care?*"), we present a collection of speculative vignettes as design fictions. The vignettes describe situations in care with robotic technologies, to which we provide considerations situated in our developed themes. In this sense, considerations address potential tensions but also spaces of possibilities for robot-mediated care. All vignettes have been created (see Sec. 3.3 for methodological details) to unfold within a day in a care home, akin to one visited during our field studies. We have organized the vignettes based on a temporal structure to address varying everyday care situations in a care home. We interrupt the temporal sequence with discussions of considerations.

The robotic applications, while fictional, represent technical capabilities that are feasible. The vignettes present applications such as a (robotic) alarm clock, robots with conversational capabilities, delivery robots (e.g., (Law et al., 2021)), and stress monitoring (e.g., (Samson and Koh, 2020)), These applications are mentioned here to illustrate potential tensions that arise when combined with the understanding of care that has been developed in Sec. 4.

> Time: 06:15; Location: Mrs. M's room

> Like every day, at 06:15 the robot starts glowing in a smooth light simulating a gentle sunrise and waking Mrs. M up. When the robot detects Mrs. M is awake it sends signal to the care worker station. "A care worker will be with you shortly" the robot announces. "Who is it going to be? Maybe Nadine?" Mrs M responds hopefully. "Let me check..."

In theme 1, we identify the importance of collaboratively developing care routines. Thus, introducing robotic technologies in everyday care implies two considerations regarding routines. First, robotic technologies will enter existing routines and can influence the development of novel routines. In the vignette, a robot is waking a CR up. Here, the accuracy and predictability of technology–an inherent strength of technologies (Dörrenbächer et al., 2020)–could be used as an advantage in developing highly consistent routines, which was identified as a key characteristic of good routines in theme 1. Second, we need to consider the essential element of developing routines in that it allows CWs and CRs to establish and widen a trusted care relation. It is a design choice whether a robot facilitates the relation between a CW and CR, e.g., by sending message to the CW and by announcing to the CR a CW will shortly arrive, or if it does not.

A similar tension can arise regarding unique CW and CR relations, as articulated in theme 3. The CR in the vignette is asking for a specific CW. Indifferent from what the robot in the vignettes is doing in reaction to the CR's request, we can formulate a third consideration in that robotic technology could be designed to support or inhibit one-on-one relations between CWs and CRs. What the robot may do in response to the request can depend on a number of factors: work schedules, workforce capacities, preferences of other CRs and the preferences of the CWs.

> Time: 06:39; Location: Mrs. M's room

> "Can we perform a pain assessment routine for the arthritis in your fingers, Mrs. M? My care planning module indicates a new assessment is due today" comes from the robot just as Nadine and Mrs. M had finished the morning care. "Great timing" Nadine says to herself while thinking the opposite. She had already noticed the arthritis must have gotten worse, but she forgot the assessment was due today. The problem is, Mrs. M does not like to talk about it at all. Nadine can already notice the reaction in Mrs. M's facial expression. "You know what, let's skip the assessment today, shall we" Nadine quickly says. Visible relief sets in on Mrs. M's side. "But I think it would be good if we can do some exercises for your hands together, what do you say?" "Fine," comes back following a short moment of consideration from Mrs. M. Nadine skips the assessment, knowing very well it will reappear tomorrow, and searches for the arthritis relief exercises on the robot's interface.

In our second vignette, we can identify how a highly accurate robotic technology for routine facilitation (theme 1) could create tension in the care relation rather than support it. Additionally, the vignette illustrates how a partially autonomous robot would enter existing negotiations within care processes (theme 2). The robot in our example embodies qualities CWs had expressed - it elicits preferences and information of CRs and desires to perform all care practices (i.e., the pain assessment). However, bringing the pain assessment up despite the CRs personal preferences to not talk about it, raises tensions and creates a space of choices that might not have emerged without the robot. We can assume a CW with an established relation to the CR, such as in the vignette, would not have addressed a sensitive topic in the same manner. As it has emerged, the situation needs resolution. In a productive attempt, the CW in the vignette uses the robot as a counterpart and dismisses it to find an entry point to motivate the CR to perform a practice beneficial to their wellbeing (i.e., the exercises). Just as the CW had grasped agency to resolve the situation and shifted the tensions, other actors could act and shift the scenario. To summarize, when designing robotic technologies for care, one needs to consider the negotiating practices of care and how the role of the technology in these negotiations is always an active one.

> Time: 09:06; Location: Hallway

> Jelena, the intern of the care station, is picking up the dishes from breakfast. She moves from room to room while the autonomous service cart trails behind her, following every footsteps but lingering in the corridor whenever she enters a room. Then the thing happens again. Sometimes the cart would not wait in front of the room she had just entered, but move ahead to the next room. No one on the floor really knows why it's happening. They speculate it might be to make them work faster, but it's almost happening randomly. Anyway, Jelena doesn't like it when it does so. Another care worker told her to just turn the thing off every time she enters a room.

The third vignette touches upon matters of work process structuring (theme 5) and preferred working styles of CWs (theme 4). Our analysis shows that care infrastructures, including digital technologies, enter and mediate care processes (theme 5). In the case of the vignette, the cart exerts influence over the pace of collecting breakfast dishes. Contrary to a purely manual cart, the autonomous cart in the vignette actively dictates the CW to move through the rooms in a certain pattern, resembling the conditions around a time recording software described by our participants. Thus, one design consideration is to anticipate and assess the influence of robotic technologies over the organization of work processes in care.

In theme 4, we discussed how patience is integral to performing care practices. From this perspective, introducing a technology that sets a different pace to the routines may be negatively experienced by both caregivers and care receivers. Therefore, our second consideration emphasizes the importance of remaining attuned to particular ways in which technology "choreographs" (Coeckelbergh, 2020) and reshapes care routines, their content, and their temporalities. When this is not considered, it risks resulting in non-use, sabotage and/or altered subjective experiences of care practices that may counter the values and expectations of good care.

> Time: 12:31; Location: Duty Room

> Nadine takes a deep breath as she walks into the duty room. It's the first break of the day, and the first moment she has to think about the fight she had with her partner the day before. The robotic unit on care worker "self-care" support has already detected an unusual stress level via sentiment analysis and biofeedback data during her working shift. At the same time as it processes whether to initiate a routine check-in dialogue in the back-end, a tear trickles down Nadine's face.

As a second facet of self-care, we have identified CWs engaging in practices of separation between work and private life (theme 4). In principle, insights regarding self-care are valuable and can lead to increased attention to support the wellbeing of those providing care to sustain good care overall. In the vignette, a robotic technology performs assessments to detect harmful stress levels in CWs, which could be one role for a robot derived from calls for CW self-care support. However, as illustrated in our themes, self-care can mean pausing private problems during working hours. The robot in the vignette could break this barrier if it initiates the 'check-in dialogue' and augments the fractures in the CW's attempt of self-caring separation as much as it could be positioned as an emotional outlet without stigmatization based on the content (Breazeal, 2011). Therefore, in case robots enter practices of CW self-care, we have to consider CWs' existing practices, desired constitution, and nuanced individual choices in relation to them.

> Time: 16:18; Location: Mr. G's room

> As usually in the afternoon, Mr. G is sitting at the table in his room, waiting for tea to be served. For a few weeks these new carts have been serving it. On the minute, the cart enters Mr. G's room. "Good afternoon Mr. G, today I bring you herbal tea and a brioche" the cart announces as every day. "Ah, brioche" "Do you like brioche? For any particular reason?" the cart goes on unexpectedly for Mr. G, as it detects another answer than just a "thank you".

In the above vignette, a scene from an ongoing process of relationship building between a CR and the robot can be observed. We draw connections to theme one and how developing care routines and relations requires sufficient time and incremental expansions of interpersonal spaces. In the vignette, the cart has been serving tea for "a few weeks", but to the surprise of the CR, it asks him a follow-up question. We can imagine Mr. G's bewilderment if the cart had been doing so the first time it had ever served tea autonomously. However, we are left to speculate how Mr. G reacts to the cart, given that it has never interacted further with him. We emphasize developing and introducing robotic technologies to care contexts in incremental and relationally sensitive manners. We may deal with a concept similar to the novelty effect (e.g., Smedegaard, 2019; Fraune et al., 2022). Instead of developing a solution that faces an initial surge of interaction before a sharp decline, developing relations with robotic technologies may benefit from slowly but steadily increasing the complexity of interactions and thereby lead to more sustainable use.

Furthermore, the vignette leaves unanswered whether the CR even wants to interact with a cart beyond having tea delivered. Technological capabilities should not impose requirements to use them, i.e., just because the cart can hold dialogue does not mean the CR has to engage in it. We formulate this design consideration in line with theme 2, expressing the importance of eliciting and following CRs preferences to the performance of care practices.

Assuming they would engage in a practice eliciting personal information from CRs, we should consider how CWs can benefit from such interactions. As theme five pointed out, information exchange and documentation are performed in varying practices, with an essential point being that relevant information for care is made available to care stakeholders across time. Therefore, in designing robotic technologies with capabilities to engage, record, and process conversations with CRs, we should consider if and how this information can be curated for CWs. Moreover, we should consider the autonomy of CRs in these instances, considering their say in which information is stored, who might have access to it, and what should not be documented.

> Time: 20:52; Location: Duty Room

> “The biography sheet suggests it is Mrs. O’s preferred bed time soon” the robot informs Maria. So she gets on the way to Mrs. O, the most recently admitted CR. O is living in a rather advanced stage of dementia. Unfortunately, that’s almost everything they really know about her. At night, she is often irritated, crying and wandering a lot. The CWs are still figuring out how the bed routine can be adapted to her needs. In that sense, the robot wasn’t too helpful as it just gave an average of what O’s children filled in via the digital biography sheet - and for preferred bedtime, they gave contradicting information.

In theme 2, we interpreted the interactions between CWs and relatives of CRs as another type of negotiation influencing specific performances of care practices. Like in the reporting, the vignette describes a situation in which information from relatives is sought after, as the CR cannot express certain information anymore. However, the contradicting nature of the information places doubt on what is accurate for the CR. Again, the robot enters these negotiations. This time, the technology computationally translates the information, amplifying some aspects (i.e., building the average) while reducing other dimensions (i.e., the contradiction). One of the suggested bedtimes might be preferable for Mrs. O. However, if the technology conceals it, it may take longer to identify which is the correct one. Again, we must pay consideration to the specific shapes a technology enters negotiations of care performances. Thinking along the lines of the unique capabilities of humans and robots and how they can be productively interweaved can be a useful approach for conceptualizing them (Dörrenbächer et al., 2020; Albers et al., 2022).

6 Limitations and future work

Our qualitative studies were conducted in Austrian care home and mobile care contexts. We acknowledge the diversity of care circumstances, actors and practices, and therefore cannot claim to represent all possible perceptions and interpretations of good care in Austria or elsewhere. What can be perceived as another limitation, is the number of participants (n = 10) in our study. We point out that the perspectives of CWs shaped our interpretations to a larger extent than the perspectives of CRs. This inclination was due to pragmatic considerations in recruitment and research capacity. However, working from a constructivist paradigm and employing qualitative methods is incompatible with claims to generalizability, but should be judged upon the transferability of results to other contexts. Facilitating conditions for transferability are a provision of contextualizing information and providing “thick descriptions” of qualitative findings (Korstjens and Moser, 2017). We argue that the 10 participants in total yielded a rich set of perspectives to draw from. They covered different positions (care workers, care recipients, care homes, mobile care) and were engaged in different ways (through interviews and card workshops). We have captured their tacit, embodied, and enacted understandings of good care in five densely described themes. We believe they are transferable with regard to the (good) care principles they bring forth and the tensions they highlight involved in the introduction of technologies into care context. That said, our own data collection and analysis could benefit from more diverse groups of participants, including more CWs of varying qualification levels and from different care contexts, and particularly including more CRs. For future work, we encourage robot designers and developers to construct a deep understanding of the particular and lived conditions under study. We hope our work can provide guidance and reference in developing understandings of good care through noticing similarities and differences to the values identified herein.

In this paper, there is limited consideration of technological capabilities, however, the focus of our work was on developing a better understanding of the care context and understandings of good care in Austria. We demonstrate the relevance of this better understanding of care to the development of robots by illustrating tensions that inevitably arise through speculative vignettes. Technological capabilities assumed in the vignettes are not infeasible, as evidenced through reference to comparable systems in development and deployment. The transferability of discussions of vignette scenarios to other care contexts lie not in the imagined systems, but in the relations between care actors, systems and care values.

Nonetheless, the exact technological components and functionalities of a system will exert influence on the effect of systems on inherent tensions of good care. Moreover, the perceptions, values and beliefs of stakeholders towards a robotic systems will shape the acceptance and use. Therefore, we point out two takeaways for further steps in developing concrete technological solutions. First, participants should be included in design processes to integrate their assumptions and values. A key area to successfully integrate robotic technologies in care is re-conceptualizing the role of stakeholders (Frennert and Östlund, 2014) and involving and empowering them to have a direct choice in design. Stakeholders in the present paper had the role of informants. In a next step, they could be invited to discuss researcher-created vignettes to express their concerns and opinions directly. Genuine formats of active participation in HRI have been called for (Lee et al., 2017; Weiss and Spiel, 2022) and have started to find their way into practice (e.g., Moharana et al., 2019; Ostrowski et al., 2021; Winkle et al., 2021) pointing to fruitful future studies.

Second, developing robotic solutions from the identified tensions and in participatory formats has to build bridges to available technological capabilities. We suggest future studies to understand the themes and tensions of good care as a guiding tool in developing solutions. Our practice of informed speculation through vignettes is transferable to other situations in which designers and developers build robots. Knowing the functional capabilities and intended use cases, developers can envision their concepts in informed, hypothetical scenarios, before making larger investments into prototypes. Thinking through the scenarios with an understanding of the values of stakeholders - either indirectly through qualitative accounts or directly in participatory formats, can illuminate promising and frictional pathways early on in the development process.

7 Conclusion

In conclusion, our study offers an approach to identify values and tensions in care contexts, and how technologies will enter these circumstances. We have conducted interviews and card workshops in a care home and a mobile care context to develop a reflexive thematic analysis. The results of our analysis contributed nuanced insights into the situated and embodied practices of care and the interpretations of good care and respective values. Our themes illustrate the importance of mutually developed care routines, balancing of ongoing negotiations between care stakeholders to performance of care, affective care spaces as possibilities to express and receive care for vulnerabilities, the reciprocal qualities CWs draw from caregiving, effective provision of care rooted in self-care of CWs, and the ongoing socio-material mediation of care performances. Furthermore, we developed six speculative vignettes as formats of design fiction. The strength of our work lies in discussing considerations and tensions that arise in developing and integrating robotic care technologies for care with developed themes.

We believe our work is valuable to a broader audience working on technological solutions to care contexts and other sensitive fields. Our contribution lies in illustrating how we can bridge the contextualized and situated understandings from field studies with considerations of the potential roles of robots as a first step of design. By prioritizing situated considerations over techno-solutionism–an approach that sees design as mere problem solving and optimization without regard for potential consequences when implemented in a context that is in fact more complex–our work can contribute to more nuanced and successful design approaches in Human-Robot Interaction. We are optimistic that our presented findings, considerations and approach can serve as starting points for future work aimed at developing novel roles for robotic technologies aligned with values of care.

Data availability statement

The datasets presented in this article are not readily available because of the sensitive nature of our research context and agreements with participants. Requests to access the datasets should be directed to RV, ralf.vetter@plus.ac.at.

Ethics statement

The studies involving humans were approved by TU Wien Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RV: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing–original draft, Writing–review and editing. AD: Conceptualization, Methodology, Writing–review and editing. HF: Conceptualization, Data curation, Methodology, Project administration, Writing–review and editing. LV: Data curation, Investigation, Methodology, Writing–review and editing. KB: Writing–review and editing. CF: Funding acquisition, Methodology, Supervision, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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