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Telepresence Robots in the Context of Dementia Caregiving: Caregivers' and Care Recipients' Perspectives

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Abstract: As a result of a rapidly aging population and the increasing prevalence of dementia among older adults, technological solutions are increasingly being considered to facilitate caregiving. This research investigates the perspectives of 20 caregiving dyads on VGo, a telepresence social robot with features designed to support caregiving. Care recipients (CRs), aged 65 and older, diagnosed with Alzheimer's disease and related dementias, along with their primary caregivers (CGs), evaluated the robot through an online interview study. The interviews integrated informative videos showcasing VGo's features and functions. Insights from the interviews revealed diverse expectations, interests, and reservations. The majority of CGs and their CRs perceived the robot's features as beneficial. In particular, the voice command capability was appreciated as an alternative to using smartphones and as a way to manage home appliances. The community feature, however, did not align well with many participants' lifestyles, and participants had a number of suggestions to enhance the robot's notification function. Based on the interview results, the study offers a set of design recommendations for telepresence social robots in home caregiving contexts. This investigation highlights the promise of social robots in caregiving contexts and underscores the need for further improvements to ensure they fit users' needs.

Keywords: social robots; caregiving; dementia; aging

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Citation: FakhrHosseini, S.; Cerino, L.; D'Ambrosio, L.; Balmuth, L.; Lee, C.; Wu, M.; Coughlin, J. Telepresence Robots in the Context of Dementia Caregiving: Caregivers' and Care Recipients' Perspectives. *Robotics* **2024**, *13*, 160. https://doi.org/10.3390/robotics13110160

Academic Editors: Martin Cooney, Mariacarla Staffa and Filippo Cavallo

Received: 31 July 2024
Revised: 23 October 2024
Accepted: 25 October 2024
Published: 30 October 2024

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1. Aging Population

The world's population is aging and undergoing a significant demographic transition. It is forecasted that the global population of people aged 65 years and older will grow significantly in the coming years, increasing from about 771 million in 2022 (9.7% of the world's population) to a projected 1.6 billion by the year 2050 (16.4% of the world's population) [1]. Yet this growth in the population of older adults will not be matched by corresponding increases among younger age groups, which will grow more slowly: "By 2050 there will be more than twice as many persons aged 65 or older than children under [age] 5 globally, whereas the number of persons aged 65 years or over globally will be almost the same as the number of children under age 12" [1]. These population aging trends are amplified in the developed world, which is at a more advanced stage of demographic transition [2]. The shifts in population demographics have yielded new demands that need to be met but also new opportunities for innovation. Expected outcomes of an increasingly older population include the following:

- Escalated demand for healthcare services: With the aging of the population, there will be an upsurge in the requirement for healthcare services, including medical appointments, hospitalizations, and prescription medications [3,4]. This could potentially strain healthcare systems' financial resources as well as the ability of these systems to find the labor needed to provide these services [5];

- Heightened necessity for long-term care: Many older adults will require extended care, including assistance with activities of daily living such as bathing, dressing, and eating. The cost and availability of such care can pose challenges for individuals, families, and governments [6];
- Increased prevalence of social isolation: As people grow older, they often experience greater levels of isolation from their social circles and feelings of loneliness and depression, all of which have been linked to declines in physical health [7–9];
- Increased demand for family caregiving: AARP [10] estimates that there are currently about 48 million family CGs in the United States, with about 42 million of these providing care to an adult aged 50 or older. The need for CGs is expected to continue to grow along with increases in the U.S. older adult population. Currently, there are seven potential family CGs per older adult. By 2050, with changes in the population structure, it is estimated there will be fewer than three potential family CGs per older adult [11].

One additional consequence of the growth of an aging population is an expected increase in the incidence of Alzheimer's disease and related dementias (ADRD). Alzheimer's disease is the most common form of dementia, and 6.7 million people in the U.S. have an Alzheimer's dementia diagnosis [12]. As people grow older, their likelihood of developing Alzheimer's dementia escalates. In the U.S., 10.8% of all people over age 65 have Alzheimer's disease, and "the percentage of people with Alzheimer's dementia increases with age. Around 5.0% of people aged 65 to 74, 13.1% of people aged 75 to 84, and 33.3% of people aged 85 and older have Alzheimer's dementia" [12] (p. 20). The number of people who have mild cognitive impairment (MCI) due to Alzheimer's disease or another form of dementia is even greater. The Alzheimer's Association [12] (p. 21) estimated that "roughly 8 to 11% of the 62 million Americans who are aged 65 and older in 2023—or approximately 5 to 7 million older Americans—may have MCI due to Alzheimer's disease". The growth of the older population is correlated with a projected increase in dementia: Matthews et al. [13] projected that 13.9 million people aged 65 or older in the U.S. will have a diagnosis of Alzheimer's disease or related dementia (ADRD) by 2060.

2. Dementia and Caregiving

The World Health Organization [14] describes dementia as a chronic or progressive syndrome that causes deterioration in cognitive function (i.e., the ability to process thoughts) beyond what would be expected from typical biological aging. Dementia affects a range of functions including memory, thinking, orientation, comprehension, calculation, learning capacity, language, and judgment. Further, changes in mood, emotional control, behavior, or motivation usually co-occur with damage to cognitive function [14].

Due to the progressive nature of Alzheimer's disease, and the severity of its impacts, those diagnosed with the disease almost always require some degree of caregiving at some point. As the disease itself progresses, the degree of care typically increases as well. Much of the care for individuals living with ADRD is provided by informal, unpaid family CGs. American Association of Retired Persons (AARP) and the National Alliance for Caregiving [10] estimate that there are currently about 48 million family CGs in the United States, with about 42 million of these providing care to adults aged 50 or older. Alzheimer's Association in 2023 [12] estimated that about half of CGs provide care to someone with ADRD. According to AARP (2020) [10], caregiving is defined as offering unpaid assistance to a family member or friend aged 18 or older to help with their self-care. Caregiving responsibilities can encompass a wide range of tasks, including healthcare, transportation, meal preparation, housework, home maintenance, coordinating services, personal hygiene, managing finances, and keeping company.

CGs experience a range of different demands related to their caregiving. Financially, AARP [10] estimates that in the U.S. individual families typically spend over $7000 per year out of pocket on caregiving expenses [15]. In 2022 alone, CGs of someone with ADRD "provided an estimated 18 billion hours of informal (that is, unpaid) assistance"—"an

average of 30 h of care per CG per week, or 1565 h of care per CG" [12] (pp. 41, 44). This labor is "valued at $339.5 billion" [12] (p. 41). Further, CGs of individuals living with ADRD report greater levels of physical, financial, and social stress and burden associated with the care they provide, compared with CGs of people without dementia [12]. Due to the increased projected demands for CGs—combined with the expected increase in ADRD and the relatively smaller number of available CGs—there is an urgent need for support and solutions for CGs.

3. Current Technological Solutions to Support Caregiving

With the rapid development of technology, numerous potential tools have been proposed and developed for diagnosing, treating, and providing support to individuals with dementia and/or their CGs. Drawing from the research by Shu and Woo (2021) [16], the primary functions that technologies commonly provide assistance with are:

- Maintenance of daily function: Technology can play a role in assisting individuals to sustain their daily activities. These technologies are designed to simulate and offer guidance for routine tasks to support individuals with cognitive challenges in managing their daily lives more effectively and independently;
- Leisure and activity: Numerous technological interventions are directed toward enhancing the leisure experiences of individuals living with dementia. Various programs are focused on making music and art more accessible and enjoyable and offering opportunities to engage with virtual environments;
- Sensors and safety: Locator devices can help to find misplaced items, sound security alerts for falls or unexpected wanderings, and detect environmental issues, such as water leaks or fire. These sensors can also notify CGs and prevent safety issues;
- Caregiving and management: Technology also offers robotics-based applications to replace human CGs, such as using social robots with remote monitoring via sensors and videoconferencing or general robotic aid in daily activities like food preparation and eating. In terms of care management, IoT systems and medication aids, such as alarms, reminders, and dispensers, can simplify and organize life for caregivers.

Social Robots: A Potential Solution

In the past decades, there have been some efforts to use social (or sociable) robots to support people living with dementia. Social robotics is distinguished from other domains of robotics due to its socially interactive focus with applications in domains such as education, aging support, or entertainment, rather than a focus on carrying out physical and mechanical tasks. Social robots are designed to interact with people in a natural, interpersonal manner [17]. They need to be able to communicate naturally with people using both verbal and non-verbal signals. They need to engage users not only on a cognitive level, but on an emotional level as well, to provide effective social and task-related support [18].

Several research studies have indicated the value of social robots in assisting in the care of older adults, including people with dementia. For example, a metanalysis conducted by Pu, Moyle, Jones, and Todorovic (2019) [19] based on 13 qualified articles (from an initial sample of 2204 articles) that contained well-designed randomized controlled experiments indicated that social robots positively impacted older users' agitation, anxiety and loneliness, medication adherence, and quality of life. The review suggested a need for further research, however, due to potential clinical heterogeneity due to the large variation in intervention types in the limited sample. In another study which was based on observations and interviews of users' experience, social robots were found to spark positive short-term effects and improve the quality of life for people with dementia [20].

Among older adults generally and among people with ADRD or MCI, the acceptability of social robots could be improved if they: (1) were easy and enjoyable to use (e.g., used human-like communication); and (2) could enhance the people's function (e.g., meet users' emotional, psychological, social and environmental needs) [21]. Previous studies have also found that the physical design of social robots is crucial to their successful adoption

(e.g., Hameed et al. [22]). Older adults generally preferred being able to personalize the robot (e.g., appearance, voice, interaction modalities) [23]. In research involving older adults, the robot 'Brian' was utilized in two different studies. One study revealed that older adults were drawn to the robot's human-like voice and supportive behaviors [24]. In the other study, participants favored human-like communication over human-like appearance [25]. Another study evaluating 10 social robots with different shapes and functions [23] identified four preferred forms of support from social robots: (1) cognitive support (e.g., locating lost items, task reminders); (2) communication support (e.g., video calls); (3) risk prevention and healthcare applications (e.g., fall detection); and (4) daily task support (e.g., online shopping).

The UC San Diego team [26] conducted a study that included both older adults and their caregivers to co-design robots with dementia caregivers. Through interviews and workshops, they identified key challenges faced by caregivers, such as repetitive questioning and emotional stress. Based on these insights, caregivers designed robots to provide support in areas like emotional regulation, task reminders, and physical therapy. The researchers found that caregivers envisioned robots as not only practical tools but also companions that could enhance positive interactions and alleviate emotional strain. The study emphasizes the importance of community-focused design in developing assistive technologies that meet the specific needs of dementia caregivers.

This particular research uses VGo, a telepresence robot that enables remote communication and interaction and allows users to virtually attend and participate in events or locations from a distance. Several prior studies with VGo have indicated its effectiveness in dementia care. For example, in one study [27], telepresence robots, including VGo, were considered as a potential tool that can provide encouragement around social connection. They support remote monitoring and long-distance control and facilitate interactions between older adults with dementia and their CGs [28]. Another study placed VGo robot in the homes of older adults who are independent and exhibit intact cognitive functioning [29]. They had generally positive feedback about the robot and found that it enhanced their physical health, well-being, social connectedness, and ability to live independently.

Despite these positive findings, other studies indicate that interventions involving social robots do not yield a positive effect on the well-being of individuals with dementia [30]. Some research has also uncovered apprehension regarding the utilization of social robots in the dementia care of older adults, related to, for example, financial considerations and ethical dilemmas, such as emotional deception and emotional attachment [31]. Emotional deception happens when users over-trust the robots, so they might have unrealistic expectations or over-rely on the robots rather than using their own critical judgment [32], while emotional attachment could trigger negative emotions among users if the robots are broken or taken away [33]. Another ethical issue is users' potential loss of freedom and privacy due to social robots' monitoring and recording of their activities [28].

The potential diverse impacts of social robots highlight the need for additional research to gain a deeper understanding of how these technologies should be designed and will affect users across different use cases. In this study, we investigated the attitudes and opinions toward VGo in the context of home care of two key groups: CRs with dementia and their CGs, both of whom represent potential future social robot users. The goals were to better understand how social robots could be utilized in home care settings. The key research questions were as follows:

1. What are CGs' and CRs' initial reactions to VGo's appearance and shape upon being introduced to it?
2. Under what conditions will remote and in-person CGs be more likely to accept VGo in the home care setting and for which particular caregiving activities? Are there individual factors or features of the caregiving situation that affect participants' attitudes toward VGo?
3. What are participants' reactions to the various functions and features of VGo they are shown? Which functions do participants believe they would use most and least

frequently for their caregiving activities? Which functions would they expect to find most—or least—useful?

4. What new or additional functions and features do CGs and CRs believe should be incorporated into VGo—or social robots more generally—to support caregiving?
5. How do CGs expect the presence and use of VGo to affect their caregiving experiences, including their levels of stress or strain? How do CRs think it might affect their experience of care, as well as feelings of social isolation and loneliness? What kinds of effects, if any, do they think VGo would have on their relationships with each other?

4. Method

4.1. Procedure

Caregivers interested in the study completed a series of screening questions to determine the dyad's eligibility for the study. Potentially eligible dyads were then invited to schedule a 10 to 15 min introductory Zoom call to discuss the study procedures, confirm the CRs' eligibility and interest in participating, answer any questions either CG or CR had about the study, and ensure that the CR would be capable of participating in the interview. Once eligibility was confirmed, each participant dyad was scheduled to participate together in an online interview that was audio and video recorded via Zoom, based on their availability. Participants completed online consent forms prior to the study interview through DocuSign.

During the Zoom interview, which typically lasted between 60 and 90 min, both members of the dyad were shown several brief videos of VGo. The videos (Figure 1) explained VGo's general functionality as well as its key features (e.g., mobility, calls, group calls, and reminders). The videos provided both explanations of how the robot works as well as visual examples of members of the research team utilizing the robot. After each video, CRs were first asked about their reactions to the robot; CGs were subsequently asked the same questions.

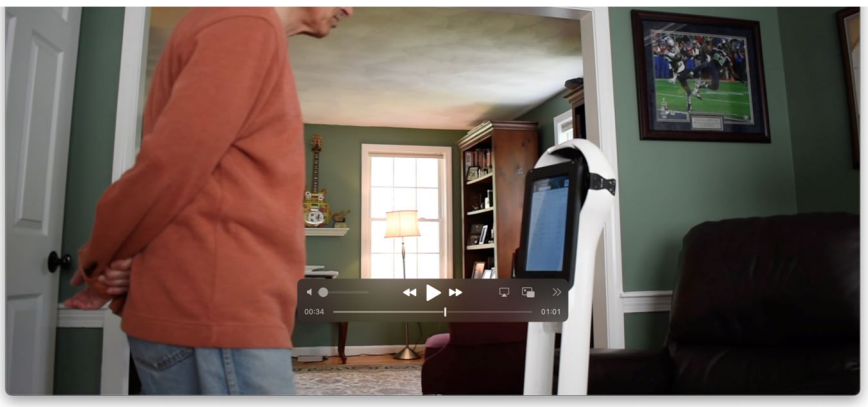


Figure 1. A screenshot of the recorded video used in the online interviews.

Following the questions about the VGo videos, CRs only were asked to answer a few follow-up questions about themselves (e.g., technology experience and demographics). Once the interview was complete, CGs were sent a separate online questionnaire via email that took about 10–15 min to complete. Following completion of the study, CGs and CRs were each compensated with a $100 Amazon.com gift card.

4.2. Participants

Participants were recruited for the study through a variety of different means, including via emails to the research lab's participant volunteer databases and to a database of Councils on Aging, and publishing advertisements on Facebook. To be eligible for the study, CRs had to be age 65 or older and have had a diagnosis of ADRD. Because CRs needed to participate in the online interviews, the disease could not be so advanced that

they lacked the capacity to take part in the interview conversation. Participants also needed to be able to access Zoom to participate in the study.

In total, 20 CRs (7 female, 13 male), aged between 65 and 92 (M = 79.15, SD = 8.75), were recruited for this study, along with their CGs (see Table 1). CG study participants (16 female, 4 male) ranged in age from 42 to 84 (M = 65.37, SD = 12.54), with a median age of 67. Fifteen CRs lived with their CGs and five lived separately. Thirteen of the CG-CR dyads were spouses, and seven were parent-adult children pairs. Among the CRs, according to their CGs, ten were in an early stage of dementia and nine were in a moderate stage. One CG did not know which stage her CR was in. The caregivers and care recipients in this study are mainly retired, highly educated, predominantly white, and exhibit a wide range of household incomes.

Table 1. A summary of participants' demographic information.

ID	CR's Stage of Disease	CR's Diagnosis	CR's Relationship to CG	Dyad Living Situation	Gender (CG/CR)	CR's Age
1	Moderate	Mild cognitive impairment (MCI)	Parent	Together	F/F	83
2	Moderate	MCI	Parent	Separate	F/M	73
3	Moderate	MCI	Spouse	Together	M/F	84
4	Early	MCI	Spouse	Together	M/F	75
5	Moderate	MCI, Alzheimer's disease, Vascular dementia	Parent	Together	F/F	90
6	Early	MCI	Spouse	Together	F/M	79
7	Early	Alzheimer's disease	Spouse	Together	M/F	89
8	Moderate	MCI	Parent	Separate	F/F	67
9	Unknown	MCI	Spouse	Together	F/M	77
10	Moderate	MCI, Vascular dementia	Parent	Separate	F/M	86
11	Moderate	Alzheimer's disease	Spouse	Together	F/M	70
12	Early	Vascular dementia	Parent	Separate	F/F	85
13	Moderate	Mixed dementia	Spouse	Together	F/M	87
14	Early	MCI	Parent	Separate	M/M	92
15	Early	Other—"Parkinson's Disease with mild cognitive impairment"	Spouse	Together	F/M	75
16	Moderate	Alzheimer's disease	Spouse	Together	F/M	77
17	Early	Alzheimer's disease	Spouse	Together	F/M	86
18	Early	MCI	Spouse	Together	F/M	84
19	Early	MCI, Alzheimer's Disease, Vascular Dementia	Spouse	Together	F/M	67
20	Early	Frontotemporal dementia	Spouse	Together	F/M	65

4.3. VGo: Features and Characteristics

The VGo robot includes two batteries, a charging dock and a power cord, and a handheld remote control. In addition to functions that are similar to traditional videoconferencing, which enable CGs to see, talk, and interact remotely with CRs, the VGo system also enables CGs to control the robot remotely to move or navigate around the CR's home to provide better supervision of and assistance to CRs. An assembled VGo is shown in Figure 2.

For the purposes of this interview study, four features and functions of VGo were presented to study participants, each accompanied by explanations from a narrator speaking over the video. The four functions and features highlighted in this study were the robot's mobility, calling function, community feature, and reminder function. Here are the explanations from the narrator:

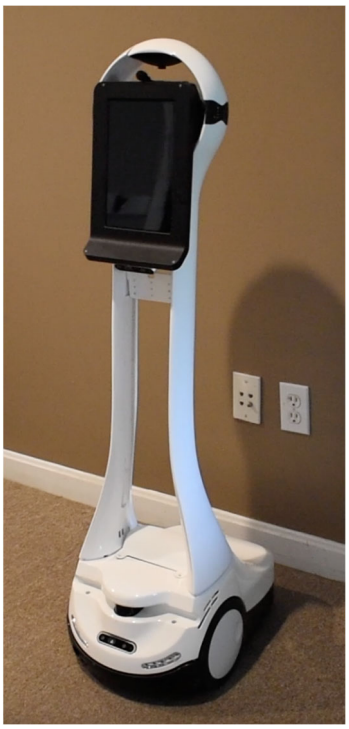


Figure 2. VGo.

Mobility: The robot moves around various areas using a pre-built map of the user's home created during the initial setup. Users can define all of the areas where the robot can go and any areas that are private or where they would not want the robot to enter can be excluded from the map and made off-limits for the robot. The robot can move to where the user wants it to go. For example, users can call the robot's name and ask it to come to them or to go to the kitchen or living room. Loved ones to whom users give access to the robot can also use their web interface to move the robot remotely and check in on someone. For example, if they want the robot to find grandma, they can request it to do that, and then the robot will move around the home to find her.

Calling: The robot also allows users to make voice and video calls through the touch-screen. Users can place or receive calls at any time, choosing whether to accept or reject incoming calls. Additionally, users can multitask during calls—for instance, they can instruct the robot to follow them, allowing them to continue the conversation while on the move. Loved ones with permission can make a call remotely from the web interface to check in on someone. When they are in a call, they can navigate through the space by choosing places on the map. It is also possible to schedule calls on the robot—for example, if a user would like to schedule calls with a loved one for every Monday at 12 p.m.

Community: In addition to making individual video calls, the robot also provides users the option to create or join a group call with their community. The community feature offers the ability to create different groups of family, friends, CGs, or even healthcare providers. This feature allows multiple individuals to join a video call simultaneously, so that they can have a group discussion or meeting. Users can either start a group call or join an existing one.

Reminders: One of the features of the robot is the ability to create reminders for various tasks or events. This can be useful in managing different aspects of daily life. By setting reminders, the user can ensure that important tasks are not forgotten. For example, the robot can be programmed to remind the user to take their medication at a specific time each day, or to remind them to complete their daily exercise routine.

4.4. Data and Measures

The study focuses on several key areas: initially, participants shared their reactions and expectations regarding their impressions of VGo. Their attitudes toward VGo's features and functions, as presented in a video, were also explored. To assess the emotional impact, CRs' feelings of loneliness and social isolation were measured using Version 3 of the University of California, Los Angeles (UCLA) Loneliness Scale [34]. Additionally, CRs' ability to complete various Instrumental Activities of Daily Living (IADL) was evaluated using the IADL scale [35]. The research also considered CRs' experience with technology and gathered demographic information, including age, gender, race, employment status, living arrangement, and educational background.

After the interview, CGs were asked to complete an online questionnaire on Qualtrics. This questionnaire assessed various aspects, such as CG stress and strain levels, caregiver guilt [36], CG technology experience, and demographic information.

4.5. Data Analysis

Interview recordings were transcribed for data analysis, and participants' answers to a series of questions were systematically categorized by key interview questions and coded; CRs and CGs were analyzed separately and jointly. Quantitative data from the interviews and questionnaires were analyzed with SPSS v.28.

5. Results

5.1. Initial Impressions of the Robot

Participants were prompted to share their first impressions of viewing the robot, any resemblances they saw to similar devices, and their guesses about its capabilities and functions. Table 2 displays the mixed impressions of the robot's design, size, and perceived resemblance to other familiar devices. Positive feedback about its appearance and shape often reflected people's perceptions of the robot's practicality and attractiveness, while concerns involved the robot's size and lack of human-like features. Participants also drew parallels between the robot and other devices they have encountered in various contexts, notably vacuum cleaners and tablet/voice assistants.

Table 2. Overview of initial reactions and comments from participants upon viewing VGo's video. Numerical values indicate the number of individuals from each group aligning with each remark.

Category	Count of Positive Feedback	Count of Negative Feedback
Robot appearance	Fine, Sleek, Nice, Interesting, and Attractive (CGs = 5 and CRs = 7)	Sterile and hospital looking, Mobility scooter, Lack of humanoid features (CGs = 6 and CRs = 2)
Size and shape	Ideal height for eye-level tablet use, Ideal size to fit against a wall (CGs = 5, CRs = 5)	Too large and Concerns about stability (CGs = 3 and CRs = 1)
Comparison to other devices	Resemblance to vacuum cleaner (CGs = 5, CRs = 3), tablets or voice assistants (CGs = 6, CRs = 2), mobility scooter (CGs = 2), and grocery store robots (CGs = 3)	

5.2. Attitudes Regarding the Robot's Functionalities and Features

Figure 3 illustrates the extent of interest and disinterest among CGs and CRs toward all four of the robot's functionalities and features highlighted in the study.

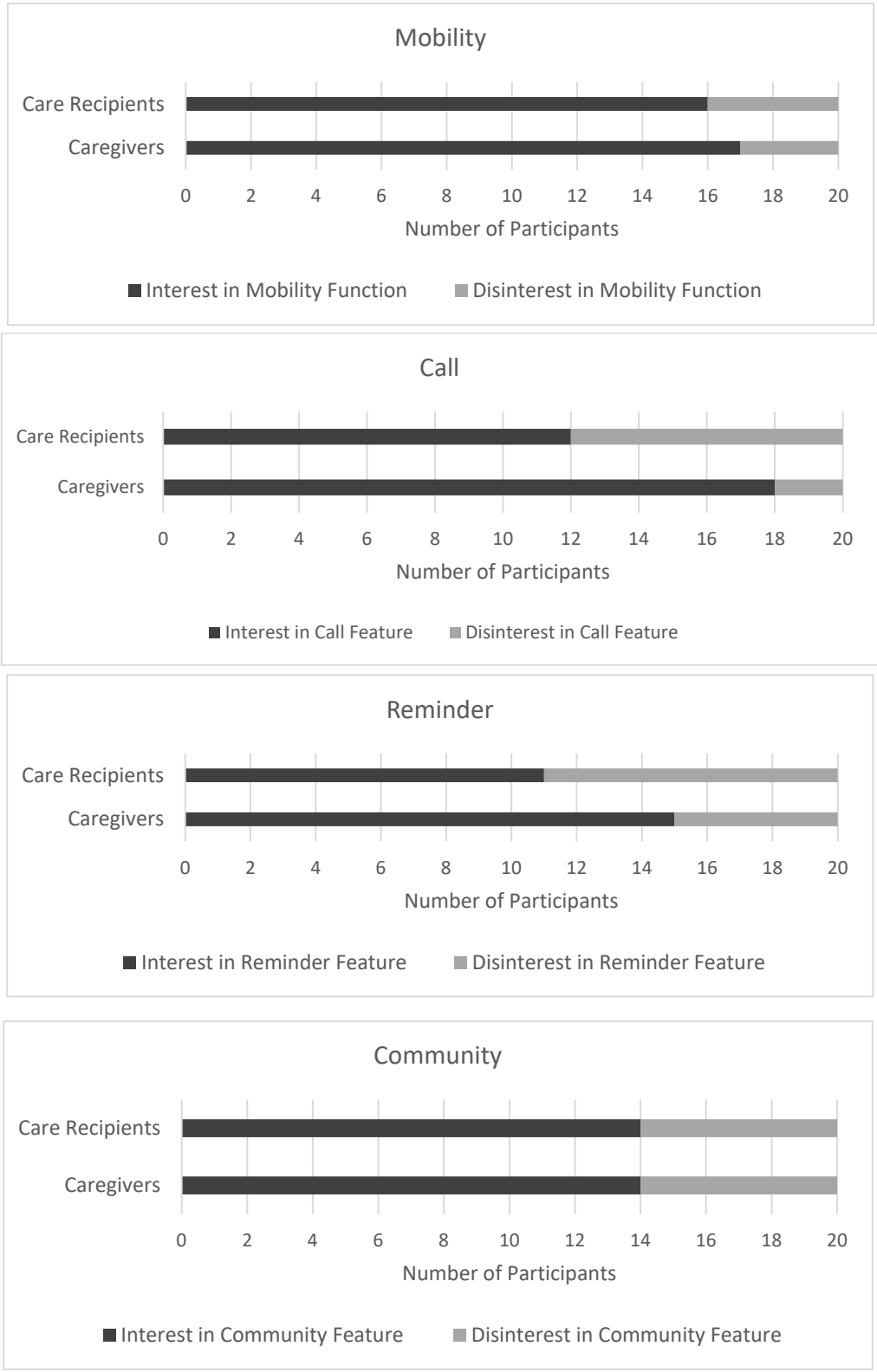


Figure 3. Caregivers and CRs' interest in different functionalities and features of the robot.

First, a *t*-test was conducted to compare the attitudes toward robot features between the CGs and the CRs based on the total number of their acceptance of the four features and functions presented. Results indicated that there was a statistically significant difference in the attitudes toward robot features between CGs and CRs, $t(18) = 2.18$, $p = 0.036$, with the

CGs showing more positive attitudes toward robot features (M = 2.5, SD = 0.6) than the CRs (M = 1.9, SD = 1.02).

5.2.1. Mobility

Caregivers: The majority of CGs (n = 17) expressed a positive opinion about VGo's mobility feature by addressing its capability for remote check-ins, especially when they are not physically present in the CRs' homes. They shared scenarios in which being able to remotely locate and check on a loved one would be invaluable, such as when the CR does not respond to phone calls or might be in need of assistance. As one CG noted, "Because I travel and if he is not responding, I want to be able to have the robot take a look around for him. That would allow me not to have somebody here to always be with him when I'm away. That would be excellent".

Conversely, a minority of CGs expressed reservations about incorporating a mobile robot into their homes. Three CGs cited reasons like the constant presence required to manage potential technical issues, like mapping errors or the robot getting stuck, as well as concerns related to space, privacy, the redundancy of technology, and a general preference to avoid new technological solutions.

Care recipients: A majority of CRs (n = 16) also liked VGo's mobility and considered it a valuable feature in emergencies. This capability was particularly noted for its advantage over fixed cameras, which cannot cover all areas of a home, thus enhancing the safety and accessibility of the CR. As one CR said: "It would be beneficial if, in the event of a fall or when receiving a call, the robot could locate me, providing valuable information to my CG about my whereabouts and condition".

The four CRs who declined to have a mobile robot in their homes cited various reasons, including limited space, discomfort with a device following them, redundancy of cellphone capabilities, concerns about noise, a preference for avoiding new technology, or the belief that they might require it later.

5.2.2. Call

Caregivers: Of 20 CGs, 18 appreciated the call feature because it allows them to use voice commands. They also valued the robot's ability to enhance accessibility to CRs, especially when a traditional phone might be out of reach or uncharged. The video call capability, hands-free operation, and the larger screen size were among the other benefits noted by CGs. In contrast, two CGs did not see the necessity for the feature for themselves at the present time, but they did not rule out future use.

Care recipients: Among care recipients, 12 out of 20 rated the call feature positively. These participants mentioned that easy access to phone calls—especially important if they were immobile—and the convenience of hands-free operation significantly improved accessibility to their caregivers. The simplicity of initiating calls was also considered a major advantage. However, due to their unfamiliarity with this new robotic technology and the belief that similar features are already available on cell phones, eight care recipients were hesitant to use VGo for calls. Concerns about Wi-Fi signal strength and the need for continuous internet access were also expressed.

5.2.3. Community

The community feature of the robot, which allows for video calls with multiple participants, was positively received by a majority of both CGs (n = 14) and CRs (n = 14). They valued the ability to connect with healthcare providers and loved ones through the voice command capability. They explained that the advantage of hands-free operation is a significant improvement over the less user-friendly existing platform. Conversely, a subset of participants showed reluctance toward adopting this community feature. They believed that virtual contact with healthcare providers was unnecessary, lacked family routines involving group calls, and expressed concerns about the potential challenges others might face in learning to use the new system.

5.2.4. Reminder

Caregivers: The reminder feature of the robot which supports medication management and the organization of daily activities, received a generally positive response from the majority of CGs. In total, 15 out of 20 appreciated its potential to assist with various tasks, such as reminding CRs about exercises, daily routines, appointments, and pet care. Six CGs, however, showed some concerns about privacy, data security, and the redundancy of the feature given the existing capabilities in the cellphones. They also noted the need for a more robust solution to ensure medication adherence, such as visual evidence of a CR taking their medication.

Care recipients: Among CRs, about half (11 out of 20) favored using the robot's reminder feature for a variety of tasks, such as medication management, appointments, chores, and social reminders. They currently used a range of methods for managing their medication, and the addition of the robot's reminders was seen as potentially beneficial. On the other hand, nine CRs were hesitant, with their concerns centering around a need to learn to use a new technology, perceived overlap with functions already performed by their smartphones, a higher degree of trust in CGs relative to the robot, and practical issues with power and Wi-Fi reliance. Additionally, lifestyle factors, such as spending time outdoors or living in multi-story homes where the robot's utility might be limited, also contributed to their reluctance.

5.3. Ease or Difficulty of Use

Based on the video they watched, half of the CGs (n = 10) and some CRs (n = 6) found the robot seemingly easy to operate, but they acknowledged a range of potential challenges. Common concerns included the complexity of the initial setup process, integration with other accounts, a steep learning curve, and the burden of tech support potentially adding to strain for CGs. Other specific challenges mentioned as potentially making the robot more difficult to use were the robot's speech comprehension for voice commands, the small display size, the fixed screen height, and issues with touch screen sensitivity.

A preference for voice control over touch screens also emerged, particularly among CGs, who believed voice commands would be more accessible for their CRs. Five CRs also mentioned the potential for touchscreen challenges, with some indicating a preference for larger fonts and as well as a more robust voice interface. One CG highlighted the need for adjustable screen height for seated users.

5.4. Caregiving Requirements and Circumstances

As part of the exploratory analysis, which does not aim to confirm any hypothesis, especially given the relatively low number of participants typical for a correlation test, the experiences and backgrounds of both CGs and CRs were examined using correlation tests to provide additional insights into why certain participants are more or less likely to accept a system. No correction was made for multiple comparisons.

First, to examine the relationships between CGs' attitudes toward robot features and their experiences and caregiving conditions, we created an overall score that summed the number of accepted features and functions for each CG and CR. Then, we ran several correlations between those scores and the participants' age, interest, comfort, and trust in technology; satisfaction in communication with CRs; CRs' strain level, and guilt; and CRs' levels of dependency and feelings of loneliness.

A moderate positive correlation was found between CGs' attitudes toward robot features and the sum of scores on CRs' IADLs ($r = 0.339$, $p = 0.01$). Results suggest that CGs' positive attitudes towards robot assistance increased with the CRs' level of dependency in performing IADLs. CGs' satisfaction with their communication with CRs was negatively correlated ($r = -0.503$, $p = 0.02$) with CGs' positive attitudes toward robot features. This shows effective communication channels with CRs were associated with greater openness to robot features. Conversely, no significant correlations were observed between CGs' attitudes toward robot features and their general attitude (interest, trust, and comfort)

regarding technology, as well as their satisfaction with communication with CRs (r = 0.410, p = 0.005), CGs' age (r = −0.106, p = 0.66), CGs' Guilt Scores (r = 0.049, p = 0.83), and their experiences of strain from caregiving tasks (r = −0.029, p = 0.9).

A set of parallel correlations was also run between CRs' attitudes toward robot features and various aspects of their experiences and backgrounds. Results indicated a moderate positive correlation between CRs' attitudes toward the robot's features and their level of dependency (IADLs) (r = 0.393, p = 0.08), but no significant correlation with their feelings of loneliness (r = 0.045, p = 0.85). A moderate negative correlation was observed between CRs' attitudes toward robot features and CRs' age (r = −0.434, p = 0.056). With the p-value approaching but not reaching conventional levels of significance, the correlation shows that older CRs tended to have less positive attitudes toward the robot features. A summary of correlation results has been displayed in Table 3.

Table 3. A summary of correlation results.

Variable	Correlation with CG Positive Attitudes Toward Robot Features	p-Value	Correlation with CR Positive Attitudes Toward Robot Features	p-Value
CGs' sum of scores on CRs' IADLs	0.339	0.01 *		
CGs' general attitude (trust, interest, and comfort) toward technology	0.104	0.66		
CGs' age	−0.106	0.66		
CGs' guilt scores	0.049	0.83		
CGs' satisfaction with Communication with CRs	−0.503	0.02 *		
CGs' (physical, emotional, and financial) experiences of strain from caregiving tasks	0.029	0.9		
CRs' Level of Dependency (IADLs)			0.393	0.08
CRs' Feelings of Loneliness			0.045	0.85
CRs' Age			−0.434	0.056

*. Correlation is significant at the 0.05 level (2-tailed).

6. Broader Implications for the Design of Social Robots

The interviews also included questions to explore CGs' and CRs' perspectives on how a robot could assist with their tasks, the functionalities they desired, and which existing tools or devices failed to meet their needs, leading them to seek alternatives. Initially, all responses, whether unique or popular, were listed verbatim. Suggestions that directly proposed new functionalities were transferred to the design implication sections. The feedback that highlighted pain points or unmet needs was reformulated into statements guiding future stakeholders on which functionalities to prioritize.

CGs have provided specific design recommendations for social robots to enhance their functionality and user experience. Some of the CGs suggest integrating the social robot with wearable health devices would be helpful. This would allow the robot to monitor the vital signs and activities of CRs. Additionally, they recommend developing an algorithm that allows the social robot to suggest books, movies, and news tailored to the CRs' interests for personalized content curation. Another feature proposed is multimedia access, which includes integrating the ability to access platforms such as YouTube and to perform web searches through voice commands. Moreover, they recommend that the robot support CGs with medication reminders and provide the functionality to monitor CRs (e.g., via video) during medication intake to ensure adherence.

CRs have offered specific design recommendations to enhance the functionality of social robots tailored to their needs. They suggested implementing a multimodal reminder system that includes visual signals, like LED notifications, along with auditory feedback, to

ensure reminders are effectively communicated. Additionally, they proposed the creation of scenario-based reminders, such as bedtime checklists, to help with daily routines and guarantee the completion of necessary tasks. Another recommendation was the capability to integrate the robot with their smartphones to manage tasks like shopping lists and music playback. Safety enhancements were also recommended, with connections to smoke and carbon monoxide detectors to increase home safety. Moreover, CRs would like the robot to facilitate interaction with AI assistants like Siri and Google to provide answers and information, thereby extending the robot's capabilities as an information resource.

This feedback was crucial in generating a comprehensive set of design considerations for social robots in caregiving, incorporating both widely supported ideas and more novel concepts. From these data, the following refined design guidelines and insights for the development of social robots, such as VGo, were derived:

General Design Recommendations for Social Robots in Caregiving Settings

- Emergency services connectivity: ensure the robot can connect to 911 services and has an easily accessible emergency feature (button and voice command) for urgent situations. One of the CGs who highlighted this need mentioned the following:

  "Would it be connected to 911? A robot like this, you would want to have a command for an emergency call the emergency security or emergency medicine have the sensitivity to know that somebody has fallen. And ask, do you need help? Like when you need new drugs, if you have to contact either the pharmacy, that sort of thing."
- Home navigation integration: facilitate the robot's interaction with the home layout by connecting it to door locks to be able to navigate within the home. As one CG mentioned the following:

  ". . . I think that's a good feature, you know. You've been calling on the phones. They don't answer, and so you could send the robot to go find them. it doesn't open doors. So that's a blockage, you know. they have a lot of doors in their house, and so it wouldn't be really accessible because of the door issue or the different levels."
- Item locator integration: to enhance the robot's role in daily convenience and practicality incorporate Bluetooth tracking technology into the robot to help users locate misplaced items. One of the CRs who noted this need stated the following:

  ". . .finding things like glasses. I don't know how that would work. How does the robot find something? But it would pair with another device like the watch."
- Smart home system compatibility: incorporate synchronization with existing home automation systems to enable users to control things like their television, lighting, and robotic vacuums through the robot. Here is one of the CR's suggestions:

  "Could the robot be made or built to open doors? If you change the locks and have the door would automatically open when the robot got so close to it." Another CG suggested the following:
  ". . .as long as it's seamless between like platforms, you know, if it's Google or if it's Apple, because I think it would be good to have like routines and reminders set up. You know, not just a reminder that you ignore. . . if it was integrated with Apple Watch, or you know, another like, because then you can, like have the summary of it on your phone. . ..It would be useful if it could turn off the lights, you know, like, if it integrated with like, the Google IoT that we already have to do that, then it's not like, oh, having to use multiple devices to do the same thing. I think the more can do like, oh, you know, things like the television or the lights or something like that or that's useful like even if it vacuum the floor, that would be awesome."
- Storage features: for physical assistance in carrying items, consider adding a storage place like a tray or shelf to the robot for storing medications and personal items, as one CR suggested the following: "I think it would have been ideal to have a shelf on it,

doesn't have to be big, of course, because it's not big, the robot itself, but medication could be laid out on it. . ."

- Therapeutic and entertainment apps: allow for the installation of therapy, audiobook, and music apps to the robot. One CG mentioned the following:

  "It'd be cool if it could also access to YouTube. Because my mom does yoga, I've set up a playlist on YouTube for her to do yoga class and if it would say, do you want to do yoga? Now I'll play it for you. So, it would be awesome if it could navigate the web for my mother."

- Transcription features: include voice-to-text capabilities to aid communications with those who have hearing impairments or prefer visual interaction. One CG suggested the following:

  "I realized that there might be a transcription of my voice to typed notes on the screen. And likewise, what the robot might be saying back to me might also be on screen. So, you have the dialogue there."

7. Discussion

This study explores the perceptions of CGs and CRs around a social robot called VGo, an upright telepresence robot with features intended to support and facilitate caregiving. The objective of this research was to explore the potential of social robots to ease caregiving tasks through specific features and functions in an ADRD care context and to assess the general willingness of CGs and CRs to accept and use such a device in the CRs' homes.

The analysis indicated that participants highlighted the significance of the robot's physical design by addressing how its appearance could be one of the determining factors in integrating it into the home environment. Overall, participants suggested that the robot's height should be around eye level, its size should be compact and not occupy too much space, and its appearance should not resemble that of typical hospital devices that should be studied based on user background and cultural themes [37].

Regarding the presented features and functions of the robot, most CGs and CRs responded positively to the robot's four main functions: calling, community support, mobility, and reminders. CGs generally showed greater acceptance of these features than CRs. The majority of CGs appreciated using a robot for remote monitoring of a CR and connecting them with medical staff or family. Both CGs and CRs showed the highest interest in the robot's mobility feature. CRs favored the mobility feature the most, while CGs preferred the calling function. However, CRs showed less interest in the calling and reminder functions. CRs' low interest in the reminder feature might be due to existing routines for managing daily tasks. Some CRs found transitioning to new technologies stressful, raising concerns about the robot's reliability on WiFi and potential issues if the internet is down or they are not home.

Prior research highlights that the acceptance of technology and social robots varies according to the perspectives and roles of different stakeholders (e.g., CG, CR, nursing staff) [38,39] Similarly, in our study, CGs showed more interest in using the social robot when their CRs' dependency in managing IADL was lower. Furthermore, CGs' satisfaction with their current communication with CRs was a significant factor in their openness to the social robot features. However, factors like CGs' age, experience of caregiving strain, guilt scores, and general attitudes toward technology did not correlate with their openness to the robot's features. Similarly, for CRs, factors such as age and feelings of loneliness were not predictive of their willingness to adopt a social robot. These findings show the potential user groups for these technologies. Although previous studies indicate that demographics can influence technology acceptance [40–42], the complex relationship between these factors suggests that further research is needed to understand their impact. Future studies should investigate other elements that might influence prospective users' decisions regarding the adoption of these technologies.

Despite participants' only exposure to the robot being through the video, they provided useful feedback that can inform the future design of social robots for caregiving.

Participants raised issues regarding small text size and potential difficulties with the use of a touch screen—challenges that are widespread across different technologies and about which there has been considerable research [43–45]. They also noted concerns about VGo's ability to navigate obstacles within the home. Voice commands emerged as participants' preferred interaction modality; voice command use was associated with ease of use and was the primary reason why CGs and CRs considered transitioning from their phones or tablets to using a robot like VGo for certain tasks, such as making calls. Participants' preferences for voice commands also align with the growing popularity of voice assistants and their association with ease of use, particularly for older adults or those with dexterity limitations [37]. Additionally, several participants wanted the robot to integrate with external services like AI home assistants, YouTube, automatic doors, and smoke alarms.

In addition, CGs and CRs expressed interest in new features and capabilities, such as having the robot find lost items, offer emergency connectivity, integrate with home systems, and carry medications. They also wanted VGo to allow users to download other applications that provide well-being services and entertainment. CGs specifically desired VGo to integrate with wearables and to offer voice-to-text transcription; personalization; interactive voice communication; assistance with medication reminders; and guidance for individuals with cognitive issues. Most of the CGs favored the robot's ability to provide remote access to their CR when they were not physically present with the CR. This need was particularly valued by those who lived at a distance from their CRs (i.e., remote CGs) or who spent extended periods away from home during the day. On the other hand, CRs expressed interest in new features, such as light-based alerts and reminders, nuanced voice recognition for voice commands, scenario-based reminders, phone integration for music apps, an ability to make shopping lists, smoke, and carbon monoxide detection, and the ability to ask questions of VGo, similar to how they might with voice assistants such as Siri or Google.

Overall, the study presents several new research findings that highlight the need to address specific, practical challenges. The results emphasize the significance of the robot's physical design, with considerations such as height, size, and appearance playing a key role. Additionally, CGs demonstrated greater acceptance of the robot's functions compared to CRs, who expressed concerns about the robot's dependence on WiFi and its reliability in case of connectivity issues. Voice commands emerged as an important feature, particularly for ease of use, and the study underscores the need for interoperability between the robot and other in-home devices. Interestingly, some demographic variables, such as age and caregiving strain, did not predict openness to adopting the robot.

Future research should aim to identify which lifestyle or demographic characteristics in CGs and CRs may predict greater acceptance and adoption of social robots in caregiving settings. Participant feedback highlighted avenues for further investigation, such as developing more effective solutions for verifying medication adherence, potentially through visual confirmation. One limitation of this study is that participants only experienced VGo via video; they did not have the opportunity physically to see and interact with VGo, even in a prototype form. Future studies should ideally involve both CG and CR participants interacting with the device in the home caregiving environment. This approach can help highlight benefits and identify opportunities for new or enhanced features that the robot could offer to support caregiving.

Author Contributions: Conceptualization, S.F., L.D. and J.C.; methodology, S.F., L.D. and L.C.; formal analysis, S.F., L.C. and L.B.; investigation, S.F., L.C., L.B., L.D. and C.L.; writing—original draft preparation, S.F., L.C. and M.W.; writing—review and editing, S.F., L.C., L.B., L.D., M.W. and C.L.; visualization, L.C.; supervision, J.C. and L.D.; funding acquisition, J.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research funded by Vecna Healthcare company. The APC was funded by MIT AgeLab.

Data Availability Statement: Data supporting the reported results are available upon reasonable request. Interested parties may contact the corresponding authors for access to the datasets, subject to privacy or ethical restrictions.

Conflicts of Interest: The authors declare no conflict of interest.

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