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Examining Social Robot Acceptability for Older Adults and People with Dementia

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Abstract

Social robots that aim to support the independence and wellbeing of older adults and people with dementia are being introduced into dementia care settings. However, the acceptability of robots varies greatly between people and the rate that robots are deployed into practice is currently low. This chapter defines robot acceptability and provides an overview of theoretical technology acceptance models. It reviews the empirical literature and identifies the individual and contextual factors that impact acceptability in relation to the needs of older adults and people with dementia, focusing on what potential robot users need to motivate them to accept robots into their everyday lives. Then the literature is discussed in the light of current discourses in gerontology, recommending what is needed to increase the acceptability of robots. The capacity of robots, to communicate in a human-like way needs to increase and robots need to be designed with in-depth end-user collaboration, to be person-centred and deployed in ways that enhance the strengths of people with dementia. Guidance for good practice in participatory design is provided. Longitudinal research that uses triangulated data from multiple sources, is recommended to identify the needs of individuals, significant others, and wider contextual factors.

Keywords: Social Robots, Acceptability, Dementia, Alzheimer's Disease, Assistive Technology

1. Introduction

Dementia is a progressive neurological syndrome that causes cognitive degeneration, memory loss, alterations in personality and mood, difficulty performing everyday tasks and communication challenges [1]. As more people live into old age it is anticipated that worldwide, dementia will affect 66 million people by 2030 and 115 million by 2050 [2].

Social robots are artificial intelligence systems that are equipped with social and communicative abilities [3]. They differ from other robots as they are designed to interact using the social rules of human behaviour [4]. Technologies have been identified as key enablers for policies that aim to support aging in place and the sustainability of welfare states [5]. Currently, social robots are being designed to support the resilience [6] and independence of people with dementia and older adults (OA). They are also being developed to supplement the care that people with dementia receive from human caregivers, as diversion therapy and entertainment [7], to reduce loneliness [8], and to perform cognitive screening tests [9].

Some OA and people with dementia positively evaluate using robots [6, 8, 10]. But a recent review involving $n = 90$ research studies found that the deployment of current assistive robots into healthcare practice is low [11]. Technology acceptance is an important predictor of the usage and adoption of technology [12].

Acceptance has been defined as the robot being willingly incorporated into the older person's life [13]. Robot acceptance is impacted by multiple interacting factors, that concern the individual, significant others, and wider society [14]. But the factors that impact robot acceptability need to be understood in more depth because individual people and groups greatly differ regarding how acceptable they find robots [15, 16]. A recent literature review that included studies investigating robots ($n = 4$) found there was low acceptance of robotic technologies amongst OA and people with cognitive impairment and their caregivers [17]. Korblet [18] also found that the acceptance of a mobile telepresence robot in a nursing home setting was lower in people with dementia ($n = 5$) than in people who visited the nursing home centre weekly ($n = 3$) and a third who had physical disabilities ($n = 3$).

This chapter provides an overview of the state of the art regarding technology acceptance theory and the empirical research on robot acceptance that involves OA and people with dementia. It also examines what is likely to increase the acceptability of robots in this context. The chapter proceeds in the following sequence. Firstly, the definition of robot acceptability is discussed and phases in technology acceptance are introduced in relation to robots as a new technology genre. It is highlighted that social robots have different features in comparison to traditional technologies. These differences affect their acceptance and how acceptance needs to be conceptualised and investigated in practice. Secondly, examples of models of technology acceptance are presented and discussed in relation to their adequacy to explain and predict the acceptance of robots in the concept of OA and people with dementia. Then, empirical research is described that has examined the acceptance factors that are important for OA and people with dementia. The final section of the chapter focuses on what is likely to increase the acceptability of robots for OA and people with dementia and recommendations are made for the future design, development, and deployment of social robots. This final section introduces the concept of collaborative robots and it draws on research findings and literature that describes current discourses in gerontology and policy recommendations.

2. Examining the acceptability of robots for older adults and people with dementia

2.1 What is robot acceptability?

2.1.1 Definitions of technology acceptability

Definitions of technology acceptability vary and they establish acceptance in relation to other concepts like technology usability, adherence, and adoption. It can be defined as the intention to use technology [17]. Such a definition regards the actual usage of the technology as occurring after acceptance. Other definitions, for example, Heerink et al. [19], regard acceptance as including usage of the technology over a long period. Technology acceptance is regarded as a process [20] in which the user is involved in ongoing evaluation and re-evaluation of the technology and their decision whether to adopt the technology [4]. Ongoing decision-making is informed by information and experiences that approve discontinuance of use or confirm the initial decision to use the technology. Cruz [20] defines technology acceptance as a process and argues that acceptance only occurs when a technology

Phase	Key Features
Expectation	Before using, initial opinion for various information sources.
Confrontation	Re-evaluate ideas due to trying out or observing others for the first time.
Adoption	Initial serious user experiences
Adaptation	After 1 month, using according to personal needs and preferences.
Integration	After 2 months, meaningfully integrated and no longer noticed in everyday life.
Identification	After 6 months, is an expression of lifestyle or a group.

Table 1.
The Phases of Technology Acceptance (Adapted from de Graaf [4]).

sufficiently satisfies all the needs and requirements of its users. The concept of technology adoption has been distinguished from acceptance. De Graaf [4], who writes from the perspective of social robots for usage in the domestic home environment, defines adoption as being the initial decision to buy and start using the technology. The process of technology acceptance has six phases [4] that start with an individual becoming aware of a technology and end with the incorporation of that technology into everyday life to the extent that its functional purpose is exceeded and the individual becomes attached to it. These phases are summarised in **Table 1**) and described below.

2.1.2 Phases of technology acceptance

The expectation phase occurs when users form an initial opinion about a technology and an expectation about it. This opinion is formed by information they receive from the media, other people, and information they might seek out wanting to know more about the technology. When users try out or observe others encountering a technology for the first time, they enter the confrontation phase. Being exposed directly to the technology may cause the user to re-evaluate and adjust their expectations. The user enters the adoption phase when they use technology in a private environment and gain their first serious user experiences. This is followed by the adaptation phase when, after approximately a month, users have a broad idea of what the technology is about and they have encountered its flaws and features. As a result of exploring its features, users adapt the technology and use it according to their personal needs. Approximately two months after confrontation, during the integration phase, the technology becomes meaningfully integrated into the user's life, to the extent that it is not noticed by them and it has been personalised to their preferences. The final acceptance phase is the Identification phase. This occurs approximately six months after confrontation. Here the technology has more than a functional purpose. It can also then express a lifestyle and potentially be used to differentiate or connect groups of people. In order for robotic technologies to reach the integration and identification phases of acceptance, they need to offer users something that traditional technologies do not [4]. Before examining acceptance in relation to robotic technologies further, it is necessary to clarify how social robots differ from traditional technologies, and what this means for their acceptance.

2.1.3 Robots as a new technology genre

Robots are a relatively new genre of technology and they are not widely used in society. The level of robot technology acceptance changes over time and between contexts. Changes are impacted by the stage of the technology's development

regarding its capacity and its level of diffusion in society [21]. The relatively little diffusion of robots in society currently impacts acceptability factors such as attitudinal beliefs about the technology. Lack of familiarity also impacts how at ease people are with a technology and their need for information in order to understand how it can be useful to them.

2.1.4 What is different about social robots?

The acceptance of robots is also impacted by the additional features that robots possess in comparison to traditional technologies. Robots are embodied devices that share the space with their users. Embodiment impacts how robots are perceived, and how people interact with robots and the type of relationship humans can build with them. OA prefer to interact with an embodied social robot rather than a computer screen [22].

Robots are also designed to behave and move more autonomously than traditional technologies. In addition, robots are designed with the intention to promote social interaction between themselves and the human user. These features impact their acceptability because the robot has a social presence and to be effective it must cause the human user to perceive it as a social identity. Variables including social presence and perceived sociability will be discussed further below in relation to the theoretical models that have used these concepts to explain and predict technology acceptance. Some examples of these models and how they have been used in research practice will now be presented.

2.2 Models used to explain and examine robot acceptability

2.2.1 Traditional technology models of acceptability

The Theory of Planned Behaviour was developed from the Theory of Reasoned Action [23]. This model proposes that people are influenced to behave in a certain way by making rational decisions about the personal and social outcomes that they anticipate as a result of their behaviour. This model may be helpful to explain the intention to use robots [4]. However, it cannot adequately explain the acceptance of robots, without being adapted. Because the decision to use robots can be impacted by emotional reactions rather than rational decisions [24].

The Technology Acceptance Model (TAM) [25] was derived to focus on the acceptance of computerised information systems in workplace contexts. TAM has been reported to explain 40% of variance in acceptance [26]. This model regards acceptance in terms of Intention to Use (ITU) the technology. Actual usage of the technology may or may not follow a potential user having ITU a robot. ITU is considered to be dependent on the user's attitudes towards the technology which is derived from their assessment of its Perceived Usefulness (PU) and on users' Perceived Ease of Use (PEOU). TAM was developed further [27] to include the impact of social influence, facilitating conditions, and habitual usage on technology acceptance.

The Unified Theory of Acceptance of Technology (UTAUT) offers a social psychological approach that can explain 70% of acceptance variance [27]. It uses constructs from eight previous theoretical models. It has four independent variables: performance expectancy, effort expectancy, social influence, and facilitating conditions. The independent variables affect the dependent variables: ITU and actual usage. Their effect on ITU and actual usage is moderated by gender, age, experience, and voluntariness of use. The UTAUT has been criticised as not being parsimonious and for combining highly correlated variables that provide an artificially high variance [4].

All the traditional acceptance models cannot adequately explain the acceptance of robots as social actors and the social aspects of human-robot interaction. They can also not fully enable the evaluation of pleasure-orientated factors that are necessary to motivate people to use robots in voluntary non-working environments [4, 28].

2.2.2 Acceptance models adapted for social robots

The Almere Model was developed using experiments (n = 4) that involved three robots, to test acceptance of social robots by OA (188) [19]. The Almere model extends and adapts the UTAUT. It has eleven constructs which are defined in **Table 2**. These constructs enable the measurement of acceptability to focus on aspects of the technology pertinent to social robots and the perception of humans towards them as autonomous embodied social entities. Heerink et al. [19] found that the model was strongly supported accounting for 59–79% of the variance in usage intentions and 49–59% of the variance in actual use. However, this was achieved using equation modelling on four separate databases without confirming their similarities [4]. It has also been suggested that users’ beliefs about their self-efficacy to use and control the robot are underrepresented in the Almere model [18].

The Almere model has been used to explore levels of acceptance and engagement with a humanoid robot, Matilda [7]. This study involved people with dementia (n = 115) living in care homes (n = 4). It used a mixed-method longitudinal experience in which the reactions of participants were coded (n = 8304) according to emotional visual behavioural and verbal engagement measures. Participants used Matilda in three repeated 4–6 hour stages of field trials and as a result of the feedback received from participants, Matilda was further developed and improved.

The Model of Social Robot Acceptance was developed by expanding and adapting the theory of planned behaviour using some elements of the UTAUT and including factors relevant to robots [4]. This model utilises eight constructs that are summarised in **Table 3**. De Graaf’s model regards users’ attitudes as being comprised of both hedonic and utilitarian beliefs and it includes consideration of control beliefs and that people may use a robot, and any other assistive device, due to habitual behaviour rather than making a rational decision to use it. This

Construct	Definition
Anxiety	Evoking anxious reactions when using the robot.
Attitude	Positive or negative feelings about the robot.
Intention to Use	The outspoken intention to use the robot over a long period.
Perceived Usefulness	The extent to which a user thinks a robot will be helpful.
Perceived ease of use	The degree to which the user believes they can use the robot.
Perceived enjoyment	Feelings of pleasure associated with the use of the robot.
Social Presence	The experience of sensing a social entity when interacting.
Perceived sociability	The perceived ability of the robot to perform sociably.
Trust	The belief the robot performs with personal integrity.
Perceived adaptability	The perceived ability of the robot to be adaptive.
Facilitating conditions	Factors in the environment that facilitate using the robot.
Social Influence	The user’s perception of what other people think about them using the robot.

Table 2.
 Constructs in the Almere Model (Adapted from Heerink et al. [29]).

Construct	Definition
Personal Norms	An individual's beliefs about using the robot, including privacy, trust, and attitude towards the robot.
Social Norms	A user's evaluation of the social consequences of using the robot. This includes social influence, media influence, and impacts on status.
Control Beliefs	User's beliefs about resources, opportunities obstacles affecting the use of the robot, including self-efficacy, previous experiences, prior expectations, personal innovativeness, safety anxiety, and the cost.
Utilitarian Attitudes	Includes perceptions of the robot's usefulness and how easy it is to use, including adaptability, embodiment, and robot personality.
Hedonic Attitudes	Evaluation of emotions, including enjoyment and pleasure that might arise from using the robot.
Habit	Behaviour resulting from the habitual use of the robot.
User Intention	The intention of the user to utilise and interact with the robot.
User Behaviour	The user interacting with the robot.

Table 3.
Constructs in the model of social robot acceptance [4].

model was tested by de Graaf [4] with respondents from an online questionnaire (n = 1248) of whom, 24.7% were aged over 60. This found that intention to use the robot increased when people believe: they have the skills to use the robot; that using it would be enjoyable; it would increase their status; when the robot would be less sociable; and cause less worry about privacy. However, only self-efficacy significantly impacted user intention to use the robot. De Graaf [4] concludes that the model is a useful guide to the identification of acceptance variables but that it needs further development and testing with other data sets. The Model of Social Robot Acceptance was used by Korblett [18] in the study examining telepresence robots that has been described above.

One limitation of applying the Almere model and the Model of Social Robot Acceptance to OA and people living with dementia is that they do not take account of disability and the fact that OA and people with dementia may have additional needs concerning technology usage. It has been argued that everyday and psychosocial functioning are better predictors of robot acceptance than chronological age per se [16]. The usage of technology is impacted by a person's level of cognitive ability which affects their psychomotor speed, domain knowledge, and visual memory [11]. People with dementia may also experience declining touch sensitivity and less ability to execute accurate and discrete movements [6, 30]. Learning new technologies can also be difficult with symptoms of dementia such as reduced working memory, information processing ability and speed, and a lack of ability to disregard unwanted information [31]. Therefore, traditional models of technology acceptability and robot-specific models may be inadequate to explain the acceptance factors pertaining to some OA, particularly those with dementia.

Models of Gerontechnology acceptance have been developed which do consider physical and cognitive health. Gerontechnology has been defined as electronic or digital products or services that can increase independent living and the social participation of OA [30]. Two examples of models are described below.

2.2.3 Acceptance models adapted for gerontechnology

The Senior Technology Acceptance Model (STAM) [30] was developed with data collected by personal interviews with community-dwelling people (n = 1012)

over 55 years living in Hong Kong. STAM extends the constructs of previous technology acceptance models by adding age-related health and ability constructs: self-reported health conditions, cognitive abilities, attitudes towards ageing and life satisfaction, social relationships, and physical functioning. Chen and Chan [30] found that STAM can explain 68% of variance in gerontechnology usage and that facilitating conditions directly impacted the usage behaviour of participants. This suggested that the support of other people, knowledge, and guidance, directly impacts the gerontechnology usage of OA. The STAM has been used to appraise changes in technology acceptance in a randomised controlled trial that involved people with dementia (n = 103) living in residential care facilities (n = 7) [12]. The link between factors impacting the acceptance of a social robot, Kabochan, was assessed to ascertain if participant's attitudes and beliefs towards the robot would be impacted by the amount and the quality of engagement they had with the robot. They found that PEOU changed but beliefs and attitudes remained unchanged despite engagement with the robot.

The Model of Gerontechnology acceptance [32] encompasses both disability and aspects of a person's living environment. It was developed within the discipline of social gerontology, developed based on a study involving OA (n = 67) living in their own homes who were interviewed in-depth to ascertain their usage of and experience with a range of assistive technology (AT). AT was defined as being any device or system that allows an individual to perform a task that they would otherwise be unable to do. McCreadie and Tinker [32] argue that acceptability of AT is impacted by the interaction between a 'felt need' for assistance, and recognition of the product's quality regarding its efficiency, reliability, simplicity and safety, availability, and cost. They found four user attributes that were particularly relevant: OA disability, living arrangements, carer needs, and personal motivations and preferences. These attributes combined to generate a felt need for assistance from the technology, which combined with external factors that impacted access to the AT: information, contacts with suppliers, knowing what help is available. McCreadie and Tinker [32] emphasis that for AT to be acceptable, an OA must have information about how an AT might address their needs and be beneficial to them. In addition, OA acted in reciprocal relationships, with a strong desire for independence and to exercise their autonomy and agency in deciding whether to accept and AT [32]. The importance of autonomy and the agency of OA and people with dementia is discussed further below.

It is apparent that although gerontechnology models of acceptance do not address constructs that are particular to social robots as embodied social presences, they do highlight other factors that are pertinent to the way OA and people with dementia evaluate the acceptance of technology. Indeed, all the types of conceptual models currently available to guide empirical research in this context appear to have merits and limitations. It is also interesting to note that a recent systematic review, that included n = 74 studies, found that most studies that examine the technology acceptance, adoption, and the usability of information communication technology for people with dementia and their caregiver partners, do not report being underpinned by theoretical models and most use bespoke approaches to measuring acceptability [20]. Therefore, it is evident that a more consistent approach to examining [20] and conceptualizing robot acceptability for OA and people with dementia needs to be developed. It may be helpful for this approach to include constructs that are pertinent to robot usage and includes factors used in gerontechnological models.

The empirical research will now be examined to identify the factors that impact robot acceptability and what is important to OA and people with dementia and is likely to impact their decision whether to use a robot.

2.3 Factors that impact robot acceptance of people with dementia and older adults

OA and people with dementia are motivated to use robots based on factors that impact them at the level of individual people and other factors that relate to people that are known to individuals (significant others), and wider society. This section of the chapter will firstly discuss how individual-level factors impact the motivation of potential and actual users to accept robots. It then addresses significant others and cultural factors.

The empirical studies included in this was obtained through searching eight databases using the following search terms: accept*, dementia*, Alzheimer*, robot*, “cognitive deficiency”, elder*, old*, technology accept*, user accept*, attitude, social robots, assistive technology. Papers were selected if they were published between 2005 and 2021, they involved people with dementia, and/or adults over 65 years old, if they were in English, and focused on robot acceptability.

2.3.1 Individual factors that impact the motivation of OA and people with dementia to accept social robots

Motivation to use robots is strongly related to their perceived usefulness. Social robots need to be relevant to the current unmet needs of potential users in order for robots to be perceived as useful [4, 14, 19, 28, 33–36]. Hebesberger et al. [36] aimed to investigate acceptance and the experience of using a humanoid robotic platform SCITOS, in a care institution in Australia. Data was collected in this 5-day pilot followed by a 15-day trial using semi-structured interviews and observations with people with dementia and their formal caregivers. They found that the robot was not perceived as useful and participants were ambivalent about the robot. Hebesberger et al. argues that acceptability is contingent on the robot meeting the specific needs of the end-users.

The identification of needs is complicated because OA and people with dementia may lack awareness of their unmet due to their cognitive difficulties [33], or because caregivers currently fulfil their needs [37] or because individuals are habituated to the challenges they are living with and don't perceive them as problems. But, people with dementia are very able to determine and articulate what they want and don't want and they know how they feel at any given moment [38, 39]. Potential users may also require information about the benefits of using the robot because they are new and unfamiliar technologies. Furthermore, the benefits of using the robot have to be real and clearly communicated to potential users [4, 28]. It is important to facilitate the development of realistic expectations to avoid users being disappointed if the expectations of using the robot are not met. This can result in a subsequent lack of acceptance [17].

In order to realise the benefit from the robot and to be motivated to use them, OA and people with dementia need to be capable of using a robot and to feel at ease doing so [16, 40]. This implies that there needs to be a user-technology fit [16] in terms of the robot capabilities to meet the users' needs. Thordardottir et al's., [17] systematic review that synthesised knowledge on the facilitators and barriers related to acceptance and the use of technology for people with cognitive impairment and caregivers found that PEOU was important and that acceptance was facilitated when technologies made low technical demands on users. A recent scoping review [41] also identified the robots need to be easy to use, to facilitate PEOU. This review included n = 53 studies and examined the use of barriers and facilitators affecting the implementation of zoomorphic robots by OA and people with dementia.

Ha and Park [42] in their survey found that increasing age may present OA with more obstacles to technology acceptance, including cognitive, motor, and sensory deficits. They also found that PEOU negatively correlated with support, i.e. there was a greater need for support when PEOU was low. But, PEOU can be changed through the support of skilled facilitators. In a study that examined the effect of the robot MARIO on the resilience of people with dementia (n = 10) [6], it was found that all the participants needed facilitation and then they successfully used MARIO's touchscreen and interacted with the robot. Chan et al. [12] also found PEOU is important and that it can be improved through engagement with a robot. This randomised controlled trial investigated how participants' attitudes and beliefs towards a humanoid robot, Kabochan that resembles a 3-year-old boy, would change, and whether a change was affected by the amount and quality of engagement with the robot. People with dementia (n = 103) living in residential care facilities (n = 7) were allocated into a group to engage with Kabochan or to a control group who received usual care. An ABAB withdrawal experimental design was used with each phase lasting 8 weeks. The controlled group received usual care throughout the 32-week study. The experimental condition received usual care during the first baseline phase and the third phase (A phases). In the second phase, the robot-engagement group had 2 weeks of introductory sessions with an occupational therapist and they became familiar with Kabochan's interactive features and how it could be used and turned on and off. Then for six weeks and during the 8 weeks of the 4th phase participants could use Kabochan as they wanted independently 24 hours a day. This study found that PEOU changed significantly ($p = -.042$) and that it was related to the intensity of constructive behavioural engagement that participants had with the robot.

PEOU is related to self-efficacy which is an important outcome measure of positive psychology in dementia that is related to a feeling of being in control [43]. In order for users to feel at ease, they need to feel in control whilst they are interacting with robots as autonomous embodied devices. In the study described above Korblet [18] found that self-efficacy was mostly mentioned by the dementia group, and not by people with physical disabilities or visitors to the nursing home centre and that lack of self-efficacy led to participants not wanting to use the mobile presence robot again. Control requires a lack of fear, but also that the robot is reliable and can function properly to perform its tasks [10]. Conversely, technical robot problems and/or a lack of robot capability can threaten acceptance [36, 44]. Frennert et al. [45] asked OA with moderate sensory and mobility impairments to state their preference for an ideal robot and OA (n = 7) who lived with mock-ups of these ideals for one week. They found that feelings of control were also linked to feelings of trust and the need for privacy. Trust may be particularly important for OA who may mistrust technology more than younger adults [40]. This was determined in an online survey conducted in Japan, with respondents (n = 100; aged 20–70). Trust is also related to the degree that a robot is autonomous and adaptive in its movement and behaviour. Korblet [18] found that trust did not play a role for participants in their research when the robot was not autonomous and it was only used for a few minutes on one occasion in a group setting. Rossi et al. [9] also found that trust and anxiety did impact technology acceptance. The more autonomous and adaptable a robot is, the more challenging it is to human comfort, the ability to trust the robot, and the need for perceived control of the robot. It may be that when robots are used over a longer period, their requirement for adaptivity may increase as they are required to respond in a larger number of human social settings. De Graaf [46] examined the acceptability of Karotz, a rabbit-like robot, in the homes of OA (n = 6) over three 10 day periods. They found that as time passed, participants wanted more control of the robot to maintain their privacy because the robot continued to remind

participants about their schedule and health-promoting activities in the presence of guests. Furthermore, how acceptable individual users find a robot depends on the individual person, the purpose of the robot, and the context [14].

The personality of the user, their interests, and values impact their response to a social robot and their perception about its social presence [9]. Rossi et al. found that having the personality trait of ‘openness to experience’ positively impacted the human-robot interaction. This study used a prototype of the humanoid robot Pepper to investigate if personality traits and user’s empathy (a feature of personality) impacted the acceptance of a robot-led cognitive test. Participants were OA (n = 21; aged = 53–82 with average of 61). Acceptance of the robot was assessed using the UTAUT constructs and a psychologist evaluated personality traits, empathy, using the NEO Personality Inventory-3 (NEO-PI-3) [47]; the Empathy Quotient (EQ) [48]. After the psychological evaluation, the robot administered to participants psychometric tasks of the MoCA [49], and in a second task the person performed activities whilst Pepper monitored them. Dialogues of the participant-robot conversation and videos of the interaction were captured by Pepper. Rossi et al. found that empathy correlates with the amount the user perceived that the robot was sociable.

People with dementia can experience volatility in their mood and difficulty regulating their emotions [39]. Variations in mood are likely to impact robot acceptability [28]. When MARIO was being used by people with dementia, who had moderate and severe dementia, facilitators had to support participants to enable them to be ready to use the robot [6]. If participants were disorientated in time or space, facilitators had to acknowledge their perception of reality at that time and help the participants to deal with whatever was causing their anxiety. For example, at the start of one session with the robot, the participant welcomed MARIO and the facilitator into her room in the nursing home, but she was concerned, believing erroneously that a person had been into her house without her permission. This participant was not ready to use MARIO until she was calmed as a result of talking with the facilitator and being reassured that all was well [6].

OA and people with dementia are also motivated to use a robot if they find that interacting with it is enjoyable [19, 41, 50]. Novelty effects may enhance the enjoyment of robot usage initially, but these can decrease over time [46, 51]. How robots can be used to sustain a person’s enjoyment and its relevance to their needs and capabilities, are discussed below. But first, the factors involving significant others and wider society that impact an individual’s motivation to accept robots will be introduced.

2.3.2 Factors that involve significant others and wider society

The perceptions of significant others, particularly caregivers can have a substantial impact on robot acceptability. Significant others, as social influences, are strong predictors of the adoption of home healthcare robots [52] and the ITU the Kompai robot [53]. Significant others can enable the usage of robots through encouragement and facilitation [6, 53] or they can impede a robot’s implementation into care settings [36, 44]. There is substantial evidence that professional health and social caregivers may have negative preconceptions about the use of robots for OA and people with dementia [44]. Caregivers may be concerned about the compatibility of robots with their work processes [41]. Casey et al. [8] explored the perceptions and experiences of using MARIO with people with dementia (n = 38), relatives/carers (n = 28), formal carers (n = 28) and managers (n = 13) in UK, Italy, and Ireland. They found that although MARIO was positively received by most of the participants, some formal care workers voiced concern that robots might replace care staff.

Human behaviour is impacted by a person's perceptions about what other people think, including thoughts related to negative ageing stereotypes that are prevalent in society [54]. People are motivated to act because they want to project a self-image that they are healthy and independent, both to themselves and other people [33, 55, 56]. The acceptance of robots by people with dementia and OA is impacted as potential users may fear being stigmatised and labelled as physically or psychologically vulnerable, dependent, in decline, or lonely if they use a robot [34, 44, 53, 56]. Dudek et al. introduced OA (n = 28) in good subjective physical and cognitive health to PLEO, a robot shaped like a dinosaur, and then assessed robot acceptance using an Emotional Attachment Scale (EA-Scale) developed by Thomson et al. [57] and the Comfort from Companion Animals Scale developed by Zasloff [58]. Then they assessed the participants' actual and ideal self and subjective robot user image. They found that participants stigmatised OA robot users and that OA may construct a more negative user image than their own self-image, in order to maintain their own positive self-image. Dudek et al. concluded that acceptance of new technologies is impacted by OA subjective interpretations of the technologies.

Another factor that impacts the level of robot acceptability for individuals, significant others, and wider society, is the familiarity of robots as a technology [44]. It is argued that people need time to learn about and become comfortable with robots as a technology [17, 44, 51] and that this may happen when robots are more prevalent. The level of robot acceptability will vary between cultures and over time, but as robots become more available and diffuse in society it is not certain that acceptability will increase [28]. Bishop et al. found that higher robot familiarity had a negative impact on attitudes and behaviours and that familiarity was linked to heightened awareness of a robot's limitations. How robots need to be design, developed, and deployed used in order to facilitate their acceptability will now be discussed.

2.4 What is likely to increase robot acceptability for OA and people with dementia

Robot acceptance is increased through personalisation of the robot, to make it meet the needs and preferences of the user and support their personhood [7, 14, 17, 44]. Personhood has been defined as 'a standing or a status that is bestowed on one human being by another, in the context of relationship and social being' [59] p.8. For example, the acceptability of the robot Maltida was increased due to personalisation that supported personhood, through the robot using human-like emotive expressions and accounting for the user's disabilities [7]. Other ways to support personhood and increase the acceptability of a robot is if the robot enables the OA and person with dementia to feel empowered, respected, and able to participate in activities that are meaningful to them [6, 10].

It is well recognised in current discourses about dementia care, that people with dementia do not experience a 'loss of self' as dementia progresses [39]. Whilst a person's identity, and personality may change, a person's central being, core values remain [39] and people with dementia maintain the potential to adapt and grow [38]. It is not enough to discern the requirements of the robot user on one occasion and personalise the robot. To ensure ongoing acceptance of the robot, there must be ongoing review and adaptation of the robot as the person uses it over time. The investigation with MARIO described above found that the creation of meaningful activity was made possible through a skilled facilitator and person with dementia working in partnership to use the robot in a way that was meaningful to the user [6]. Facilitators learned about the user's preferences and used the robot creatively in ways that were not identified before usage, even though MARIO was initially

personalised for each individual using information obtained from each person with dementia, their caregivers, and relatives. For example, the following conversation was observed between a participant, Margaret, who had moderate dementia, and a facilitator whilst they used MARIO's applications. It illustrates how new knowledge of a participant's interests were used to further personalise MARIO.

The facilitator and Margaret were chatting through the photographs then Margaret chose the music application.

Margaret 'It's very good', looking at MARIO's face while the music is playing for 1 minute and then she says, 'I would like to get home'.

Facilitator 'Yes. Does the music remind you of something?'

Margaret 'I would like to do that myself the same as other people'

Facilitator 'You'd like to be more independent?'

Margaret 'Yes (pause) ... Do you like the music?'

Facilitator 'Yes, it's lovelydoes it remind you of something?'

Margaret 'Jeanie of the light brown hair'.

Facilitator 'Is that a song?'

Margaret 'Yes'

Facilitator 'Would you like MARIO to play it?'

(OME Margaret Session 10, [6]).

Another way in which robots may be made more acceptable is if their investigation, design, development, and deployment are guided by models of gerontology that focus on the strengths and abilities of OA and people with dementia, rather than their disabilities. New ways of using robots may be possible if the lens of successful aging or resilience as strength-based models of care are applied to social robots [6, 44]. Such models would facilitate the development of guidelines and protocols for robot usage that aim to ensure the autonomy and dignity of OA and people with dementia are upheld [12] and that their priorities and goals are central to the robot design and usage.

The robot's physical appearance, behaviour, and communication style, and ability, combine to impact the robot's social presence and perceived sociability. There is huge variability in the optimal appearance of social robots [14]. But, robot acceptability will increase when robots are technically improved and able to behave and communicate in a convincing human-like way [14]. To support human communication, robots need to: enable a convincing emotional exchange; understand the user's intention; and provide complementary reactions [28]. This is because people anthropomorphise about a robot [60] and want this autonomous embodied presence to be compatible with human norms of behaviour, (or that of an animal if it is a zoomorphic robot). There is some evidence that OA are more likely to regard robot interaction as pleasurable if robots are designed to display positive emotion [28]. However, the user must interpret that the robot behaves in a way that is compatible with their status and is appropriate for the psych-social context [61, 62].

Cobot or collaborative robots are currently being developed and used in the manufacturing industry. These robots are designed to move and perform delegated repetitive tasks, working alongside humans. Unlike other robots, Cobots can be taught by human users through example, rather than through programming. As such they are intended for direct human-robot interaction, to be used in a shared space in close proximity to humans. They can be smaller, more mobile, and they are reputedly safer than their traditional robotic counterparts [63]. No research to date has explored the usage of collaborative robots in health and social care settings. However, it may be possible to design collaborative robots that support the independence of people with dementia and older adults and that support the work of human caregivers. As discussed above, one of the moral and ethical objections to using robots in the health and social care setting is that human-human contact will be reduced. Because collaborative robots work alongside human workers, as a tool, these fears may be mitigated. In addition, the ability to learn by example could make collaborative robots easier to use in a clinical and practical context by people who don't have programming capability. Collaborative robots have the potential to be used more flexibly in response to the individual needs of users and to meet their requirements as these needs change. It has been argued above that flexibility, attention to individual needs, and ease of use, are key requirements for robots to be acceptable to users in the health and social care context. Collaborative robots could potentially help individuals, alongside the care provided by humans, to take food and drink and to perform other daily living activities. Indeed, the collaborative element of cobots could also improve the person-centred usability of other robotic and non-robotic devices that currently assist the movement of people who are physically impaired.

The acceptability of all robots will be enhanced if robots are designed, developed, and deployed with the significant, early, and repeated input of OA, people with dementia, and significant others, including health and social care professionals. All these stakeholders need to work in partnership with researchers and developers, in participatory design processes [11] so that robots are optimally relevant and able to meet the needs of users. Iterative participatory design was used in the development of the robots Matilda and MARIO. Both robots were improved and customised to meet the needs of people with dementia with prolonged, iterative phases that involved the assessment of needs [64], development using the feedback of users, and testing in clinical environments [7, 8].

There have been some developments that will facilitate the participation of stakeholders in research and will encourage a focus on issues of safety and ethics [44]. A European Commission framework requires that users, innovators, and society mutually interact and engage in processes that are transparent so that products are developed to be acceptable, sustainable, and desirable [65]. Dementia-specific developments have also been advanced. For example, in Europe, the Alzheimer's Society has produced comprehensive guidelines on how the ethical challenges of involving people with dementia in research can be managed [66] and best practice guidelines have been produced [67]. In addition, a European funded project (prospero.via.dk/en) is also underway that aims to understand what health and social care professional needs regarding robotic technologies and how caregivers can contribute to the development of robots.

Very few longitudinal studies have investigated robot acceptability [14, 20]. Robot acceptability will also improve if developers and researchers consider, in-depth, the context into which the robot is going to be deployed. The technology must be examined in the context it will be used, with longitudinal research designs [44], for over two months [4]. An in-depth understanding of the context, including the needs and motivations of all stakeholders, will also be facilitated by

triangulating the data from multiple data sources that include qualitative research methods [4, 6]. Currently, robot acceptance is mostly measured using indirect methods such as questionnaires, and interviews, rather than direct observation during human-robot interactions [20]. Observational ‘in the moment’ methods are particularly advantageous to understand the experiences of people with dementia, who may not recall accurately and in detail, their experiences after interactions have taken place. Furthermore, people with severe dementia may be unable to use questionnaires, and reliance on proxy recordings of their attitude and beliefs [12] may not be accurate.

3. Conclusion

The chapter has defined the acceptability of social robots and discussed how acceptability can be understood and predicted as conceptualized by theoretical models of acceptability. It has discussed factors that impact the acceptability of social robots by OA and people with dementia and made recommendations as to how acceptability may be increased. It has been argued that current acceptance models for social robots need further development to accommodate the needs of OA and people with dementia who experience physical and cognitive disability. Models of gerontechnology may be useful to identify the needs and characteristics of OA and people with dementia that are pertinent to robot acceptability. Models need further development and testing to ensure they can fully inform both the acceptability evaluations of autonomous embodied social robots.

The multiple interacting factors that impact robot acceptance at the individual, community and societal levels have been discussed. It is vitally important that robots are useful, enjoyable to use, easy to use and that they support the personhood and strengths of OA and people with dementia. Enjoyable social interaction requires robots to have good quality humanlike communication skills. It would enhance the acceptability of robots if future design, development, and deployment of robots are underpinned by strength-based theories. This would ensure that processes are driven by the motivations and goals of OA and people with dementia. It is also important that the context surrounding robot deployment is assessed in-depth using longitudinal designs and that all aspects of their development are guided by potential users, significant others and health, and social care stakeholders.

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Conflict of interest

The authors declare that they have no conflict of interest.

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