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Acceptance of Needy Socially Assistive Robots: A Systematic Review

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Abstract
As the average age of developed countries continues to increase the methods used to care for these frail individuals needs to adapt to keep up with demand. Socially Assistive Robots (SAR) are a potential solution to this problem, however they have been held back by adoption issues for a number of reasons. One of the biggest barriers to adoption is the lack of acceptance by their intended users. Through this literature review we intend to explore the factors that influence SAR acceptance and the work that has been done into the implementation of a robot with "needy" characteristics. Research papers were gathered from some of the leading research databases for computer science that were published between 2004 and 2022, as that was the initial launch of Paro, one of the first SARs to see widespread success. We conducted a search for papers on the topic of SAR acceptance for the elderly or otherwise vulnerable and found a total of 52 that matched our acceptance criteria. This review highlighted some of the ways that SARs can be adapted towards specific demographics in order to increase acceptance. We have also identified the current gap in the research for studies focused around the concept of a "needy" robot. While aspects of that kind of design have been viewed positively in several of the studies found here, we found none that focus on this concept as a primary research aim, indicating that there is value in further investigation of this type of SAR.

Keywords Socially assistive robots · Independent living · Needy robots · Technology acceptance

1 Introduction

As the number of elderly people in the world grows an urgent problem that needs to be solved is how to effectively care for these people with dignity. While dedicated care workers can be an effective solution for providing care, they are in high demand and short supply. This problem is expected to grow exponentially, particularly in countries such as Japan where the number of elderly people is beginning to outpace the number of young people that could fill these carer roles [1]. An alternative solution to this problem is the use of socially assistive robots (SARs). SARs are robots specifically designed to provide support for their users [2, 3]. This support can manifest in many forms but generally includes providing therapeutic and social functions for the user. While they cannot provide all of the same help that a dedicated carer would be capable of, they have a range of advantages of their own. Notably, SARs are not constrained by the same factors as care workers, providing benefits such as the ability to be available 24/7.

Previous studies have shown the ability of pets to encourage healthy ageing. Therapy pets have been proven to reduce loneliness, increase socialisation and provide companionship to older adults [4, 5]. They have also been able to improve the symptoms of various psychological and mental health issues, such as depression [6]. Despite this, there are many challenges for elderly adults when it comes to pet ownership. Elderly people, particularly those living in assisted living facilities, can find it difficult to look after themselves, let alone another living being [7]. Robotic companions do not have these downsides, and can be used by an elderly user without risk to themselves or anyone else. SARs can be used as an alternative to having a therapeutic animal companion or pet, especially in instances where the user may not be capable of providing care for a real animal [8, 9].

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Unlike smart home devices and other commercialised robots, emphasis is put on how physically and socially appealing SARs are, rather than focusing on functionality alone. SARs generally have anthropomorphic, or zoomorphic, features designed to appeal to their user as a companion, rather than a simple machine. Paro [10] one of the most popular type of SAR is designed to look like a baby seal. While other SARs have been designed to look more humanoid such as Pepper [11], or more abstract and fit for a specific purpose like Astro [12].

General home assistants such as Amazon Alexa, Google Home and Apple HomePod have seen high rates of adoption by users, with over 38% of the UK and 35% of the USA population owning a smart speaker of some sort in 2021 [13, 14], this same adoption rate has not been seen by SARs. Attempts have been made to enter the SAR commercial market, such as in the case of Amazon Astro, a SAR designed to pair with existing smart home devices provided by Amazon [12], however, these products have remained in the early stages and as such have not resulted in significant market penetration.

While the type of functionality provided by SARs undoubtedly has an impact on their acceptance, this literature review aims to provide an overview of the other factors that contribute to this. We will look at existing studies that detail how readily accepted SARs are and the factors and traits that influence this acceptance. The primary goal of this article is to investigate the viability of implementing a "needy" socially assistive robot into the homes of vulnerable people seeking to live independently.

1.1 Key Terms

1.1.1 Socially Assistive Robots (SARs)

SARs are a category of robot designed to provide aid through social interaction, rather than through direct physical aid [2]. Rather than focusing on assisting users physically, they are able to support the mental, emotional and cognitive well being of individuals by engaging them in dialogue, providing companionship and through encouraging other activities. These robots are typically used to support vulnerable individuals, such as the elderly or otherwise frail [3]. Typically they aim to incorporate zoomorphic or human-like traits in order to encourage empathy and the fostering of connections from users.

1.1.2 Neediness

The Britannica dictionary [15] defines neediness as "needing a lot of attention, affection, or emotional support". Needy traits in this context are behaviours and actions that encourage or require the interaction and support of a human user. This may come in the form of an SAR emulating a pet or small child which needs care, however, without the responsibility and need for the potentially vulnerable individual to provide actual physical care to another individual. Pets acting in this capacity have already been shown to have a positive impact on the well-being of vulnerable individuals [4–6].

Animals typically display needy traits in the form of simple gestures, including nudging and vocalising to request attention when hungry, or otherwise needing care, creating a sense of emotional connection and social obligation. Digital devices, such as smartphones, display similar pseudo-needy traits by demanding attention through various notifications, warnings, and alerts. However, the frequency and insistent nature of these prompts can be negatively viewed as intrusive to the user.

For this paper, we define neediness as a robot that shows some form of dependence on the user in an endearing way, whether this is an entirely artificial requirement or not. This needs to be designed to be engaging rather than frustrating, thus encouraging users to build companionship with the SAR and making them want to interact, rather than feeling that they need to interact. Examples of behaviours that would be considered needy in the context of an SAR include:

- Seeking assistance or reassurance
- Expressing embarrassment or vulnerability
- Spontaneous interactions
- Displaying fatigue and similar characteristics

Several of these behaviours are already observed in existing studies [16–19], however they are not explicitly recognised as needy traits in those papers. Our definition of neediness is informed by work that sought to define needy SARs through the creation of a framework for future development [20].

1.1.3 Acceptance

In the context of SARs, acceptance refers to the users willingness to engage with and use robots in their daily lives. Given the limited scope and duration of most studies, it is challenging to determine whether participants would continue to use SARs long-term in everyday life. Therefore, this review draws on a variety of methods used in the found studies to assess SAR acceptance, this will range from the results of questionnaires created using technology acceptance models, to observations, interviews and other novel methods of obtaining the perspective of participants. These varied methodologies provide a comprehensive view of many of the factors influencing SAR acceptance. Section 5.1 discusses the various methods found as part of this review.

2 Methods

2.1 Research Questions

This article aims to answer the question of whether a SAR with "needy" characteristics would be accepted into the home of people living independently. To achieve this we aim to examine three key research questions:

- RQ1) Which SAR traits and behaviours are favoured or disliked by users?
- RQ2) Do personal factors, particularly protected characteristics, such as age, gender and culture, impact SAR acceptance?
- RQ3) What existing research has been done into the creation of a "needy" SAR?

2.2 Preferred Reporting Items for Systematic Reviews and Meta-Analyses

This study utilised the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [21] for identifying and reviewing papers in this study. PRISMA consists of a checklist and flowchart that provide several guidelines to ensure that a systematic review is conducted with relevant evidence of the steps taken at each stage.

The first stage of this process was performing a comprehensive search to identify all potentially relevant papers. This search was conducted in June 2022 on several of the most popular research databases for the field of Computer Science, namely: ACM Digital Library, Scopus, IEEE Xplore, Springer Link and DBLP. The following search terms were used: (("Social" OR "Assistive" OR "Socially" OR "Companion" OR "Anthropomorphic") AND ("Robot") AND ("Acceptance" OR "Favorability") AND ("Elderly" OR "Vulnerable")). To cut down on unrelated papers, where possible search results were limited to the field of Computer Science or Human Computer Interaction.

The second step of the PRISMA process is to define the inclusion and exclusion criteria for papers. For this study the following inclusion and exclusion criteria were used.

2.2.1 Inclusion Criteria

- Studies published between 2004 and 2022. 2004 was chosen as the starting date for study collection as this is when the first version of Paro [10], one of the first SARs to see widespread commercial use and success in care home settings [22], was released. This is also the year that the humanoid NAO [23] began development, another robot that would see widespread adoption and led to various innovations.
- Studies should be on the acceptance and attitudes towards SARs.
- Studies must be in English, or have an English translation available.

2.2.2 Exclusion Criteria

- Studies on robots that would not be classified as a SAR, such as general home smart devices or wearable technology.
- Studies on robot functionality without considering the impact this has had on robot acceptance.
- Studies on telepresence rather than autonomous SARs.

3 Search Outcomes

In this section, we will outline how the papers were narrowed down to the few that we chose to use for this review. The exact reasoning behind these papers being excluded can be seen in the PRISMA Statement flowchart Fig. 1.

During the initial search, 694 papers were discovered. Of these papers, 21 were removed as duplicates leaving 673. The titles and abstracts of these papers were retrieved and examined to decide which were relevant to this study. After this initial screening process, 577 papers were excluded, leaving 95 studies. Using the search tool available in EndNote PDF copies of these studies were retrieved. All papers at this stage of the report were able to be retrieved, meaning that no papers had to be excluded to due an inability to retrieve their document.

The final step of the screening process was to read the remaining 95 papers and compare their contents with the inclusion and exclusion criteria detailed above. At this stage, 43 papers were identified as matching the exclusion criteria or failing to match the inclusion criteria. Post-screening, 52 studies remained to answer the research questions posed in this article [16–19, 24–71].

4 Results

4.1 RQ1) Which SAR Traits and Behaviours are Favoured or Disliked by Users?

This section explores user preferences for traits and behaviours in current SARs. This will include research into functionality, as well as other features and factors that influence acceptance rates.

Multiple studies have examined how the personality traits of SARs impact user acceptance. In a comparison study by Bartl et al. [26], researchers assessed user responses to two distinct personas: a "companion" and an "assistant". The key difference between the two SAR personas was the use of informal, filler language and friendly gestures in the companion robot, while the assistant type was more direct and used formal language. Despite offering identical functionality, a clear preference was shown by the elderly participants for the companion SAR, with the majority of participants rating it as both more likeable and intelligent. This suggests that the presence of a relatable persona can significantly influence user perception, even if the robot's tasks remain the same. Further research supports the importance of robots having a distinct personality. Bevilacqua et al. [27] found that even childlike or negative robots were rated more positively than those with a neutral attitude. Indicating that more socially communicative robots result in users feeling more comfortable and expressive when interacting with them, despite not having a drastic effect on overall acceptance [43, 44].

Gross et al. [40] introduced specialist SARs to individuals with mild cognitive impairments who live alone. This SAR was designed to navigate around the property and keep its users engaged with basic cognitive training and writing applications similar to the type of activities that participants are usually requested to do as part of their care. While both of these functions were appreciated by users, they liked when the robot would navigate towards them and talk, particularly when the robot took initiative or was providing reminders. Many participants ended up treating the robot more like a pet or a person, rather than a simple machine, identifying and then insisting that it had certain personality traits and characteristics that were not originally intended by the researchers. Initially, participants were cautious or even afraid of the robot, with some only participating to support their partner. By the end of the trial, all participants had developed positive attitudes towards the SAR. While the study did not explicitly identify the reason for their initial apprehension, other research by Ng et al. [54] indicates individuals can be heavily influenced by popular culture, such as films and books.

In a paper by Gross et al. [19], independent elderly individuals were provided with a SAR that would live at home with them for a week, without supervision present. As with their other study [40], the majority of participants felt that they had developed a personal relationship with the robot by the end of the trial. One of the unique aspects of the work was that when the robot got stuck it would call for help. Rather than seeing this as a frustrating quirk of the robot, this was viewed positively by most participants as they found it an endearing trait that contributed to their attachment.

Short term trials in Austria involved a small humanoid SAR interacting with elderly people [65]. They found that participants didn't feel anxious, and even felt high levels of trust towards it due to the shape and size of the robot. When users feel less anxious towards a SAR they find them easier to use [51].

While the key functionality of the robot is important for initial adoption, other factors such as ease of use, companionship and novelty all play an important role in the overall enjoyment of the robot [63]. Human-like characteristics are particularly popular with elderly users, particularly social features such as facial features and variance in tone of voice [51]. Hedonic factors such as enjoyment and playfulness, while not necessarily important for accepting a SAR, can be helpful for establishing a relationship between the user and a SAR. Perceived enjoyment also has an effect on the intention to use a robot [45]. For elderly users specifically, intention to use accurately predicts actual usage [45]. Social factors, while less crucial for forming a relationship, play an important role in acceptance, as more socially communicative robots increase user comfort and likelihood of acceptance as communicative partners [46, 50].

Emotional experiences with robots can be as important as robot task performance in terms of user acceptance and assessment of effectiveness, as was found in a study that provided a service robot to assist nurses in routine patient services [71]. Patients were handed "medicine" by a service robot in a simulated patient environment, with the intention of testing three robot features, facial configuration, voice messaging and interactivity. All three of these features were deemed important as the approval of robots with any of these features was significantly higher than of the robot with none of them [71]. While useful interactions, such as medication reminders, are generally seen as positive, activities that replace what would be human interaction, such as playing mahjong, are viewed negatively [48]. Instead, SARs can be used to enhance group activities, such as in the case of "Nadine", a humanoid SAR that was used to assist with bingo games in a care home [53]. They found that when Nadine was present, residents appeared to be happier and calmer, and that care workers did not need to intervene with support as often. These changes were present immediately and did not improve or degrade over time, indicating that the amount of time required for users to adapt to the robot in this context was low.

Robots acting in a playful manner and appearing with zoomorphic features can help to facilitate their introduction, as it is non-threatening and easy to make sense of for users, even in instances where they suffer from dementia [52]. In a study by Marchett et al. [52], residents were initially distressed when introduced to a Roomba, as they found it hard to make sense of, but were either amused with the

zoomorphic robot cat and happy to interact with it, or at the very least tolerated it. While they were happy to interact with the robot, they were acutely aware of the fact that it was a machine and not an animal, as the participants objected to the researchers treating the robot as a living being, such as by introducing it as a real cat.

A 3-month trial was conducted focused on the impact that having a humanoid SAR, Pepper, had on the workers within a care home [33]. Workers were happy to use the robot regularly, with most choosing to use it for at least an hour each day, despite the lack of obligation to do so. This usage was primarily setting up activities and games that involved residents interacting with the robot. Initially, the robot was used with no set pattern, however as time went on it was integrated into the regular schedule of activities at the care home. It had a positive effect on the workers' mood as it provided extra ways to interact with residents, but its ability to reduce workload was limited, despite early expectations that residents would be able to participate in activities with the SAR without much supervision. Many of the care workers were skeptical at the beginning of the study but came around after interacting with the robot. At times using the robot resulted in a stressful experience, particularly in instances where there were technical issues that could not be easily fixed. It's important that they are provided with the skills and knowledge that will allow them to fix these problems, or even to prevent them before can occur.

Trust between the caregiver and SAR is an important factor to consider when installing a SAR in a care home. While the anthropomorphism of the SAR is useful for increasing acceptance by people being cared for [52], it's demonstratively less important for caregivers, as Erebak and Turgut [38] found that anthropomorphism had little impact on the level of trust from caregivers. Instead, the most important factor was how much the caregiver intended to use the SAR and how happy they were with using it to automate tasks.

A robot was installed at a facility for elderly people with two different care programs, exercise with cognitive tasks and brain training with arithmetic operations [64]. The care programs were effective in their use cases, but not particularly efficient. One of the main findings was that the effectiveness of the interaction was heavily dependent on the user's own abilities, which was a problem as the facility had users with a large range of skill levels. A suggestion made was to allow caregivers to customise the robot to ensure the robot was made usable for different skill levels.

Because of the importance of social influence, social stigma can be one of the biggest factors blocking the acceptance of SARs [69]. This can extend to general negative word of mouth, which can also lead to innovation rejection [30]. Rejection was prevalent even when the negative word of mouth was separate from the specific robot being trialled. Younger users, as well as those that are suffering from sadness or loneliness, have been shown to be more influenced by the opinions of others [28]. One way to de-stigmatize SARs is to focus on implementing designs that are universally popular with as large of a demographic as possible.

Technology understanding is important for SAR acceptance. Users need sufficient training with technology in order to achieve long-lasting use and successful use of SARs [27]. This is particularly important for elderly users who are typically not engaged with and may be uneasy of modern technology [69].

SARs need to adapt not only to the environment, but also to the specific social situation of each interaction [57]. Adaptive behaviours make interactions more intuitive, which increases the ease of use and overall acceptance [25]. Regular and consistent communication can result in social ties forming between SARs and users, further enhancing acceptance likelihood [59]. The ability to convey emotion and affection meaningfully to users is another important factor [61]. To be effective, the SAR must communicate affection in a way that feels genuine and with varied expressions, as simply showing affection is not always enough to elicit a reciprocal response [35].

Overall while many of those questioned were initially reluctant to interact with an SAR, by the end of their respective studies these opinions usually changed. Thus indicating that better understanding of SARs, and the benefits that they provide, will result in greater adoption.

People primarily like SARs with "sociable personalities" over those that communicate through a less personable, more straightforward way. They also appreciate SARs that have been designed to look friendly with zoomorphic features.

Caregivers are at risk of being forgotten about when it comes to SAR design. It's important that they are catered for to ensure adoption, particularly in care home environments. We found that their needs differ from independent users that are intending to use the SAR, as they evaluate factors such as trust and technical understanding more importantly.

4.2 RQ2) Do Personal Factors, Such as Age, Gender and Culture, Impact SAR Acceptance?

To ensure that a wide range of vulnerable individuals are supported, aspects of SAR design need to cater to different demographics and backgrounds. As part of this review we chose to investigate whether factors such as age, gender and culture have an impact on overall acceptance, as well as the difference in preference for features and behaviours within these groups. One of the factors that had the largest impact on the acceptance of SARs is the age of the user. Overall current research indicates older people are significantly more

likely to want a robot in the house over younger people, as they are more likely to perceive greater benefits through their usage [24, 29, 49, 54, 70]. However attitudes differ not only in how favourable people are towards using an SAR, but also when it comes to the traits and features that they expect to see in them.

Older adults have little knowledge about robots and receive most of their information about the subject from movies or children, thus providing them with a preconceived notion of how the robot should look and act [54]. Despite their lack of experience, in the study by [54] they were open to the idea of integrating more technology into their lives, including robots, as long as the benefits were made clear to them.

Biswas et al [29]. conducted a study wherein users from various age ranges were shown videos demonstrating different methods of interacting with a robot. The two primary methods of interaction displayed were voice commands and a built-in touchscreen tablet. They found that people over 65 and under 21 preferred speech over a tablet-driven interaction, while people between those two age ranges preferred the tablet. The reasons for this appeared to differ between the ages, however, as younger people chose speech due to perceived convenience, while older people in some cases chose it due to necessity caused by disability. Speech is one of the most important factors for acceptance by elderly users as it ensures that the robot is usable by users that may have some form of physical disability, and has been found to greatly reduce the learning curve for elderly users [55]. Younger people on the other hand were more experienced with smartphones and indicated that would be a good alternative method to interact with the robot.

When compared to a tablet interface elderly users preferred to be provided with a robot. They perceived it as being more usable as they found it less complex and easier to learn than the tablet equivalent. A higher willingness to use the device at home was also shown [41].

Robots should speak in a natural manner and ensure that all words are enunciated clearly and at a suitable volume. Older users in particular can be negatively impacted by issues such as hearing loss which can make it difficult for them to hear a robot under normal conditions, resulting in frustration and a reluctance to use the device [18].

The voice of the robot also appeared important to users, with the vast majority requesting that the robot be provided with a female voice, or the option to change it on request [29]. This functionality was particularly important to the younger participants.

Delay between SAR responses can make it difficult for users to anticipate what the robot is doing. Speech recognition issues can be compounded by factors that are more common in elderly users, particularly in a care home setting, such as distant speech, multiple speakers or dysarthric speech. The presence of visualised feedback for speech can also increase the robot's readability [55].

The main area in which people from different generations differ is in their concerns over robot usage. Most users were accepting of the robot, and all ages agreed that they expected the service robots to be able to help with household chores while achieving a good level of reliability and efficiency, but almost all users expressed concerns about the robots as well [70]. Generally younger users were concerned about privacy and cost, working adults were more sceptical of robot reliability, while older people were more positive and forgiving of flaws, but concerned about the difficulty of learning new technology and the potential that they may lose some independence as the SAR would take on a caregiver role.

Elderly users also worry about potential safety issues with having an autonomous robot in the house. One concern that arose was that robots may be let loose and drive towards people [18]. When passing over items, such as coffee, the participants requested that the robot instead place the cup on a table, rather than trying to hand it over directly. In general, users wanted the robot to stay at least one arm's length away from them, and for it to only move at a human walking speed [54].

Very little research is available on SAR acceptance from children. One study found that the perception of children between 6 and 13 of robots is generally positive and curious, with many supporting the idea of their own grandparents owning such a robot [61].

Researchers have looked into the impact of external factors such as social influence, hedonistic factors, performance expectancy, perceived usefulness and perceived ease of use [34, 39]. Each of these factors appeared to have a high impact on the user's motivation to utilise a SAR, although gender differences had a large impact on which of these factors were preferred. Women were generally more motivated by social expectations and entertainment, while men were more motivated by perceived usefulness and ease of use [39]. In terms of overall acceptance, elderly women were more accepting of robots and were more likely to think their lives would be improved by a SAR when compared to a similarly aged man [34]. Although male users appear to have more experience with computers and as such are more likely to perceive a robot as easier to use [42].

Subtle gender cues lead to people believing that robots are gendered, resulting in them applying social expectations to these robots [56]. This can have both a positive and negative effect in robot perception. Participants were likely to perceive robots with the opposite gender cues as more

uncanny than robots that are intended to share their gender, with men, in particular, being more likely to be impacted by this.

Factors such as education, technology proficiency and prior experiences appeared to have a significant impact on whether people felt positively towards robots. Service personnel, politicians, healthcare workers, people with a higher education level, older adults, people living in big cities and people with past robot experience were more positive towards SARs and perceived them as more useful and easier to use [32, 42]. However, the more educated a person was, the less likely they would be to perceive a robot as a social entity [42]. This experience was mirrored across regions as studies in both Europe and Asia corroborated this [24, 31, 34, 37].

Robots should be designed to accommodate different generations and cultures, by ensuring that they are respectful to social rules [37]. Research has been done into creating a robot that is targeted towards people from a specific geographic area and religion. Trovato et al. [66] used skeuomorphism to create a SAR in the shape of a Daruma, a figure of good luck in traditional Shinto and Buddhist beliefs. Daruma dolls are popular in both China and Japan and are a regular sight in both countries, particularly in areas where Shinto or Buddhist beliefs are common. The study was performed with 25 elderly people living in a care home, or that use care home facilities, in Japan. They found that while the elderly people studies were initially resistant to the idea of using new technologies such as robots, after interacting with the Daruma robot they were generally comfortable with the device. The few participants who were initially completely against, or afraid of, the idea of a robot changed their minds by the end of the study. The main intention of this study was that the Daruma robot would be more easily accepted than a generic humanoid robot such as the Nao, due to its familiarity with the target demographic. While this study indicates that the robot was popular, without conducting an equivalent study with a different device there is no definitive proof this was due to the design and not simply their reaction after interacting with an SAR.

The preferences between the age groups differed greatly. Older users were more receptive to adopting a SAR and understanding of flaws when compared to younger users. Concerns also differed between age groups, with younger users worrying more about security and privacy, while older users were more concerned about losing independence [70]. The two genders that we found studies for during this review showed some difference in their perception of what they would like the SAR to do. Men were likely to evaluate the SAR based on its perceived usefulness and ease of use, while women considered social expectations and entertainment more important [39, 42]. Geographic culture appeared to have the smallest impact on acceptance, as users from similar demographics in different regions appeared to have similar preferences. However, this may be influenced by the fact the majority of studies found in this review were performed in similarly wealthy countries, as seen in table 5.

4.3 RQ3) What Existing Research has been Done into the Concept of a "Needy" SAR?

An aspect of SAR design that warrants further investigation is that of integrating "needy" traits and features into a robot. The display of human-like emotions and facial features are received positively by users [58]. More specific human-like signs of distress or frustration were particular traits, which could be considered needy, that were popular among participants in the studies found. In a study by Gross et al. [19] the robot would call for help when impeded or stuck. Rather than viewing this negatively, participants found this aspect of the robot "endearing" and increased their acceptance of the device. Robots when asking for help should have sad or fearful eye expressions and should use polite language to achieve a pleasant interaction [68].

Expressing tiredness or minor failures to respond were viewed positively, despite instances where it resulted in poorer quality services being provided by the robot [17, 18]. While some acceptance of lower quality services can be viewed positively, this is not the case where the defective service has a long-lasting negative impact on the user, as this can erode trust with the SAR [36, 60].

Users are likely to ascribe human-like traits to companion robots, even in cases where this was not intended. Participants in the study by [40] would regularly decide that a robot has a particular personality, forgiving any faults as though it was a pet or person. Embarrassment is important for social functions and would allow for SARs to create a better impression and integrate more naturally with humans when they fail. Perceptions of embarrassment from a robot do not rely purely on the robot being humanoid, simply having some human characteristics such as a voice and face, has shown the ability to express this effectively [16]. In fact more human-like robots do not always result in more accurate emotional portrayals [67].

We found that very few studies have been published with the sole purpose of developing or assessing a "needy" robot. However, aspects of design and traits that can be considered "needy", such as calling for help and expressing tiredness, were evaluated positively by multiple studies found during this review. This indicates the potential for more thorough research to be done specifically focused on these traits.

5 Discussion

An aspect present in the majority of studies found for this review was that participants were initially reluctant to interact with a SAR [18, 33, 66]. This was seen across all age ranges and ability levels, however in most cases by the end of these studies participants changed their minds and were happy to interact with the SAR that was shown. While this is positive for acceptance for the short-term duration of the studies, not much research was available for whether this would continue to remain the case in the long term.

A key factor in SAR acceptance is whether or not they are provided with a personality [27]. While most smart devices on the market, such as the Amazon Echo or Google Home employ a clinical approach to their designs, preferences were shown in this study for SARs that were more personable. When given the choice a robot that interacts using formal language was less positively viewed than a robot that used more casual and friendly language [26, 43, 44]. Personable qualities come in many different forms. Independent robots that take the initiative in navigating around the property and beginning conversations with participants were viewed positively. Similarly responding quickly to questions and requests was also an important factor for whether they were accepted.

While participants, particularly those suffering from dementia, can be initially apprehensive, or even fearful, of robots, zoomorphic features and design can help to ease these feelings [40]. Specific studies have modified the design of their robot to be animal-like while tuning the behaviour to match, resulting in a significantly more positive reception from participants. Preferences around the size were less specific, but being shorter than the height of the person that it is supporting was viewed favourably by most [54]. It is important not to attempt to deceive users by pretending the robot is a living being, however, as most people found this demeaning.

One of the biggest issues that users face is the inability, or the lack of confidence, to use a SAR in any capacity. It cannot be assumed that users, particularly the elderly, will have extensive knowledge of technology, for this reason, the SAR must be easy to learn and use effectively. This has shown to be important not only to care receivers but also for ensuring that caregivers have the confidence to correctly utilise the SAR [33].

Multiple studies found that potential SAR users were concerned about whether the robot would be able to understand them when using voice control [49, 54]. Inaccurate speech detection was one reason stated for why this concern was present, however, another aspect was the way in which technology is usually aimed at an English-speaking target audience. An aspect that came up in multiple studies was the importance of ensuring that voice control was accurate and able to detect voice commands over a distance without errors. Users would quickly become frustrated when the robot did not react appropriately to voice commands and people that are unable to speak English or speak it as a second language, were concerned that they would be excluded [49, 54].

While most studies focus on the usage and acceptance of SARs from the perspective of a person receiving care, it's also important to consider the requirements of caregivers when designing a SAR that will be used in a care home. Trust, willingness to use and technical ability are all important factors to consider in order to ensure that caregivers are able to effectively use a SAR [33, 38]. Not only will this cut down on frustration for the caregiver, but will also ensure that they're able to utilise the SAR to its fullest.

Personal factors have a large effect on the acceptance of SARs. Education, wealth and experience with robots were some of the greatest factors in whether or not users would accept a SAR [32, 42]. As wealth and education can be difficult to directly influence, a more positive presentation of robots in the media may lead to better SAR perception in the future.

Xu et al. [70] opted to group their participants into three distinct categories based on age, namely elderly, middle "working age" and young adults. Concerns and preferences differed between users in these distinct ranges. The general finding was that people from the older generation were happier to use a SAR than those that were younger. Older people were most concerned about what adopting a SAR would mean for their independence and ability to be left alone. Some participants were also weary that this might result in less human interaction, as they believed that a robot could result in fewer visits from family members or care workers. They were also concerned that their level of technical proficiency could make it difficult for them to use the SAR effectively. Younger people were more concerned about privacy, as there were concerns about how much monitoring would be done of them, and where this data would be held. Middle "working age" users on the other hand were mostly concerned with functionality, as whether the robot would be useful in their day-to-day life was their main priority.

The chosen methods of interacting with the robot was also something that differed between generations. Both older and younger users showed a preference for using voice controls [55]. However the reason differed as older users considered it a necessity, while younger users preferred voice due to convenience. Voice commands can be more accessible and user-friendly than other methods of control, as less technology proficient users can find it difficult to navigate a

touchscreen interface [41]. Middle "working age", between the ages of 21 and 65, users were the outlier group as they had a preference for using touch control due to its familiarity [41].

Customisation was particularly important to younger users and may provide a method of bridging the gap in acceptance between younger and older people. While most users showed a preference for a feminine voice for the SAR, younger users in particular requested the option to choose for themselves. Also suggested was the ability to customise functionality to accommodate users who are unable to use traditional interfaces [64]. This could be extended to also allow for other traits, both functional and physical, to be changed by the user, increasing usability by allowing users to match functionality to their level of ability.

The studies we found during this review only explicitly considered the male and female genders. Of the two genders, the aspects that are expected and considered important between men and women differ in some capacity. Generally, it was found that women considered social expectations and entertainment as important, while men favoured perceived usefulness and ease of use [39]. While these preferences may not always be consistent, it is important to ensure that they are kept in mind when designing a robot to appeal to a specific demographic. From the works reviewed in this study, the difference in SAR perception between regions was not significant, with several studies indicating that their results were similar across geographic boundaries despite the same test cases. This was particularly apparent in the studies comparing whether or not user wealth and education had an impact on acceptance, as the findings were mirrored on studies conducted in both Europe and Asia. It is not clear whether other regions are the same in this matter, particularly as the countries used in existing studies are relatively wealthy.

While a great deal of work has been done into investigating the acceptance of SARs particularly for the elderly or otherwise vulnerable, there is a large gap in the research for the implementation of a needy robot. Many of the characteristics that could be considered needy, such as asking for help or failing tasks and displaying embarrassment, have already been identified as desirable in several studies [17–19, 68]. However, this research has only noted the benefits of these individual traits in studies focused on other factors. Further investigation needs to be done to ascertain whether integrating multiple intentionally needy traits in a SAR will increase user acceptance.

5.1 Acceptance Measures

As detailed in Table 1, a diverse range of different means were used in order to measure the acceptance of SARs, aiming to understand how users perceive and interact with these robots. These methods ranged from structured approaches through the use of frameworks, to more open-ended approaches, such as interviews and observations, allowing for both precise and exploratory insights into SAR acceptance.

Many studies opted to utilise established frameworks such as Unified Theory of Acceptance and Use of Technology (UTAUT) [72], Technology Acceptance Model (TAM) [73] and System Usability Scale (SUS) [74], which are commonly applied in technology evaluation to assess acceptance, usability and performance. Others chose to use

Table 1 Methods used for evaluating SAR acceptance

Method	Description
Technology Acceptance Model (TAM)	Evaluates acceptance of technology through perceived usefulness and ease of use.
Unified Theory of Acceptance and Use of Technology (UTAUT)	Builds upon the TAM with a more comprehensive criteria.
Almere Model	Measures functional and social acceptance in robot interaction.
Adapted UTAUT/Almere	Custom adaptations to measure SAR-specific acceptance.
Behavioural Coding	Categorises user reactions as positive, neutral, negative, or non-responsive.
Interaction Coding Schema	Structured coding of video interactions to assess engagement.
Godspeed Questionnaire	Measures users' perceptions of robot anthropomorphism and likability.
Robot Attitude Scale	Evaluates attitudes toward SAR features and functionalities.
Observational Analysis	Observes and records real-world interactions and acceptance indicators.
Semi-structured Interviews	Collects qualitative feedback on user experience and satisfaction.
System Usability Scale (SUS)	Quantifies usability perceptions of SAR interfaces.
Empathy Scales	Assesses user empathy toward the robot.
Self-Assessment Manikin	Visualises emotional responses to SAR interactions.
Scenario Acceptance Scale	Measures acceptance in various usage scenarios.
Daily and Final Interviews	Provides continuous and end-of-study insights on SAR engagement.
Reaction Categorisation	Simplifies user reactions into positive, neutral, or negative categories.
Perceived Anthropomorphism	Assesses human-like qualities perceived in SARs.

Table 2 Country-wise distribution of SAR studies and their percentage of the total (N = 52) [16–19, 24–71]

Country	Total Studies	Percentage
Austria	2	3.85%
Canada	1	1.92%
China	1	1.92%
Denmark	1	1.92%
EU Wide	4	7.69%
Finland	1	1.92%
France	2	3.85%
Germany	4	7.69%
India	1	1.92%
Italy	1	1.92%
Japan	5	9.62%
Netherlands	5	9.62%
Norway	1	1.92%
Portugal	1	1.92%
Singapore	3	5.77%
Spain	1	1.92%
Taiwan	2	3.85%
Turkey	1	1.92%
UK	6	11.54%
USA	1	1.92%
Unknown	8	15.38%

frameworks that have been tailored specifically for SARs, such as the ALMERE model, which identifies several key characteristics that they deem as crucial for SAR acceptance [75]. Some researchers developed custom variations of these frameworks to measure additional factors that have not been considered by the traditional frameworks, tailoring their approach to capture unique aspects that are deemed important for measuring acceptance.

Qualitative insights have been obtained through the use of semi-structured interviews and contextual observations. Unlike the quantitative approaches taken by other studies, participants are able to provide their own specific insights regarding motivations, concerns and other social dimensions that impact their acceptance of SARs.

Alternative methods of assessing acceptance included more novel means, such as through the use of visual and computer vision analysis of video recordings in order to observe real-time engagement to capture non-verbal cues that indicate user comfort and engagement. These methods analysed user's facial expressions and physical responses to their interaction, providing a more dynamic view of their emotional responses to the SARs. Ultimately we can see that from the variety of different means used to evaluate acceptance, that the very concept of acceptance differs based on the context of the study and the expected outcomes.

Table 3 Continent-wide distribution of SAR studies and their percentage of the total (N = 44) [16–19, 24–36, 38–40, 43–49, 51–55, 57–61, 63–66, 69–71]. Studies with "Unknown" countries have been omitted

Continent	Total Studies	Percentage
Africa	0	0.00%
Antarctica	0	0.00%
Asia	13	29.55%
Australia	0	0.00%
Europe	29	65.91%
North America	2	4.55%
South America	0	0.00%

Table 4 World Bank classification of countries by income level July 1, 2024 - for FY25 [76]

Income Classification	GNI per Capita (USD)
Low Income	$1,145 or less
Lower Middle Income	$1,146 - $4,515
Upper Middle Income	$4,516 - $14,005
High Income	$14,005 or more

Table 5 Number of studies grouped by economic classification according to the World Bank [76] (N = 40) [16–19, 24, 26–30, 33–36, 38–40, 43–49, 51–54, 57–61, 63–66, 69–71]. Studies with "Unknown" or "EU Wide" as their location have been omitted

Economic Classification	Total Studies	Percentage
High-Income	37	92.50%
Upper-Middle-Income	2	5.00%
Lower-Middle-Income	1	2.50%
Low-Income	0	0.00%

5.2 Study Locations

The studies found in this literature review were largely conducted in western and European countries, with a significant concentration in a select few countries such as the Netherlands, UK, and Japan Table 2. More than half of the studies were conducted in Europe Table 3. Our review of the literature found no studies from Africa, Antarctica, Australia, or South America.

World Bank classifies countries into four income groups based on their gross capital income per capita for the previous year [76]. The four classifications can be seen in Table 4. As shown in Table 5, 92.50% of the countries included in this study are classified as "High-Income" by World Bank [76]. Countries classified as "Upper-Middle-Income" and "Lower-Middle-Income" make up a much smaller percentage of the total. Notably, none of the countries involved in this study are classified as "Low-Income" Table 6.

These geographic and economic factors may influence the acceptance rates of SARs as individuals in wealthier

Table 6 Economic classification of study locations [16–19, 24–71] by World Bank [76]

High-Income	Upper-Middle-Income	Lower-Middle-Income
Austria	China	India
Canada	Turkey	
Denmark		
Finland		
France		
Germany		
Italy		
Japan		
Netherlands		
Norway		
Portugal		
Singapore		
Spain		
Taiwan		
UK		
USA		

countries may have more access to technologies in their daily lives and are likely to have a higher level of digital literacy as a result. This familiarity will influence their opinions of SARs due to the potential for an increased level of comfort when interacting with new technologies. However, those in lower income countries may be reluctant to accept SARs due to the associated costs and skepticism about functionality and reliability. For these reasons, the studies found in this review may not generalise as well for non-European and low-income countries, indicating the need for further research across a more diverse economic, geographic, and cultural context.

6 Conclusion

Demographics differ in their wants and needs when it comes to the type of SAR that they will accept. One method to bridge this gap is to provide the user with the ability to customise the functionality of the robot in some way, whether this be in functionality or simply social characteristics [29, 64]. We have also highlighted the importance of including care workers when designing a SAR, as their needs regularly differ greatly from those of care receivers [33, 38].

The most important traits of the SAR appeared to differ between the two genders for which we have data, with men caring more about the usefulness and ease of use, while women were more concerned about entertainment and social experience [39]. Users with a high level of education, particularly those with technical backgrounds, were also more positive of SARs than those without [32, 42].

Different age groups not only show differing levels of acceptance but also have different priorities when it comes to SAR functionality, security and usage [24, 29, 49, 54, 70]. Several of these factors were directly tied to age, such as older people preferring voice control due to the perceived ease of use when compared to a physical interface [55]. Other factors however, including security and privacy, are not so directly dependent on users age, and may instead by influenced by cultural factors, such as growing concerns surrounding multinational companies taking control of user data and the safeguards that have been put in place by local governments, like GDPR in the EU [70]. For these reasons, the aspects that are important to elderly users may change over time as the younger generation gets older.

While age, financial situation and education [32, 42] appeared to have a great deal of impact on acceptance and general views about robots, geographical location appeared to have minimal effect on this [24, 31, 34, 47]. This may be influenced by the fact that most current research has been performed in relatively wealthy countries, as seen in Table 5. More work can be done to ensure that similar studies are conducted in a more diverse range of countries with different economic backgrounds to ensure that their needs are accurately catered for. Another aspect that will benefit from future research is the development of SARs that cater towards a specific regional or religious culture through the use of culturally understood iconography and symbols, such as the Daruma [66]. Existing work in this field is limited but shows the potential to have a significant impact in the future.

The findings of this study highlight several avenues that warrant further study and investigation. Aspects that could be seen as "needy" have been shown to increase acceptance, but there is a lack of research in neediness as the defining trait for a SAR [16–19, 36, 40, 58, 60, 68]. We suggest that a robot designed around the concept of embracing that neediness would be positively received, particularly for the predominantly elderly demographics that would use this type of device.

Appendix a PRISMA Report

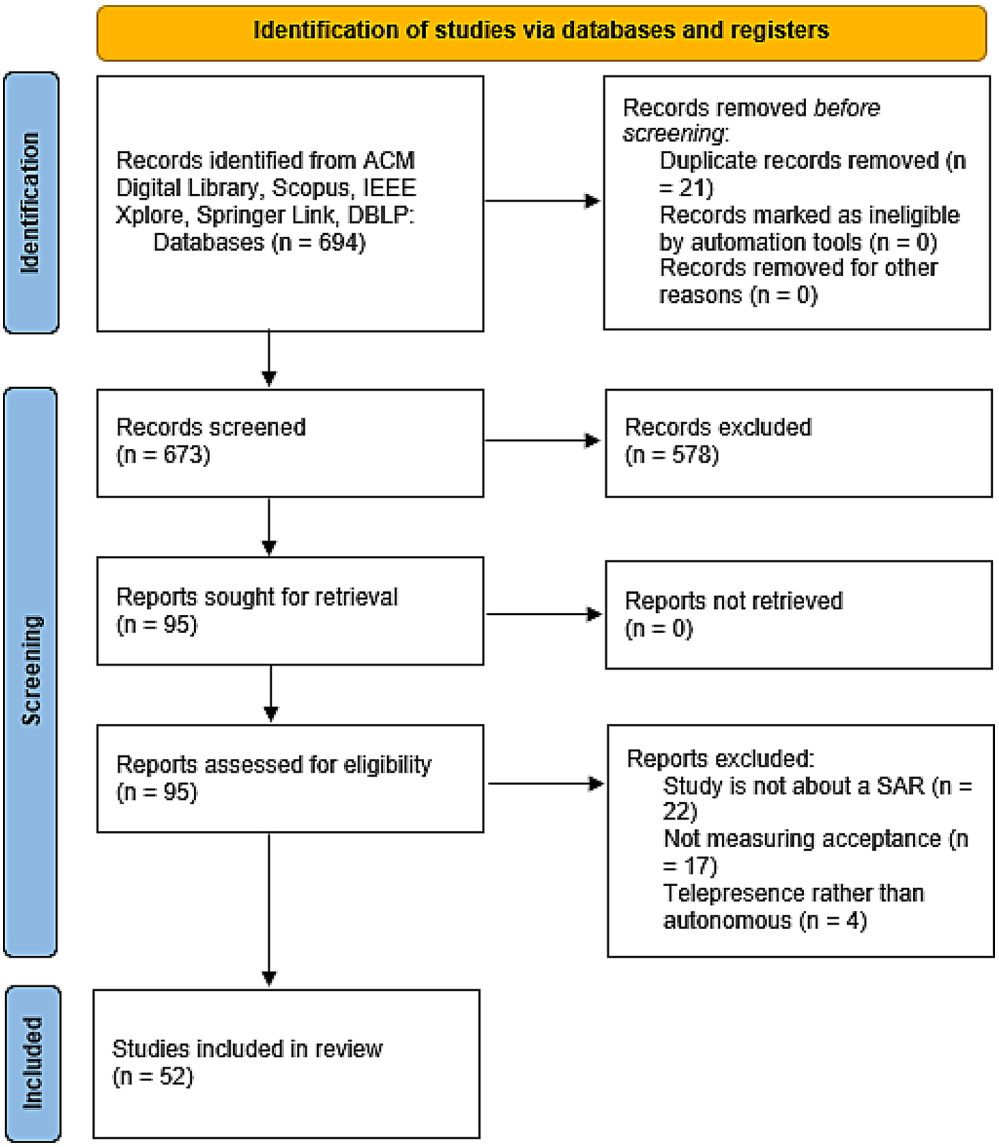

Fig. 1 PRISMA flow diagram

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Data availability The datasets analysed during the current study are available in the ACM Digital Library, Scopus, IEEEXplore, Springer Link and DBLP repositories.

Declarations

Ethical approval Not applicable.

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Statistics bureau home page/population estimates monthly report. https://www.stat.go.jp/english/data/jinsui/tsuki/index.html.
2. Feil-Seifer D, Matarić MJ (2005) Defining socially assistive robotics. In: Proceedings 2005 IEEE 9th Int Conf Rehabil Robot 2005:465–468. https://doi.org/10.1109/ICORR.2005.1501143
3. Bedaf S, Gelderblom GJ, Witte LD (2015) Overview and categorization of robots supporting independent living of elderly people: what activities do they support and how far have they developed. 27:88–100. https://www.tandfonline.com/doi/abs/10.1080/10400435.2014.978916;https://doi.org/10.1080/10400435.2014.978916
4. Gan GZH, Hill AM, Yeung P, Keesing S, Netto JA (2019) Pet ownership and its influence on mental health in older adults. 24:1605–1612. https://www.tandfonline.com/doi/abs/10.1080/13607863.2019.1633620;https://doi.org/10.1080/13607863.2019.1633620
5. Brickel CM (1995) A review of the roles of pet animals in psychotherapy and with the elderly. 12:119–128. https://journals.sagepub.com/doi/abs/10.2190/W4LL-P7PJ-XG1C-2M5M;https://doi.org/10.2190/W4LL-P7PJ-XG1C-2M5M
6. Moretti F, et al (2011) Pet therapy in elderly patients with mental illness. Psychogeriatrics 11:125–129. https://onlinelibrary.wiley.com/doi/full/10.1111/j.1479-8301.2010.00329.x?msockid=06638995c45965ef17499b55c56164d0;https://doi.org/10.1111/J.1479-8301.2010.00329.X
7. Enders-Slegers MJ, Hediger K (2019) Pet ownership and human–animal interaction in an aging population: rewards and challenges. 32:255–265. https://www.tandfonline.com/doi/abs/10.1080/08927936.2019.1569907.; https://doi.org/10.1080/08927936.2019.1569907
8. Tkatch R, et al (2020) Reducing loneliness and improving well-being among older adults with animatronic pets. 25:1239–1245. https://www.tandfonline.com/doi/abs/10.1080/13607863.2020.1758906;https://doi.org/10.1080/13607863.2020.1758906
9. Bates M (2019) Robotic pets: a senior's best friend? IEEE Pulse 10:17–20. https://doi.org/10.1109/MPULS.2019.2922565
10. Paro therapeutic robot. http://www.parorobots.com/.
11. Pepper the humanoid and programmable robot softbank robotics. https://www.softbankrobotics.com/emea/en/pepper.
12. Amazon.com: amazon astro, household robot for home monitoring, with alexa, includes 6-month free trial of ring protect pro. https://www.amazon.com/Introducing-Amazon-Astro/dp/B078NSDFSB.
13. UK smart speaker adoption surpasses U.S. in 2020 - new report with 33 charts - voicebot.ai. https://voicebot.ai/2021/06/18/uk-smart-speaker-adoption-surpasses-u-s-in-2020-new-report-with-33-charts/.
14. The rise and stall of the U.S. smart speaker market - new report - voicebot.ai. https://voicebot.ai/2022/03/02/the-rise-and-stall-of-the-u-s-smart-speaker-market-new-report/.
15. Britannica E (2024) Needy definition and meaning - Britannica dictionary. Britannica
16. Park S, Healey PGT, Kaniadakis A (2021) Should robots blush? https://doi.org/10.1145/3411764.3445561
17. Iwasaki Y, Gushima K, Tamaki E (2019) Interaction with the mercurial robot: work assisting robot express the tiredness. https://doi.org/10.1145/3324033.3324040
18. Carros F, et al (2020) Exploring human-robot interaction with the elderly: results from a ten-week case study in a care home. Association for Computing Machinery 1–12. https://doi.org/10.1145/3313831.3376402
19. Gross HM, et al (2019) Living with a mobile companion robot in your own apartment - final implementation and results of a 20-weeks field study with 20 seniors. 2253–2259. Institute of Electrical and Electronics Engineers Inc., Cited By:18 Export Date: 22 June 2022 CODEN: PIIAE https://ieeexplore.ieee.org/document/8793693
20. Jones N, Loizides F, Jones K (2023) A theoretical framework for the development of "needy" socially assistive robots. Lect Notes Comput Sci 396–401. https://doi.org/10.1007/978-3-031-42293-5_42
21. Page MJ, et al (2021) The prisma 2020 statement: an updated guideline for reporting systematic reviews. BMJ 372. https://doi.org/10.1136/BMJ.N71
22. Šabanovic S, Bennett CC, Chang WL, Huber L (2013) Paro robot affects diverse interaction modalities in group sensory therapy for older adults with dementia. IEEE Int Conf Rehabil Robot. https://doi.org/10.1109/ICORR.2013.6650427
23. Nao the humanoid and programmable robot softbank robotics. https://www.softbankrobotics.com/emea/en/nao.
24. Andtfolk M, Nyholm L, Eide H, Rauhala A, Fagerström L (2021) Attitudes toward the use of humanoid robots in healthcare–a cross-sectional study. AI and Society. https://link.springer.com/content/pdf/10.1007/s00146-021-01271-4.pdf;https://doi.org/10.1007/s00146-021-01271-4
25. Bajones M, et al (2019) Results of field trials with a mobile service robot for older adults in 16 private households. J Hum -Robot Interact 9(2):Article10. https://doi.org/10.1145/3368554
26. Bartl A, Bosch S, Brandt M, Dittrich M, Lugrin B (2016) The influence of a social robot's persona on how it is perceived and accepted by elderly users. Agah A, Salichs MA, He H, Cabibihan JJ, Howard AM (eds) vol 9979 LNAI 681–691 Springer Verlag. https://www.researchgate.net/publication/307594655_Ethical_Decision_Making_in_Robots_Autonomy_Trust_and_Responsibility_Autonomy_Trust_and_Responsibility. Cited By:8 Export Date: 22 June 2022 Correspondence Address: Lugrin, B.; Human Computer Interaction, Germany; email: birgit.lugrinuni-wuerzburg.de
27. Bevilacqua R, Felici E, Cavallo F, Amabili G, Maranesi E (2021) Designing acceptable robots for assisting older adults: a pilot study on the willingness to interact. Int J Environ Res Public Health 18(20). https://www.mdpi.com/1660-4601/18/20/10686;https://doi.org/10.3390/ijerph182010686. URL., cited By:1 Export Date: 22 June 2022 Correspondence Address: Amabili, G.; IRCCS INRCA Scientific DirectionItaly; email: g.amabiliinrca.it
28. Bishop L, Van Maris A, Dogramadzi S, Zook N (2019) Social robots: the influence of human and robot characteristics on acceptance. Paladyn 10(1):346–358. https://www.degruyter.com/document/doi/10.1515/pjbr-2019-0028;https://doi.org/10.1515/pjbr-2019-0028. cited By:20 Export Date: 22 June 2022 Correspondence Address: Bishop, L.; Cardif UniversityUnited Kingdom; email: bishoplm2cardif.ac.uk
29. Biswas M, Romeo M, Cangelosi A, Jones RB (2020) Are older people any different from younger people in the way they want to interact with robots? scenario based survey. J Multimod User Interf 14(1):61–72. https://doi.org/10.1007/s12193-019-00306-x. https://link.springer.com/content/pdf/10.1007/s12193-019-00306-x
30. Carlotta B, Rainer H, Bechtold US, J H, et al Socially assistive robots diffusion in elderly care: a pre-adoption study through agent-based modeling, Steenhuis HJ (eds). et al. Institute of Electrical and Electronics Engineers Inc.https://ieeexplore.ieee.org/document/8482001. Cited By:1 Export Date: 22 June 2022…
31. Carradore M (2021) Social robots in the home: what factors influence attitudes towards their use in assistive care? Ital Sociol Rev 11(3):879–901. https://italiansociologicalreview.com/ojs/index.php/ISR/article/view/497;https://doi.org/10.13136/isr.v11i3.497. export Date: 22 June 2022 Correspondence Address: Carradore,

M.; Department of Human Sciences, Italy; email: marco.carradoreunivr.it
32. Carradore M (2022) People's attitudes towards the use of robots in the social services: a multilevel analysis using eurobarometer data. Int J Soc Robot 14(3):845–858. https://link.springer.com/content/pdf/10.1007/s12369-021-00831-4;https://doi.org/10.1007/s12369-021-00831-4. cited By:1 Export Date: 22 June 2022 Correspondence Address: Carradore, M.; University of Verona: Università degli Studi di VeronaItaly; email: marco.carradoreunivr.it
33. Carros F, et al (2022) Care workers making use of robots: results of a three-month study on human-robot interaction within a care home. https://doi.org/10.1145/3491102.3517435
34. Chen N, Liu X, Sun Y (2020) Study on acceptance of social robots by aging adults living alone. In: Stephanidis C, Antona M, Gao Q, Zhou J (eds) LNCS 482–494 (Springer Science and Business Media Deutschland GmbH). https://dl.acm.org/doi/10.1007/978-3-030-60149-2_37. Export Date: 22 June 2022 Correspondence Address: Sun, Y.; Beijing University of Chemical TechnologyChina; email: y_sun_kyuoutlook.com, vol 12426., pp..
35. Cooney M, Nishio S, Ishiguro H (2014) Affectionate interaction with a small humanoid robot capable of recognizing social touch behavior. ACM Trans Interact Intell Syst 4(4):Article19. https://doi.org/10.1145/2685395
36. Cormons L, Poulet C, Pellier D, Pesty S, Fiorino H (2022) Testing social robot acceptance: what if you could be assessed for dementia by a robot? a pilot study. Institute of Electrical and Electronics Engineers Inc. 92–98. https://typeset.io/pdf/testing-social-robot-acceptance-what-if-you-could-be-715l5p4z7n.pdf. Cited By:5 Export Date: 22 June 2022
37. Diaz M, Saez-Pons J, Heerink M, Angulo C Emotional factors in robot-based assistive services for elderly at home. 711–716. https://ieeexplore.ieee.org/abstract/document/6628396. Cited By:10 Export Date: 22 June 2022 Correspondence Address: CETpD Technical Research Center for Dependency Care and Autonomous Living, Rambla Exposició, 59-69, 08800 Vilanova i la Geltrú, Barcelona, Spain
38. Erebak S, Turgut T (2019) Caregivers' attitudes toward potential robot coworkers in elder care. Cogn Technol Work 21(2):327–336. https://doi.org/10.1007/s10111-018-0512-0. https://link.springer.com/content/pdf/10.1007/s10111-018-0512-0
39. Forgas-Coll S, Huertas-Garcia R, Andriella A, Alenyà G (2021) How do consumers' gender and rational thinking affect the acceptance of entertainment social robots? Int J Soc Robot. https://link.springer.com/content/pdf/10.1007/s12369-021-00845-y.pdf;https://doi.org/10.1007/s12369-021-00845-y. export Date: 22 June 2022 Correspondence Address: Forgas-Coll, S.; Business Department, Avda. Diagonal, 690, Spain; email: Santiago.forgasub.edu
40. Gross HM, et al Further progress towards a home robot companion for people with mild cognitive impairment. 637–644. https://ieeexplore.ieee.org/stampPDF/getPDF.jsp?tp=%26arnumber=6377798%26ref=
41. Hammer S, Kirchner K, André E, Lugrin B Touch or talk?: comparing social robots and tablet pcs for an elderly assistant recommender system. IEEE Computer Society. 129–130. https://dl.acm.org/doi/10.1145/3029798.3038419. Cited By:7 Export Date: 22 June 2022
42. Heerink M Exploring the influence of age, gender, education and computer experience on robot acceptance by older adults. 147–148. https://dl.acm.org/doi/10.1145/1957656.1957704. Cited By:87 Export Date: 22 June 2022 Correspondence Address: Heerink, M.; Windesheim Flevoland University of Applied Sciences,, Almere, Netherlands; email: m.heerinkwindesheimflevoland.nl
43. Heerink M, Kröse B, Evers V, Wielinga B (2006) The influence of a robot's social abilities on acceptance by elderly users. Institute of Electrical and Electronics Engineers Inc., 521–526. https://ieeexplore.ieee.org/document/4107860?arnumber=4107860. Cited By:91 Export Date: 22 June 2022 Correspondence Address: Heerink, M.; Instituut voor Information Engineering, Almere, Netherlands; email: m.heerinkhva.nl
44. Heerink M, Kröse B, Evers V, Wielinga B (2010) Relating conversational expressiveness to social presence and acceptance of an assistive social robot. Virtual Reality 14(1):77–84. https://doi.org/10.1007/s10055-009-0142-1. https://link.springer.com/content/pdf/10.1007/s10055-009-0142-1
45. Heerink M, Kröse B, Wielinga B, Evers V (2008) Enjoyment intention to use and actual use of a conversational robot by elderly people. https://doi.org/10.1145/1349822.1349838
46. Heerink M, Kröse B, Wielinga B, Evers V Measuring the influence of social abilities on acceptance of an interface robot and a screen agent by elderly users. British Computer Society. 430–439. https://www.scienceopen.com/hosted-document?doi=10.14236/ewic/HCI2009.54. Cited By:35 Export Date: 22 June 2022 Correspondence Address: Heerink, M.; Hogeschool Van Amsterdam,, Almere, Netherlands; email: m.heerinkhva.nl
47. Huang T, Huang C (2020) Elderly's acceptance of companion robots from the perspective of user factors. Universal Access Inf Soc 19(4):935–948. https://dl.acm.org/doi/10.1007/s10209-019-00692-9;https://doi.org/10.1007/s10209-019-00692-9. cited By:3 Export Date: 22 June 2022 Correspondence Address: Huang, T.; Doctoral Program in Design, 1, Sec. 3, Zhongxiao E. Rd., Taiwan; email: huangtianyang615163.com
48. Huang T, Huang C (2021) Attitudes of the elderly living independently towards the use of robots to assist with activities of daily living. Work Reading, Mass 69(1):55–65. https://pubmed.ncbi.nlm.nih.gov/34024801/;https://doi.org/10.3233/WOR-205166. cited By:1 Export Date: 22 June 2022
49. Joglekar P, Kulkarni V Humanoid robot as a companion for the senior citizens. Institute of Electrical and Electronics Engineers Inc. https://ieeexplore.ieee.org/document/8745399. Export Date: 22 June 2022
50. Klamer T, Allouch SB Acceptance and use of a social robot by elderly users in a domestic environment. https://eudl.eu/doi/10.4108/icst.pervasivehealth2010.8892. Cited By:61 Export Date: 22 June 2022 Correspondence Address: Klamer, T.; Department Media, Society and Organization,, Enschede, Netherlands; email: T.Klamerutwente.nl.
51. Louie WYG, McColl D, Nejat G (2014) Acceptance and attitudes toward a human-like socially assistive robot by older adults. Assistive Technol. 26(3):140–150. https://www.tandfonline.com/doi/full/10.1080/10400435.2013.869703;https://doi.org/10.1080/10400435.2013.869703. cited By:85 Export Date: 22 June 2022 CODEN: ASTEF Correspondence Address: Louie, W.-Y.G.; Autonomous Systems and Biomechatronics Laboratory, Department of Mechanical and Industrial Engineering, University of Toronto, 5 King's College Road, Toronto, ON, M5S 3G8, Canada; email: Geoffrey.Louiemail.utoronto.ca
52. Marchetti E, Grimme S, Hornecker E, Kollakidou A, Graf P (2022) Pet-robot or appliance? care home residents with dementia respond to a zoomorphic floor washing robot. https://doi.org/10.1145/3491102.3517463
53. Mishra N, et al (2021) Does elderly enjoy playing bingo with a robot? a case study with the humanoid robot nadine Magnenat-Thalmann N (eds) et al, 13002 LNCS 491–503 (Springer Science and Business Media Deutschland GmbH). https://dl.acm.org/doi/10.1007/978-3-030-89029-2_38. Export Date: 22 June 2022 Correspondence Address: Mishra, N.; Institute for Media Innovation, Singapore; email: nidhimishra2906gmail.com vol….
54. Ng J, Tan O, Wong A, Kiat KW (2012) Older adults' attitudes toward homes service robots. https://doi.org/10.1145/2425296.2425312

55. Oliveira J, et al Speaking robots: the challenges of acceptance by the ageing society. 1285–1290. https://ieeexplore.ieee.org/stampPDF/getPDF.jsp?tp=%26arnumber=8172470%26ref=
56. Otterbacher J, Talias M (2017) S/he's too warm/agentic! the influence of gender on uncanny reactions to robots. https://doi.org/10.1145/2909824.3020220
57. Pütten AMVD, Krämer NC, Eimler SC (2011) Living with a robot companion: empirical study on the interaction with an artificial health advisor. https://doi.org/10.1145/2070481.2070544
58. Rincon JA, Costa A, Novais P, Julian V, Carrascosa C (2019) A new emotional robot assistant that facilitates human interaction and persuasion. Knowledge Inf Syst 60(1):363–383. https://doi.org/10.1007/s10115-018-1231-9. https://link.springer.com/content/pdf/10.1007/s10115-018-1231-9
59. Sabelli AM, Kanda T, Hagita N (2011) A conversational robot in an elderly care center: an ethnographic study. https://doi.org/10.1145/1957656.1957669
60. Salem M, Lakatos G, Amirabdollahian F, Dautenhahn K (2015) Would you trust a (faulty) robot? effects of error, task type and personality on human-robot cooperation and trust. https://doi.org/10.1145/2696454.2696497
61. Søraa RA, Nyvoll PS, Grønvik KB, Serrano JA (2021) Children's perceptions of social robots: a study of the robots pepper, av1 and tessa at norwegian research fairs. AI and Society 36(1):205–216. https://doi.org/10.1007/s00146-020-00998-w. https://link.springer.com/content/pdf/10.1007/s00146-020-00998-w
62. Stuck RE, Rogers WA (2017) Understanding older adult's perceptions of factors that support trust in human and robot care providers. https://doi.org/10.1145/3056540.3076186
63. Syrdal DS, Dautenhahn K, Koay KL, Ho WC (2014) Views from within a narrative: evaluating long-term human–robot interaction in a naturalistic environment using open-ended scenarios. Cogni Comput 6(4):741–759. https://doi.org/10.1007/s12559-014-9284-x. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4255091/pdf/12559%5F2014%5FArticle%5F9284.pdf
64. Takanokura M, Kurashima R, Ohhira T, Kawahara Y, Ogiya M (2021) Implementation and user acceptance of social service robot for an elderly care program in a daycare facility. J Ambient Intell Humaniz Comput. https://link.springer.com/content/pdf/10.1007/s12652-020-02871-6;https://doi.org/10.1007/s12652-020-02871-6. export Date: 22 June 2022 Correspondence Address: Takanokura, M.; Department of Industrial Engineering and Management, 3-27-1 Rokkakubashi, Kanagawa-ku, Japan; email: takanokurakanagawa-u.ac.jp
65. Torta E, et al (2014) Evaluation of a small socially-assistive humanoid robot in intelligent homes for the care of the elderly. J Intell Robotic Syst 76(1):57–71. https://link.springer.com/content/pdf/10.1007/s10846-013-0019-0;https://doi.org/10.1007/s10846-013-0019-0. cited By:58 Export Date: 22 June 2022 CODEN: JIRSE Correspondence Address: Torta, E.; Eindhoven University of TechnologyNetherlands
66. Trovato G, et al The creation of darumato: a social companion robot for buddhist/shinto elderlies. 606–611. https://ieeexplore.ieee.org/stampPDF/getPDF.jsp?tp=%26arnumber=8868736%26ref=
67. Tsiourti C, Weiss A, Wac K, Vincze M (2017) Designing emotionally expressive robots: a comparative study on the perception of communication modalities. https://doi.org/10.1145/3125739.3125744
68. Westhoven M, Grinten TVD, Mueller S (2019) Perceptions of a help-requesting robot - effects of eye-expressions, colored lights and politeness of speech. https://doi.org/10.1145/3340764.3340783
69. Wu YH, et al (2014) Acceptance of an assistive robot in older adults: a mixed-method study of human-robot interaction over a 1-month period in the living lab setting. Clin Interventions Aging 9:801–811. https://pubmed.ncbi.nlm.nih.gov/24855349/;https://doi.org/10.2147/CIA.S56435. cited By:116 Export Date: 22 June 2022 Correspondence Address: Wu, Y.-H.; Hôpital Broca, 54–56 rue Pascal, Paris 75013, France; email: yahuei.wubrc.aphp.fr
70. Xu Q, Ng JSL, Tan OY, Huang Z (2015) Needs and attitudes of singaporeans towards home service robots: a multi-generational perspective. Universal Access Inf Soc 14(4):477–486. https://doi.org/10.1007/s10209-014-0355-2. https://link.springer.com/content/pdf/10.1007/s10209-014-0355-2
71. Zhang T, et al (2010) Service robot feature design effects on user perceptions and emotional responses. Intell Serv Rob 3(2):73–88. https://link.springer.com/content/pdf/10.1007/s11370-010-0060-9;https://doi.org/10.1007/s11370-010-0060-9. cited By:39 Export Date: 22 June 2022 Correspondence Address: Kaber, D. B.; Edward P. Fitts Department of Industrial, Raleigh, United States; email: dbkaberncsu.edu
72. Venkatesh M (2003) Davis & Davis. User acceptance of information technology: toward a unified view. MIS Q 27(3):425
73. Davis FD (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q 13(3):319
74. Brooke J (1996) SUS: a 'quick and dirty' usability scale 207–212. CRC Press
75. Heerink M, Kröse B, Evers V, Wielinga B (2010) Assessing acceptance of assistive social agent technology by older adults: the almere model. Int J Soc Robot 2(4):361–375
76. Metreau E, Young KE, Eapen SG (2024) World Bank country classifications by income level for 2024-2025. https://blogs.worldbank.org/en/opendata/world-bank-country-classifications-by-income-level-for-2024-2025;. Accessed 2024-10-31

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