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Exploring potential of a socially assistive robot in facilitating daily activities for older adults

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Background: As the older adult population continues to rise, there is a need to support their ability to age in place. Socially assistive robots can fill these needs and improve older adults' quality of life.
Objective: Our goal was to understand the perceptions of technology and open-source robots that could be implemented in the home. We wanted to understand how a socially assistive robot, namely Misty, can assist in engaging older adults in social interaction and other activities. We were interested in older adults' perceptions as well as their ideas for additional uses of this type of socially assistive robot.
Methods: We used a mixed methods approach. Questionnaires assessed participant characteristics, robot and technology experience, technology proficiency and readiness, and responses to emotion words related to Misty. Following video demonstrations of Misty, we used semi-structured interviews to assess perceptions about the robot, ideas for additional uses, and recommendations for the ideal design of a socially assistive robot for use in their home.
Results: The older adults generally had positive perceptions of using the Misty robot and felt that "responsive" and "friendly" were words that described it. They indicated that they would enjoy using the Misty robot and that it would be useful for activities of daily living. They had varied suggestions for design improvements that may be indicative of the need for the personalization of social robots.
Conclusion: Understanding how socially assistive robots can support older adults in their homes will advance the design of these robots to support diverse needs and be adopted for everyday use. The mixed methods approach provided different insights into older adults' perceptions. In general, the participants were receptive to the idea of having socially assistive robots in their homes and had suggestions for applications. We provide design recommendations based on their input.

Keywords: socially assistive robot, aging in place, participatory design

Introduction

Older adults may find the availability of necessary support for age-related changes such as caregiving and home modification limited and costly. Coupled with a lack of home and community-based service resources, these challenges emphasize the need for innovative solutions. One such solution is socially assistive robots (SARs) to provide assistance through social interaction. SARs can assist with various everyday activities and provide access to necessary resources such as emergency support and activity engagement.

Acceptance of socially assistive robots in the home

Successful implementation of robot SARs in the homes of older adults requires their interest in adoption and acceptance. Encouragingly, older adults have shown interest in using robots in home settings (Ajaykumar & Huang, 2023; Whelan et al., 2018; Zafrani et al, 2024) such as to support health monitoring and fall detection (Van Aerschot & Parviainen, 2020; Shishehgar et al., 2018), indicating a desire to incorporate this technology into their daily lives.

SAR social capabilities may positively impact older adults' mental health, reducing anxiety, stress, and depression (Petersen et al., 2017, Scoglio et al., 2019;). SARs have been shown to reduce loneliness, enhance mental and physical health, and support the cognitive function of older adults with cognitive impairments (Macis et al., 2022; Tapus et al., 2010). SARs have a promising potential in supporting older adults (e.g., companionship; Robaczewski et al., 2021), but concerns pertain to how use may impact engagement in physical activity (Deutsch et al., 2019). These concerns underscore the importance of ensuring robots are designed to address a range of needs and encourage older adults to maintain rather than replace their physical activity. The acceptability of robots in home settings, particularly among older adults, is influenced by a range of factors, including cognitive, affective, and emotional components

(Scopelliti et al., 2005). These factors are further shaped by the design and functionality of the robot, with a need for consideration of the social, aesthetic, and emotional aspects of human-robot interaction (Becchimanzi et al., 2022).
Nagamachi (2014) emphasized the importance of integrating ergonomic principles into robotics to enhance user comfort and quality of life, particularly in elder care. Kansei engineering aims to develop a new product based on human emotion and improve product development (Nagamachi, 2016). Research in Kansei ergonomics for older adults has focused on various aspects of product design and community ergonomics. Nagamachi et al. (2000) and Chen et al. (2017) emphasized the importance of considering the affective preferences and needs of older adults in the design of functional products, highlighting the demand for mobility-assisting and communication products. Kansei engineering focuses on human emotion in the interaction between the user and the technical system and aims to optimize the relationship between people and machines. This human-centered approach seeks to enhance emotions such as desire, need, comfort, relaxation, ease of use, beauty, attraction, and good taste—collectively known as "Kansei." The objective is to identify the most appropriate emotion for each situation, analyzing context from the perspective of positive relationships between human life and living conditions to find the most comfortable design elements.

Commercially available robots

Commercially available SARs have been shown to support older adults (Zafrani et al., 2024). SARs are capable of emotional support and companionship and encouraging social interaction. For example, interventions with dementia patients showed that PARO may alleviate negative emotions and reduce behavioral symptoms (Hung et al., 2019). Pepper is a SAR designed to interact through humor and emotion recognition, detect emotions, tell jokes, and motivate users to drink water (Bechade et al., 2019). SARs can be personalized for tailored engagement and adapting to user needs. Robots such as Pepper and PARO have the potential to provide companionship and emotional support to people who live alone or need social interaction, but little is known about how these robots support individuals in their daily lives in the home. Many commercially available robots have functional limitations, such as solely providing social interaction or being immobile. This can pose challenges, as the types of activities individuals require assistance within the home are diverse.

Therefore, leveraging open-source robots that can adapt to a diverse set of user needs may enable users to be supported based on their needs and preferences. We chose Misty (https://www.mistyrobotics.com/), a commercially available SAR equipped with many features, including a 4K camera, touch panels, far-field microphone, depth sensors, RGB LED, bump sensors, LCD display, thread-based drive system, and hi-fi speakers. Misty is capable of room mapping, object, and face recognition, and has an emotive face, as well as an online dashboard to easily program and disable functions.

What sets Misty apart is its adaptability to users' evolving needs, especially in home settings where older adults may require varying levels of assistance over time. Misty is a SAR designed to interact with humans using natural language processing, computer vision, and machine learning, which allows it to understand and respond to user preferences, behaviors, and needs. This adaptability opens Misty as a valuable tool for supporting independent living and improving the quality of life for older adults. By understanding older adults' attitudes towards Misty, we can gauge the likelihood of acceptance, adoption, and preferred task support.

Study objectives

Our goal was to explore older adults' perceptions and interests in using a market-ready SAR. This study was conducted during the COVID-19 pandemic, which limited in-person data collection. To provide participants with an understanding of the robot's functionalities and capabilities, we developed a suite of video demonstrations for Misty. These demonstrations were used to elicit ideas on how a SAR may be used in the home and their emotional responses toward using it. The research goals were to:
1. Understand how Misty might support older adults aging in place with health, social, and assistive applications.
2. Understand potential facilitators and barriers toward the use of Misty.
3. Explore emotional responses to Misty.
4. Identify design considerations for SARs for the home.

Method

Participants

A total of 13 older adult participants ranging from 65-91 years of age (M=76, SD=9.64) were recruited through local (e.g., TechSAge Registry and the Osher Lifelong Learning Institute) and online outlets. Participants had to be 65+ years of age, proficient in English, have access to internet and a device to use Zoom, and score above 27 on the Telephone Interview for Cognitive Status – Modified (TICS-M; de Jager, Budge, & Clarke, 2003). Refer to

Table 1. Participant characteristics (n=13)

Variable	n	Percentage
Gender		
Female	9	69.2
Male	4	30.8
Ethnicity		
White	11	84.6
Black or African American	2	15.4
Education		
Master's degree	9	69.2
Bachelor's degree	3	23.1
Some college or in-progress degree	1	8.7
Household income		
$25,000 – 49,999	2	15.4
$50,000 – 74,999	4	30.8
≥$75,000	4	20.8
Do not wish to answer	3	23

Table 1 for additional information about the participants' characteristics.

Materials

Measures and questionnaires

We used the TechSAge Background Questionnaire (Remillard et al., 2020) to collect demographic information. Technology acceptance, technology readiness, and robot familiarity were collected from the Technology Readiness Index 2.0 (TRI- 2.0; Parasuraman, 2014), Mobile Device Proficiency Questionnaire – 16 (MDPQ; Roque & Boot, 2018), Robot Familiarity and Use Questionnaire (Smarr et al., 2013). We developed a modified Kansei Word Questionnaire (Nagamachi, 2014) to explore emotions related to the use of SARs. Survey responses were recorded using Research Electronic Data Capture (REDCap; Harris et al., 2019).

Demonstrations

Four videos demonstrated Misty's functionalities and capabilities. First was a commercial filmed by Misty Robotics that provided an overview of functionality, sensors, and customization. The remaining videos were filmed by the research team and focused on three activities: social interaction (e.g., conversing with Misty), controlling the environment (e.g., turning off the smart thermostat), and providing reminders (e.g., remembering to take medication).

Interview

The semi-structured interview was informed by theoretical frameworks that guide technology adoption (Davis, 1989; Venkatesh et al., 2012). Following the first general video demonstration, we explored participants' perceptions of Misty, including enjoyment, usefulness, and potential for assisting with daily activities. After each activity demonstration video, we assessed thoughts about that specific activity, communication preferences, and ideas for that activity. We then asked general questions about likes, dislikes, appearance reactions, trustworthiness, willingness to adopt, and other perceptions. The final section was a participatory design exercise wherein participants described their ideal robot design (added after the first two participants), key features they wanted, what it would look like, and how it would assist them. The script is available from the authors. Interviews were recorded and transcribed using Otter.ai (https://otter.ai).

Procedure

The procedural flow is illustrated in *Figure 1*, which shows the inclusion criteria as well as the survey and demonstration sequences. Participants who met the inclusion criteria were scheduled for a session. They provided informed consent and completed the TRI-2.0, robot familiarity, and MDPQ-16. The assessor shared the screen, read the questions to the participant, and then filled in the survey with the participant's answers. They then watched

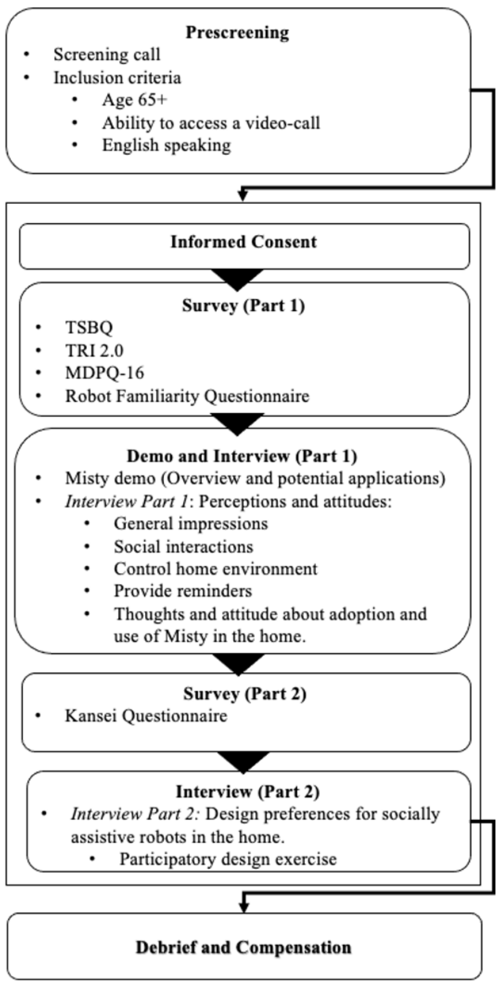

Figure 1. Study flow

Notes: TSBQ – TechSAge Background Questionnaire; TRI 2.0 – Technology Readiness Index 2.0; MDPQ – 16 – Mobile Device Proficiency Questionnaire

Table 2. Technology and robot experience (n=12)

Survey	Mean	Standard deviation
Technology readiness index 2.0[a]	3.44	0.39
Mobile device proficiency questionnaire -16[b]	3.98	0.97
Robot familiarity questionnaire[c]	1.43	0.19

Note: These surveys were included after the first participant, resulting in n=12 for these measures.
[a]Scale is 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating higher technology readiness.
[b]Scale is 1 (never tried) to 5 ([can do] very easily), with higher scores indicating more proficiency.
[c]Scale is 1 (not sure what this is) to 5 (have used or operated this robot frequently), with higher scores indicating more robot familiarity.

the videos interspersed with the semi-structured interview questions. Participants were debriefed and compensated with a $25 Amazon e-Code.

Qualitative analysis

The qualitative analysis aimed to identify factors that affect the participants' perception of Misty. Thematic analysis (Braun & Clarke, 2006) was used to identify common patterns and desired features between the participants. Once the two coders reached 88% interrater reliability (Brennan & Prediger, 1981), the coders then coded their individual transcripts.

Results

Our research question focused on how a SAR might assist older adults. We contextualized the study with Misty to provide participants with a specific example of the types of supports (e.g., controlling a home environment, providing health reminders) a SAR might be able to provide.

Technology and robot experience

Participants were asked about their familiarity with technology and robots (*Table 2*). They were above average in technology readiness and proficiency using mobile devices. They were unfamiliar with robots but had experience with general technology. These experience levels provide the context for their attitudes about using Misty in their homes.

General perceptions

When reporting initial impressions, 8 participants reported they would enjoy using Misty (62%), and 11 thought Misty would be useful (84%) for various daily activities, including health support, the Internet of Things, daily activities, domestic support, potential, and reminders. A participant mentioned, "It would be nice she could do activities, you know…I could also train her." When asked about willingness to use Misty, eight were primarily positive (62%), and 12 were open to using it (92%). When asked about their feelings about a robot, the word "responsive" was most commonly followed by "friendly."

Table 3 provides information about adoption considerations, features, functions, and support. Participants identified multiple barriers and facilitators to adopting Misty into their homes.

Kansei questionnaire

To explore perceptions toward SARs, we implemented the Kansei Word questionnaire, in which participants indicated how each word described Misty. *Table 4* provides means and standard deviations of the Kansei words, and *Figure 2* shows the response dispersion to the Kansei questionnaire.

The responsive feeling was rated highest and least dispersed. This was followed by a friendly feeling, but it was more dispersed (between 2 and 4). Pleasant and interactive were rated highly, with a median of 3, with the highest concentration of votes between 3 and 4. The lowest ratings were for secure/safe and meaningful, with a median of 3. Feelings such as meaningful and useful showed the greatest dispersions. Thus, the participants had a disparity of opinions regarding how they associated those words with the Misty robot.

Supporting social interactions

The older adults thought Misty would be useful (8/13 participants; 62%), reporting that they would enjoy using Misty or a socially assistive robot to engage them in social interaction. A participant noted, "… if you had no one else to talk to, yeah, it would be nice for social interaction. To carry on a conversation." Participants noted that they would enjoy using the non-verbal communication cues. Generally, the participants were interested in the idea of using a robot to support communication, be a social companion, and provide reminders.

Table 3. Design considerations for home application

Themes	Design considerations
Adoption	Easy to use (e.g., controls, interactions)
	Usefulness (e.g., adaptable to user needs)
	Support home related activities (e.g., cleaning)
Appearance and features	Autonomy (e.g., docking, locomotion)
	Customizable (e.g., accessories, colors, voice, size)
	Resemblance to cultural references (e.g., R2D2, Rosey robot)
Functions	Home controls (e.g., thermostat)
	Manipulate objects (e.g., cups, laundry)
	Companionship (e.g., social engagement)
Support	Information accessibility (e.g., health information)
	Communication (e.g., facilitates conversations)
	Reminders and alarms (e.g., appointments)

Table 4. Kansei words

Word	Mean	Standard deviation
Responsive	3.38	0.87
Pleasant	3.08	1.19
Interactive	3.00	1.08
Friendly	3.00	1.29
Easy	2.92	1.17
Competent	2.92	1.19
Convenient	2.77	1.30
Useful	2.62	1.45
Secure Safe	2.31	1.18
Meaningful	2.08	1.32

Note: The Kansei words are scored from 1 (not at all) to 5 (very much), with a higher score indicating the more the word describes the socially assistive robot.

Controlling the environment

After the demonstration of Misty controlling the environment by turning off the lights, 6 participants (46%) were open to using Misty for this support. They reported many ways Misty could help them, including domestic tasks, communication, reminders, or cleaning. However, a participant reported feeling worried that they may decrease their physical activity: "I'd say it's a good thing for some people, and others, maybe not so much. The very act of getting up from a place, walking over to do something, and sitting back down again allows you to move again, move your legs, right?" Participants had concerns about Misty's size and limited ability to accomplish more demanding tasks (e.g., washing clothes).

Reminders

After the video of Misty providing reminders, 90% of the participants responded positively to using this feature. They identified grocery lists, calendar reminders, appointments, and medication reminders and specifically mentioned the timing of reminders as essential. One participant shared that they preferred to receive an overview of their daily activities at the beginning of the day before receiving individual task reminders, "Like what I have to do that day, like this phone call, tasks I have to do, appointments I have to go to." Some were concerned about Misty's ability to remind them about an extensive assortment of medications.

Ideal robot design

Participants were asked to think about their ideal SARs and what features and capabilities they would like for them to have. They preferred personalized SARs, where their appearance and stature could be modified (e.g., hydraulic arms). Some reported wanting the robot to be like a pop culture robot, "Sleek like ET with little sleeker and plastic and the sound system is good." Overall, the older adults shared their thoughts about features they enjoyed, their preferences of how the robot appears, and how it can provide everyday assistance (see *Table 5*).

Discussion

Participants completed a series of questionnaires, watched video demonstrations, and were interviewed using a semi-structured format. The goal was to explore the potential of a SAR for three situations: social interaction, controlling a home environment, and providing reminders. We used Misty as an example, but the results can be generalized for other SARs.

Three main insights emerged. First, familiarity with robots was generally low, indicating a need for increased exposure and education about these technologies. Second, participants expressed interest in the assistance SARs could provide with daily tasks, including household chores, information provision, navigation aid, daily planning, and memory support. Third, perceptions of Misty were positive, with a desire for effective communication, health support, performance of household tasks, enhanced mobility, and integration with voice assistants. Misty's friendly and customizable appearance, reminiscent of popular culture robots, was well received, suggesting a familiar and less intimidating design might increase acceptance and use. Although we focused on a specific SAR to ground the experience, our findings provide general insights into how older adults seek assistance with daily tasks and the potential role of open-source SARs in supporting them. Their desire for clear communication and familiar form factors are relevant to other SARs to guide their design and functionality. Although other market-ready robotic solutions might provide support for everyday home activities

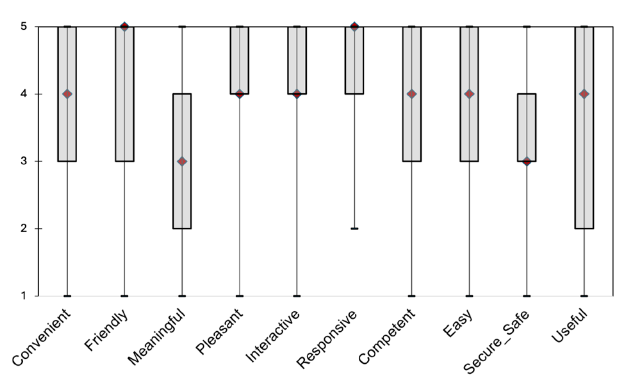

Figure 2. Kansei questionnaire response dispersion
Note: The Kansei words are scored from 1 (not at all) to 5 (very much). The higher the score, the more the word *describes the socially assistive robot.*

Table 5. Ideal robot design

Key features	How do you see the robot assisting in your day-to-day life?	What would the robot look like?
Communication	Dependence	Animal-like
Complex vocabulary	Domestic capability	Autonomous
Domestic chores	Information	Custom colors
Easy repairability	Knowledge	Custom size configuration
Health support	Navigation	Humanoid
Home mapping	Planning	Jetsons' robot
Learnability	Reminders	Mobile
Misty's features	Retrieval	R2D2
Mobility		Smaller
Organization		Taller
Planning		

or social engagement) their capabilities cannot always meet the diverse set of needs that may be required (Hung et al., 2019; Mois et al., 2022; Rogers et al., 2020). Furthermore, differences in functional abilities can impact the types of support required. For example, persons with mobility impairments may want a robot to control their home environment, whereas those who live alone may want a robot to facilitate social engagements. These insights deepen our understanding of the diverse set of functionalities that robots should be equipped with to support individuals in their homes. Leveraging open-source robotic solutions can be an important step in meeting individual needs and supporting user autonomy and independence. The capabilities and functionalities of these robots should adapt to needs and preferences and enable users to toggle features to fit their individual needs. These tasks make it easier for older adults to assimilate SARs into their daily lives before introducing more complex tasks such as health monitoring or cognitive support.

Robots' wayfinding abilities (e.g., obstacles, flooring), connectivity (e.g., Wi-Fi), and compatibility with other home technologies (e.g., smart devices) can affect adoption. Additionally, homes (e.g., houses, townhomes, apartments) where older adults reside are not always equipped with the infrastructure (e.g., broadband internet, space for navigation) to support optimal robot use. Designers and developers must consider where robots will be deployed to ensure successful implementation and continued use. Additionally, safety (e.g., tripping hazard, mechanical failure) and privacy concerns (e.g., data sharing, unauthorized access) must be addressed through autonomous and user-controlled features. For example, implementing functionalities such as self-docking when the robot battery is low and easy access to enabling and disabling cameras and toggling user controls can give the user more agency.

The Kansei Word Questionnaire provided insights into the emotional and subjective feelings towards SARs and their potential implications for adoption and use. If classified as emotional words, the Kansei words convenient, friendly, meaningful, and pleasant can represent feelings that are more easily and readily accepted by older adults. If classified as cognitive words, the Kansei words interactive, responsive, competent, and easy, also feelings well accepted by older adults. This could indicate that using technologies such as the Misty robot to assist in daily activities would be welcomed. The words that stood out the most to describe the robot were responsive, interactive, and friendly; this is like their recollection of pop culture robots. Given the human desire for a fulfilling home life, there are many applicable situations where SARs can facilitate daily activities for older adults, especially in promoting independence and comfort at home.

We acknowledge the limitation of the small sample size (n=13. Future research efforts should include larger samples and allow participants to interact with Misty in person, allowing for a more immersive and comprehensive experience. This may also clarify some participants' confusion with Misty's size and abilities. Expectations and perceptions for a broader range of SARs (e.g., PARO, Pepper) would also be informative.

Conclusion

The participants had generally low familiarity with robots but showed interest in the potential benefits of a SAR like Misty. Key areas of interest included assistance with daily tasks, health support, and improved communication capabilities. Customizable features and a familiar, friendly appearance were important to the participants. These insights can guide future developments in SARs to better meet the needs and preferences of older adults.

The implementation of SARs in the home presents opportunities for expanding access to resources to enhance the quality of life and everyday activities. Open-source robotic solutions provide a promising potential to create tailored experiences to meet individual preferences and needs. However, deploying a robot in the home requires careful consideration of how individuals will be supported and assisted with troubleshooting (e.g., enabling feature) and technical issues (e.g., Wi-Fi disconnection). To learn more about developing SARs, there needs to be in-person observation of older adults interacting with them in home environments. Developing a diverse set of support approaches such as guides, tutorial videos, and live support may play a key role in supporting continued use. In this study, the Kansei questionnaire was used to verify older adults' acceptance of collaborative robots such as Misty Robot. Future studies should explore older adults' emotional reception toward SARs.

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