Designing Care Robots for use by Alzheimer's Dementia Patients Using a Person Centered Care Model

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

The past century has seen a drastic improvement in the way society treats people living with Alzheimer's Dementia (AD). A primary method of achieving this has been building suitable environments meant as residential communities for people living with AD. Countless macro-scale models have been implemented aimed at improving residents' quality of life (Gaugler et al., 2014), designing building layouts and staffing systems that would attempt to empathize with the residents' needs (Janicki et al., 2005). These models also include mesoscale elements such as controlling lighting, sign visibility, and designing for safety. A subset of gerontology, the study of aging and the problems associated with aging, has also focused on micro-scale elements such as differing the coloration of dishes to improve the caloric intake of people living with AD (Brush et al., 2002). Needless to say, the environment has the potential to have a profoundly positive impact on the daily lives of people with AD, especially those living in designed environments such as care homes or memory care facilities - collectively referred to as care facilities in this paper.

These lived environments also increasingly contain new technologies, following a pattern of innovations in the dementia care space. One example is easy-to-read clocks to prevent confusion regarding time. Another more prominent example is monitoring cameras where caregivers can have a 24-hour access view to a resident's living space. Another subset of gerontology has looked at the potential of using assistive/care robots for use by people living with AD. These technologies are emerging and have great potential to benefit users but may also be rejected. This research paper aims to analyze design elements and perceptions of this emerging technology and attempts to answer the question: how can we best design for people living with AD?

AD is a currently incurable degenerative brain disease that progressively affects patients' memory, thinking, and behavior over time, affecting 6.5 million Americans over the age of 65. AD represents a massive burden on the healthcare system and economy in the United States with very few solutions to the many problems the disease introduces. In 2022, the cost of care for people 65 and older with AD and other related dementia conditions was $321 billion. 65% of that cost came from Medicaid and Medicare and a quarter came from out-of-pocket ("2023 Alzheimer's Disease Facts and Figures," 2023). Currently, there are only five FDA-approved medications that attempt to treat AD, four of which only target symptoms and all of which have undesired side effects (Yiannopoulou & Papageorgiou, 2020). Cognitive therapies and music therapy have emerged in recent years as promising treatment options yet both have seen inconclusive results (Carrion et al., 2018; Na et al., 2019). Care robots attempt to relieve some of the burdens associated with AD while possibly improving the quality of life of people living with AD. However, these technologies are emerging and their role in the dementia space is uncertain. Therefore, it is essential to determine whether care robots fit within care models used by care facilities; models which set a standard of care and attempt to promote the values and dignity of patients.

The dominant model used by care facilities is person-centered care (PCC) (Calkins, 2018; Gaugler et al., 2014). PCC is a theoretical care model which stresses individuality, meaningful engagement, and patient agency. For example, in the context of dementia care, PCC would propose understanding patients through their perceived realities to gain insight into the origins of behavior. PCC proposes many design features that attempt to empathize with the resident's reality while trying to balance the autonomy and safety of the individual (Calkins, 2018). The idea of PCC followed a history of applying humanistic principles, focused on individualism and personal worth, to the care of people living with AD starting in the 1980s. The shift in attitude towards this vulnerable population after the 1980s was caused by AD's reclassification as a disease rather than a mental illness. This led to decreased physical and chemical constraints as well as the need to develop care facilities (special care facilities) in nursing homes since mental institutions started denying patients with dementia. This evolved into higher-quality assisted living facilities that attempted to emulate a typical home environment Gaugler et al., 2014). PCC is given credit for many of these improvements (Siegler et al., 1997) and has led to a rise in the quality of life for residents (Chenoweth et al., 2009). Because person-centered care has been proven to be effective and has been a historical driver in the care of AD residents, it is a good theoretical model used to evaluate the emerging technology of care robots.

There are many types of care robots commercially available and being developed. These technologies could be categorized in a few ways. The first is their function. These robots may provide a social role to decrease feelings of isolation and promote healthy interactions. They may also serve as an aid to remind users how to perform physical tasks or perform physical tasks for users. They may also function as cognitive crutches providing games to promote cognitive functioning or to remind users of times and locations. A second way these robots can be categorized is by the degree of human involvement. Robots could be completely controlled by AI, pre-programmed by caretakers, or controlled by a teleoperator (caretaker or otherwise). The varying functions of these robots speak to the tensions inherent in developing these technologies. On a micro-scale level, some of these tensions are a reflection of the relationships between caretaker and patient. Both often want different things concerning how patients are cared for. Patients value autonomy and dignity while a caregiver may focus on safety and trying to decrease the burden placed on them. This was seen in an interview study on 10 dyads of caregivers and patients focused on care robot technologies (Wang et al., 2017). The caregivers wanted safety features and features that placed stressful situations onto a robot rather than themselves so they could focus on other more meaningful activities with the patient while patients preferred features that promoted their autonomy. The tension between caregiver and patient is an essential theme when analyzing these technologies. On a macroscale level, tensions stem from stigmas surrounding care robots and robotic technologies in general. These stigmas surround reservations about the ability of robots to replace a human as a social companion which was brought up in the interview study and even more nuanced questions over whether a robot should be proactive or only react to the command of a user (Koutentakis et al., 2020).

Methods

First, a literature review of PCC was conducted to understand its overall goals, principles, and consistent themes as applied to the dementia care space. Criteria for inclusion in the literature review included having been published in a journal related to gerontology and having a significant number of citations to represent a consensus in the field. Then, a literature review of studies on the use of care robots was conducted. First, review papers looking at many care robots were found to identify specific and commonly researched/referenced care robots to find research papers on. Then, these individual care robots were researched by finding research studies by the developers of the robot or by third parties. This collection of research was used to collect information on the effectiveness and design/functionalities of a given care robot while all literature research was used to understand the perception of care robots by study participants. The researched care robots were categorized based on intended use (social, physical, cognitive) and physical form (humanoid, anthropomorphic, machine-like). Commercially available care robots were also researched by collecting user responses from online reviews. Themes from online comments as well as from research papers were generated and compared to themes generated from the review of PCC. This analysis determined the degree of compatibility between the current development of care robot technology and PCC.

Results

Person Centered Care

PCC is widely used in healthcare and its core themes are similar across different healthcare spaces. However, PCC must be looked at in the context of dementia to include a nuanced view and show how the person-centered philosophy has transitioned into person-centered residential dementia care (PCRDC) in the dementia space. PDRCD presents behavioral symptoms of dementia not as symptoms at all but as reactions to a person's physical and social environment (Fazio et al., 2020). Therefore, the first step of a person-centered behavioral support approach is to discern the meaning and cause of disruptive/unpleasant behavior and also understand that these behaviors are an exemplification of their distress. For example, a refusal to take medications might be an expression of the desire for autonomy rather than a mistrust of medications or disliking side effects, although those may also be contributing factors. Understanding patients as individuals with certain behaviors manifesting for different reasons exemplifies the need for flexibility in care. PCRDC was also based on a shift away from medical and pharmacological treatments to behavioral support approaches like music therapy. The themes of shifting away from medical solutions and focus on the environment were mirrored in other reviews of PCC as well (Fazio et al., 2018).

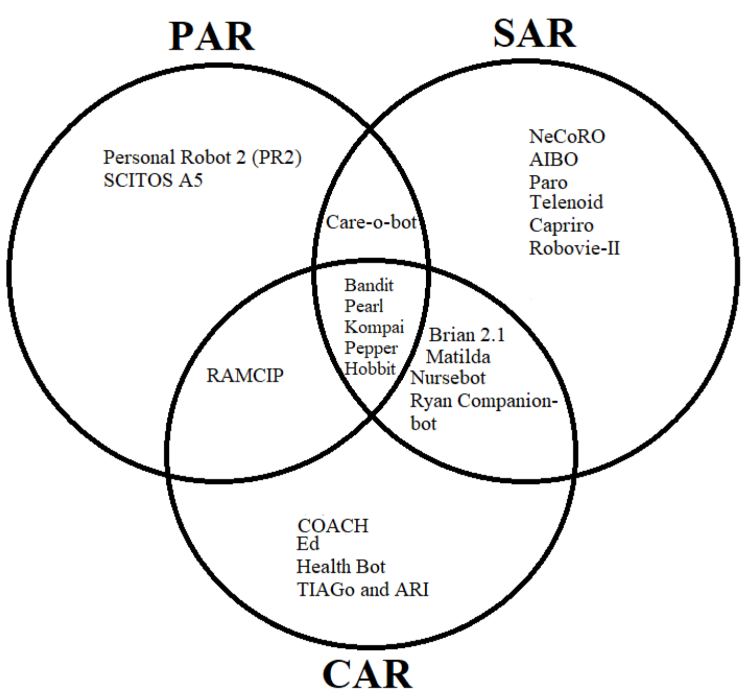
Looking at how PCC is measured can elucidate a lot of important themes. Edvardsson et al. studied how older adults with dementia, care staff, and family members describe PCC (Edvardsson et al., 2010). They found that core themes were personalized environment, organizational support, environmental accessibility, flexibility, and promoting normalcy. White et al. developed their own PCC measuring system and used categories to quantify PCC: personhood, autonomy, knowing the person, comfort, nurturing relationships, and physical and organizational environment (White et al., 2008). Hunter et al. studied the influence of individual and organizational factors on PCRDC and categorized PCC for quantification: autonomy, personhood, knowing the person, comfort care, and support for relationships (Hunter et al., 2016). From a brief literature review of PCC and more specifically PCRDC, the core themes across the literature were revealed. The themes most relevant to the use of care robots were the shift of thinking away from medical treatment, the autonomy of the patients, nurturing relationships, and flexibility/personalization. These themes were used to analyze how compatible care robots are with PCC (PCRDC).

Care Robots Design

To assess if the design of care robots targeted for use by older adults with dementia follows PCC, the design of those care robots must be assessed. 23 care robots that targeted use commercially or for research by older adults with dementia were found. Three different functional categories were found: Socially Assistive Robots (SARs), Cognitively Assistive Robots (CARs), and Physically Assistive Robots (PARs) (Figure 1). SARs functioned as points of social and/or emotional attachment for users. CARs functioned as supplements to users' declining cognitive capabilities, acting as reminders or schedulers. CARs also often functioned as ways users could maintain cognitive capabilities by also acting as gaming devices focused on cognitive games/activities. PARs were not a category that was found in the literature for dementia care robots but it was found that many care robots attempted to function either to supplement users' declining physical capabilities or to promote users to maintain their physical capabilities by encouraging physical activity. The same care robots can also be categorized by appearance (Table 1). Care robots were presented as animal-like, humanoid (all having only an upper body that was human-like), or machine-like. Machine-like care robots often had the outline of a humanoid and a head feature but lacked distinctive arms, hands, and/or facial features.

Figure 1

Distribution of care robots based on function (Abdollahi et al., 2017; Asgharian et al., 2022; Beer et al., 2017; Costa et al., 2018; Fasola & Mataric, 2013; D. V. Hebesberger et al., 2017; Jayawardena et al., 2016; Khosla et al., 2017; Kostavelis et al., 2019; A. V. Libin & Libin, 2004; Louie et al., 2014; Mihailidis et al., 2008; Mitsunaga et al., 2007; Montemerlo et al., 2002.; *NurseBot*, n.d.; Ohkubo et al., 2003; Sorbello et al., 2014; Vincze et al., 2018; Wang et al., 2017; Wu et al., 2014)



More specific design elements were charted in Table 2. The first category is software. This is a reflection of the complexity of the system. The second category is communication which embodies both how the system interacts with humans and how humans interact with the system. The third category is movement which embodies how the system interacts with the environment. The last categories, data and activities, embody more specific functions of the robots. The subcategory information management often included scheduling and reminder systems. The subcategory entertainment often included connection to the internet, games, and music.

Table 1

Distribution of care robots based on physical appearance (Abdollahi et al., 2017; Asgharian et al., 2022; Beer et al., 2017; Costa et al., 2018; Fasola & Mataric, 2013; D. V. Hebesberger et al., 2017; Jayawardena et al., 2016; Khosla et al., 2017; A. V. Libin & Libin, 2004; Louie et al., 2014; Mihailidis et al., 2008; Mitsunaga et al., 2007; Montemerlo et al., 2002.; *NurseBot*, n.d.; Ohkubo et al., 2003; *RAMCIP Robot: A Personal Robotic Assistant; Demonstration of a Complete Framework | SpringerLink*, n.d.; Sorbello et al., 2014; *User Experience Results of Setting Free a Service Robot for Older Adults at Home | IntechOpen*, n.d.; Wang et al., 2017; Wu et al., 2014)

Animal	**Humanoid**	**Machine-like**
NeCoRo (cat)	Bandit	ED
AIBO (dog)	Nursebot	Kompai
Paro (baby seal)	Ryan Companion-bot	Health Bot
Capriro (cat)	Telenoid	SCITOS A5
	TIAGo and ARI	RAMCIP
	Robovie-II	Hobbit
	Pepper	Matilda
		Care-o-bot
		Pearl
		Personal Robot 2

Table 2

Summary of care robot design features: (a) machine learning, (b) speech recognition, (c) face recognition, (d) emergency detection, (e) verbal communication, (f) non-verbal communication, (g) verbal control, (h) touch screen control, (i) object manipulation, (j) autonomous navigation, (k) teleoperated, (l) autonomous recharging, (m) information management, (n) health monitoring, (o) entertainment, and (p) cognitive games/training (Abdollahi et al., 2017; Asgharian et al., 2022; Beer et al., 2017; Costa et al., 2018; Fasola & Mataric, 2013; D. V. Hebesberger et al., 2017; Jayawardena et al., 2016; Khosla et al., 2017; A. V. Libin & Libin, 2004; Louie et al., 2014; Mihailidis et al., 2008; Mitsunaga et al., 2007; Montemerlo et al., 2002.; *NurseBot*, n.d.; Ohkubo et al., 2003; *RAMCIP Robot: A Personal Robotic Assistant; Demonstration of a Complete Framework | SpringerLink*, n.d.; Sorbello et al., 2014; *User Experience Results of Setting Free a Service Robot for Older Adults at Home | IntechOpen*, n.d.; Wang et al., 2017; Wu et al., 2014)

Category		Software				Communication				Movement				Data		Activities	
Robot	**Type**	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**	**(k)**	**(l)**	**(m)**	**(n)**	**(o)**	**(p)**
PR2	PAR								✓	✓	✓				✓		
SCITOS A5	PAR				✓	✓			✓	✓	✓		✓			✓	
RAMCIP	PAR/CAR	✓			✓	✓			✓	✓	✓			✓	✓		✓
Care-o-bot	All	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓		✓	
Bandit	All		✓			✓	✓	✓						✓			✓
Pearl	All		✓	✓		✓		✓	✓				✓	✓	✓		
Kompai	All		✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pepper	All	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Hobbit	All	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
COACH	CAR				✓	✓											
ED	CAR					✓						✓					
Healthbot	CAR		✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	
TIAGo/ARI	CAR	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nursebot	CAR/SAR	✓	✓			✓		✓	✓		✓			✓	✓		
Ryan Companion-bot	CAR/SAR		✓			✓	✓		✓							✓	✓
Matilda	CAR/SAR		✓	✓		✓	✓	✓			✓			✓		✓	✓
Brian 2.1	CAR/SAR		✓			✓								✓			✓
NeCoRo	SAR						✓										
AIBO	SAR		✓				✓				✓						
Paro	SAR						✓										
Telenoid	SAR											✓					
CAPRIRO	SAR		✓				✓				✓						
Robovie-II	SAR		✓			✓	✓				✓					✓	

User Views on Care Robots

Animal-like care robots have been extensively studied as possible therapeutic devices in dementia care facilities. These studies focused on popular and commercially available products. A. Libin and E. Libin studied NeCoRo with older adults with dementia and found that past experiences with pets greatly influenced how users interacted and felt about NeCoRo. Generally, those who had pets in the past were more open to using NeCoRo. They concluded that "interactions with the robot serve as the mediator between the person's past communication and personal experiences in different situations" (A. V. Libin & Libin, 2004). For the users, NeCoRo became a relatively blank slate for them to express themselves. In a different study, A. Libin and Cohen-Mansfield found that a plush cat toy had the same therapeutic effectiveness as NeCoRo (A. Libin & Cohen-Mansfield, 2004). In a similar study, AIBO being used in short therapy sessions had a less therapeutic effect than a toy dog, and the therapist's intervention was required to promote interaction (Tamura et al., 2004). In a study comparing AIBO with a live dog in nursing homes, there was no statistically significant difference in their ability to decrease loneliness. Both staff and residents were reluctant to interact with AIBO but that diminished with increased exposure time. The study concluded that AIBO was good when using a live animal was unfeasible (Banks et al., 2008). Paro, likely one of the most studied care robots (Hung et al., 2019), actually showed that it had greater therapeutic effects than stuffed animals (Takayanagi et al., 2014). However, a study also noted, "that staff in the residential care setting were challenged to use PARO effectively to provide care due to restricted work routines" (Bemelmans et al., 2016). Another study found that the removal of Paro after the study had negative effects since the residents became attached to Paro (Liang et al., 2017).

Humanoid and more robot-like care robots have also been studied extensively. These studies differ since most of the robots are currently in development or were made for research purposes initially. Abdollahi et al. surveyed caregivers and older adults with dementia on interactions with and features of Ryan Companion-bot. While it showed promise as a therapeutic device and those surveyed liked many features of Ryan Companion-bot including music playing, photo album displaying, and scheduling, the authors concluded that it could not replace human interaction (Abdollahi et al., 2017). Research on Brain 2.1 found that older adults with dementia liked the human aspects of the robot; lifelike emotional expression, facial expressions, voice modulation, and human-like appearance (McColl et al., 2013). Researchers used the robot ED to facilitate post-use interviews with 10 dyads of caregivers and older adults with dementia, referred to as OAs in the paper. The findings from this study were conflicting. Many OAs saw the benefits of using care robots but contradictorily said they would probably never use one. This was mostly due to the stigma of using care robots meaning you were more disabled. However, OAs also saw how care robots could promote their independence, decrease the burden on caregivers, and decrease relationship strain. However, some caregivers mentioned that they would lose purpose if a care robot took over their role or would decrease the time their OA spends with them. Interestingly, caregivers focused on the safety benefits of care robots while OAs focused on independence. Both OAs and caregivers saw ED as an appliance and doubted they would become emotionally attached (Wang et al., 2017). Sabelli et al. conducted an ethnography on the use of Robovie-II in a care home. They found that the staff believed in the benefits of the robots which drove them to encourage and recommend ways for residents to interact with Robovie-II. They also found that residents viewed Robovie-II in relation to their own lives. For example, one resident thought of it as a friend while another thought of it as a grandchild (Sabelli et al., 2011). Hebesberger et al. conducted a long-term study on SCITOS A5 in a care hospital. They found a sentiment among staff that care robots were an inevitable, necessary evil and they would prefer robots to do physically strenuous tasks so they could spend more time with patients. Interestingly, staff wanted a robot with more human-like qualities such as a pre-recorded human voice (D. Hebesberger et al., 2017).

Customer Reviews of Care Robots

Customer reviews of the robot NeCoRo were found on Amazon. NeCoRo is likely the only commercial care robot that is being sold at a large enough scale to be able to analyze customer reviews. The product was specifically targeted toward older adults with dementia/their caregivers. It was often the case that a caregiver would be the buyer but findings reflect both the user's and caregiver's perspectives. Overall, comments were highly positive with some negative reviews due to mechanical failures of the product or customer service issues. Older adults with dementia were often previous cat owners who were no longer able to care for a pet whether they were physically unable or their care home disallowed pets. Caregivers describe their loved one's interactions with NeCoRo as a genuine emotional attachment, many thinking that their loved one thought that the robot was a real cat. NeCoRo has a fake fur coat and can imitate purring, although not too realistically according to some caregivers. Many also thought the mechanical clicking for neck and movements was a bit jarring. However, when caregivers mentioned the impact it had on their loved one, it was always very positive - mentioning how it can prevent loneliness, have a calming effect, and can be a good pet substitute. Most loved ones named the robot as well and gave it a lot of attention. Caregivers saw how impactful the device was and were quick to replace batteries or repurchase NeCoRo after a mechanical failure.

Discussion

Theme 1:Shift of thinking away from medical treatment

Many of the mentioned care robots were explicitly designed as therapeutics or medical devices. They function to monitor health, promote maintenance of cognitive function through games or activities (Table 2), or promote physical activity. This is one of the innate incompatibilities of most care robots with PCRCD. Perhaps, this could partly explain the success of commercially available products like NeCoRo, AIBO, and Paro. While they have therapeutic benefits, their design is simple. They merely mimic the most basic behaviors of pets. These products solved a non-medical problem: how can older adults with dementia have pets with animal restrictions in care facilities or physical limitations of being able to care for a live pet? Even though care robots framed as therapeutics may seem incompatible with this theme, care robots were often framed in opposition to the use of drugs as medical treatments. Many of the aforementioned studies found that the use of care robots in care facilities decreased loneliness and improved moods. These care robots, as opposed to those that targeted specific symptoms of dementia or AD such as decreased cognitive or physical ability, are perhaps more compatible with PCRDC. This is because they do not attempt to treat dementia but attempt to solve problems any person could have such as loneliness or depression which happen to be frequent in those who have dementia. Many robots could also act as behavioral support therapies since they were able to play music and promote physical or cognitive activity (Fazio et al., 2020).

Theme 2: Autonomy

Wang et al. (2017) showed that older adults with dementia mostly felt that care robots could promote their independence from their caregivers. This applies more to robots classified as CARs or PARs as SARs were viewed as unable to fully replace human-human interactions. CARs would function to act as schedulers, reminders, or task trainers to relieve caregivers. PARs would relieve caregivers of physical tasks. In these respects, care robots have been adequately designed to promote autonomy. Most CARs had a type of information management system and most PARs had some ability to manipulate objects. Some PARs lacked the latter since they were designed as physical trainers to promote exercise and therefore the ability to manipulate objects was not included. However, even functioning as physical trainers could relieve burden from caregivers.

Theme 3: Nurturing Relationships

The design features of the care robots offer conflicting possibilities when it comes to nurturing relationships. Many designs included screens with entertainment apps or games which on one hand promote activity (to varying extents) and decrease boredom but on the other hand could promote isolation depending on the context of its use in private or public spaces. Many designs also included systems that promoted connectivity such as the ability to call or skype. Many also were explicitly designed to be controlled by a teleoperator connecting users to a human, albeit behind a robot facade. Nevertheless, teleoperated robots connect humans to other humans physically and could be used for special circumstances where in-person interactions are difficult.

Theme 4: Flexibility/personalization

This theme is perhaps the most important and most difficult for care robots. PCRDC promotes that the individual's wants, needs, beliefs, environment, and relationships should be considered when thinking about care. But how can you design a product for a demographic while also catering to theoretically an infinite number of needs? This is where care robots are most lacking. Most lack machine learning elements, systems that are able to learn and adapt without following explicit instructions, that will be crucial for responding dynamically to users' needs. Ideally, care robots could be programmable for personalization. For example, ED was programmed by researchers to help older adults with dementia to wash their hands through a video tutorial and encouragement. To adhere to PCRDC, ED would need machine learning to be able to develop a training program for any task its user asks for. Privacy concerns aside, most lacked facial or voice recognition needed to identify specific individuals. This is necessary if the care robot is meant for use by many users in a care facility or hospital. PCRDC also means being able to accommodate different users' situations. This issue becomes apparent when some care robots lack verbal control and solely rely on touch screen control. Care robots have miles to go with respect to flexibility and personalization but concurrent improvements in machine learning technologies may be able to help care robots meet the high standard.

Theme 5: Maintenance of Technology

The theme of maintenance was a surprising and yet unsurprising finding in this research on care robots. Russell and Vinsel's 'theory' of maintenance (Russell & Vinsel, 2018) can be easily applied to care robots and is an important lens to view human-robot interactions. If older adults with dementia are the users, then more often than not caregivers are the maintainers. They fix, recharge, replace, and personalize the robots when the users cannot. In the case of Robovie-II, the staff maintained the use of Robovie-II by actively encouraging its use by residents. For teleoperated care robots like Telenoid, their use is required to have a human actor involved. If care robots are an inevitable, necessary evil, then human involvement in the maintenance of those robots is equally a given. Human actors will never be separated from the care robots even if their developers/designers are. This theme of maintenance implies that robots should be designed with caregivers in mind. This may seem counterintuitive to theme 4 (Flexibility and Personalization), which at some points stress the individuality of the user, but designing for caregivers may be an important aspect of theme 3 (Nurturing Relationships). Older adults with dementia and their caregivers have a complex and intertwined relationship. Understanding this and designing the involvement of caregivers in the use of care robots could prove beneficial for adhering to the PCRDC model. One reason is that care robots may never understand dementia or the perceived realities of those with dementia, but caregivers can understand. Involvement of caregivers in care robots can fill the gaps in the PCRDC model - namely considering the individual's environments and understanding the cause of disruptive behavior.

Conclusion

Care robots have the potential to help older adults with dementia in relation to their declining cognitive and physical abilities through CARs and PARs, respectively. SARs may even be able to promote social wellness. However, even with decades of research and development and proven benefits, therapeutic or otherwise, care robots have not become widely accepted in the United States. Striving to adhere to PCRDC may be a step towards wider acceptance and use. There are many gaps though. Some of these gaps can be attributed to the lack of machine learning which would make care robots reactive and proactive. This emphasizes the need for widely adopting machine learning technologies in care robots to create dynamic systems reflective of individual user wants and needs. Additionally, care robots often focused heavily on therapeutic aspects and had the potential to promote isolation. Finally, developers must acknowledge caregivers' complex relationships with older adults with dementia and consider ways to involve caregivers, not just as buyers of a product, but as maintainers of their product. A major limitation of this research is that it failed to consider the cultural context of the development and research of each care robot as well as that culture's relation to PCRDC. The care robots researched were developed across the world: USA, Japan, Germany, Korea, France, Australia, Austria, Greece, and Spain. Perceptions of care robots do vary across countries (Castelo & Sarvary, 2022; A. V. Libin & Libin, 2004). Continuation of this research would involve an extensive review of the same set of robots looking at different themes of how older adults with dementia and caregivers in different cultures perceive care robots.

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