

Exploring the Effect of Companion Robots on Emotional Expression in



A Pilot Randomized Controlled Trial

ABSTRACT

This pilot study aimed to compare the effect of companion robots (PARO) to participation in an interactive reading group on emotions in people living with moderate to severe dementia in a residential care setting. A randomized crossover design, with PARO and reading control groups, was used. Eighteen residents with mid- to late-stage dementia from one aged care facility in Queensland, Australia, were recruited. Participants were assessed three times using the Quality of Life in Alzheimer's Disease, Rating Anxiety in Dementia, Apathy Evaluation, Geriatric Depression, and Revised Algae Wandering Scales. PARO had a moderate to large positive influence on participants' quality of life compared to the reading group. The PARO intervention group had higher pleasure scores when compared to the reading group. Findings suggest PARO may be useful as a treatment option for people with dementia; however, the need for a larger trial was identified.

In Australia, an estimated 245,400 people are diagnosed with dementia and, as the population ages, this number is predicted to

rise to 1.13 million by 2050 (Access Economics, 2009). The majority of people with dementia spend the last part of their life in residential care,

as the symptoms of dementia can be challenging for families to manage in the community. People with dementia may exhibit behavioral deficits or excesses that cause stress for the individual, caregivers, and other residents in care facilities. Furthermore, residents who display agitation and aggression are at risk from the cyclic nature of these disruptive behaviors, which are regularly managed with sedation and isolation. Consequently, feelings of frustration and agitation are heightened and physical functioning is reduced, which then leads to the additional, regular use of antipsychotic medication (Australian Institute of Health and Welfare, 2004). Alongside a decline in physical functioning, psychologi-

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Older Adults With Dementia



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cal symptoms related to dementia, such as altered communication and depressed mood, can often cause people with dementia to feel socially isolated and lonely. Apathy, loneliness, and depression can make it challenging for care staff to engage this population in meaningful activities. Residents who are withdrawn are at high risk for further cognitive and functional decline and poor quality of life (QoL) (Yeager & Hyer, 2008).

Empirical studies indicate that people with dementia retain affective capability (i.e., mood and emotions) and can react to stimuli regardless of whether these reactions lead to the enhancement of emotional memory (Hamann, Monarch, & Goldstein, 2000). Researchers have found that communication with animals can have a positive effect on older adults by increasing their social behavior and verbal interaction, fostering the building of relationships through interaction

with others, and decreasing feelings of loneliness (Churchill, Safaoui, McCabe, & Baun, 1999; Kanamori et al., 2001; Sellers, 2006). There are situations, however, where a substitute, such as a robotic pet, may be a better match. The presence of animals in residential care settings can place residents at risk of infection and injury and create a number of other problems, including increased stress for animals that are repeatedly fed and handled by numerous residents, conflict among residents who claim animals as their own, fear among residents who do not like animals or a particular type of animal, and additional duties for nursing staff (e.g., feeding, walking, cleaning the animals). To counter these issues, researchers have investigated the use of robotic animals for use in instances where the presence of real animals is contraindicated.

Robotic pets, also called *emotional companion*, or *therapeutic robots*, have recently been introduced into long-

term care as companions for individuals with cognitive impairment and other physical disabilities (Libin & Cohen-Mansfield, 2004). The advantages of robotic pets have been listed as the highly imitative, life-like behavior; modeling of emotional states usually experienced by humans; and provision of alternative models of communication (e.g., tactile-kinesthetic, visual sensory, emotional, and social) (Kramer, Friedmann, & Bernstein, 2009; Tamura et al., 2004). Furthermore, these studies have reported improvements in QoL, relationships, and loneliness in older adults who have interacted with robotic pets (Kramer, Friedmann, & Bernstein, 2009; Tamura et al., 2004). PARO, a therapeutic companion robotic seal, has been shown to have a psychological effect on people with dementia, improving their relaxation and motivation as well as improving the socialization of individuals with others, including caregivers (Wada & Shibata, 2007; Wada, Shibata, Musha, & Kimura, 2008).



Figure. PARO, a therapeutic companion robotic seal. Photo courtesy of Takanori Shibata.

PARO, invented by Takanori Shibata, a researcher at Japan's National Institute of Advanced Industrial Science and Technology, is a therapeutic, pet-type robot with the appearance of a baby harp seal (Figure). It has tactile sensors and moves its tail and flippers and opens its eyes when petted. Artificial intelligence software changes the robot's behavior based on a host of sensors that monitor sound, light, temperature, and touch. It responds to sounds, can learn its name, and learns to respond to words its owner uses frequently. It can show emotions such as surprise, happiness, and anger, and will cry if it is not receiving sufficient attention. It produces sounds similar to a real baby seal and is active during the day and sleeps at night. Previous research in a Japanese aged care facility found that PARO increased residents' social interaction and decreased stress (Wada & Shibata, 2007). Previous studies, however, have had serious methodological limitations, including small samples (or case studies), no or inappropriate control groups, and limited outcome measures. Furthermore, a number of these studies included people with and without dementia.

This small-scale project aimed to provide initial pilot data on the effectiveness of PARO in engaging people with dementia to inform justifications for more extensive research.

The study sought to compare the effect of PARO to participation in an interactive reading group on emotions in people living with moderate to severe dementia in a residential

Robots may present a supplement to activities currently in use and could enhance the life of older adults as therapeutic companions, and in particular, for those with moderate to severe cognitive impairment.

care setting. The university human research ethics committee gave approval for the study, and informed consent was sought from both the participant (individual with dementia) and the person legally permitted to give consent on his or her behalf.

METHOD

Participants

A purposive sample of older adults with dementia was recruited from a residential aged care facility in Queensland, Australia in 2011. Residents 65 and older were eligible to participate if they had a diagnosis of mid- to late-stage dementia or met the criteria for probable dementia as per the *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition, text revision (American Psychiatric Association, 2000) and were physically able to participate in the activity (i.e., they were not blind or severely deaf).

Setting

The management from one residential care facility in the north of Brisbane, Queensland, Australia, participated in the study. The facility offers 52 low-care and 62 nursing home beds. Approximately one third of residents in the facility have dementia.

Intervention

Both intervention and control activities ran for 45 minutes, three afternoons per week, for 5 weeks with groups of nine. Participants then crossed over into the opposite activity and the protocol was repeated. A 3-week wash-out period was included between crossover to reduce potential carry-over effects (Ayalon, Gum, Feliciano, & Areán, 2006). Treatment fidelity was monitored through a standardized protocol manual and weekly spot checks of the intervention.

The PARO intervention involved activities around the concepts of discovery, engaging an emotional response, social interaction in the group through discussion about PARO, and touching PARO. Discovery encouraged participants to examine PARO while being passed around the group. Individuals were asked if they would like to get to know PARO. To help engage an emotional response, the facilitator showed PARO to each individual and demonstrated how PARO

responded. For example, the facilitator held PARO close to participants' faces and stated, "Hello, XX. If we talk to Millie (name of PARO), she will listen and respond. Let's see what happens when you speak to Millie." Social interaction encouraged residents to discuss PARO within the group. The facilitator encouraged discussion through set questions such as, "What does everyone think of PARO?", "Who used to have a pet?", and "How does Millie compare to your pet?" Participants were encouraged to touch PARO and to talk about how the fur felt and other opportunities such as looking at and describing PARO's eyes and eyelashes.

Reading activities for the control group involved being read to, looking at pictures, and social interaction in the group through engaging participants in questions about the readings.

The facilitator of the intervention and control activity was a bachelor degree-educated activity therapist (W.F.). Two members of the research team (W.M., C.J.) using a protocol manual that outlined content of each session, divided into four key areas, trained the facilitator. The key areas included:

- Procedure, which was designed around the following areas—introduction, emotions, social interaction, and closure.
- Explanation—how to implement activity and the process for each of the four areas.
- Time—the time proposed for each of the four key areas.
- Equipment—equipment requirements for each session and each of the four areas.

One PARO was introduced in Weeks 1-3 and then a second PARO was introduced into the group in Weeks 4 and 5. The aim of introducing two PAROs was to allow participants more individual time with the robot. The facilitator was taught the protocol in three sessions using people not engaged in the research. He was given the protocol to learn and for referral when needed. The

TABLE 1
MEANS AND STANDARDIZED DIFFERENCE IN MEANS FOLLOWING INTERVENTION (N = 18)

Outcome Measure	Mean (SD)		Cohen's <i>d</i>	
	PARO Group	Reading Group	Upper	Lower
AWS	46.2 (12.2)	46.8 (13.0)	-0.1	0.0
QOL-AD	37.2 (8.2)	26.4 (16.8)	0.6	1.3
AES	38.7 (13.7)	36.5 (13.7)	0.2	0.2
GDS	4.7 (2.9)	4.3 (3.5)	0.1	0.1
RAID				
People with Dementia version	9.8 (6.5)	7 (6.9)	0.4	0.4
Proxy version	12.8 (11.2)	17.1 (15.1)	-0.3	-0.4
OERS				
Pleasure	32.7 (17.2)	21.1 (17.7)	0.7	0.7
Anger	12.8 (6.0)	11.6 (5.6)	0.2	0.2
Anxiety	13.2 (5.6)	10.6 (3.6)	0.5	0.7
Sadness	12.2 (5.4)	9.9 (3.9)	0.4	0.6
Alert	48.1 (20.3)	45.1 (21.2)	0.1	0.1

Note. SD = standardized difference in means; AWS = Revised Algae Wandering Scale–Nursing Home version; QOL-AD = Quality of Life in Alzheimer's Disease Scale; AES = Apathy Evaluation Scale; GDS = Geriatric Depression Scale; RAID = Rating Anxiety in Dementia Scale; OERS = Observed Emotion Rating Scale.

reading control group protocol was designed around the same four key areas and aimed to engage participants' interest in the reading activities read out loud by the facilitator and using question and answer activities as outlined in the reading control protocol.

Outcome Measures

At baseline, mid-point (after first 5-week intervention arm), and postintervention (after the second 5-week intervention arm), participants were assessed on QoL, mood states, and behavior using the Quality of Life in Alzheimer's Disease Scale (QOL-AD, modified version; Edelman, Fulton, Kuhn, & Chang, 2005), Rating Anxiety in Dementia Scale (RAID; Shankar, Walker, Frost, & Orrell, 1999), Apathy Evaluation Scale (AES; Marin, Biedrzycki, & Firinciogullari, 1991), Geriatric

Depression Scale (GDS; Yesavage, 1988), and Revised Algae Wandering Scale–Nursing Home version (AWS; Algae, Beattie, Bogue, & Yao, 2001). In addition, mood state was measured during each reading and PARO session using the Observed Emotion Rating Scale (OERS; Lawton, Van Haitsma, & Klapper, 1999). Two members of the research team trained research assistants not involved in the facilitation or control of the intervention in how to use the outcome measures.

Sampling

The study sought to include 18 participants (nine in each treatment group), which is less than one third of the number ($N = 58$) we estimate would be required for a larger study, based on a large effect size (0.35), with a power of 0.80, $\alpha = 0.05$, and a 10% rate of attrition (Cohen,

TABLE 2

RELIABILITY CHANGE INDICES (RCIs) OF OUTCOME MEASURES FOR THE PARO GROUP (N = 18)

Outcome Measure	Pre-Post Intervention (Σ Change Scores)	Reliability Change Index ^a	Reliable Change	Clinical Significance
QOL-AD	5.00	4.48	Yes	Yes
AWS	5.29	1.86	Yes	Yes
AES	1.50	7.51	No	No
GDS	-0.67	1.29	No	No
RAID				
People with Dementia version	-2.50	3.80	No	No
Proxy version	4.53	5.42	No	No

Note. QOL-AD = Quality of Life in Alzheimer's Disease Scale; AWS = Revised Algase Wandering Scale–Nursing Home version; AES = Apathy Evaluation Scale; GDS = Geriatric Depression Scale; RAID = Rating Anxiety in Dementia Scale.

^a Test-retest reliability used in RCI computations was based on published literature for these measures.

1992). The sample size was appropriate for the pilot design, given that all 18 participants experienced both the PARO and reading group activities and acted as their own controls.

Randomization

Under the guidance of the biostatistician (S.B.), a research assistant (C.G.), not associated with data collection, conducted the randomization process using a computer-generated program to determine the different ordering of treatments for each participant. Although the intervention and control facilitator was not blinded to the intervention, the facilitator was blinded to all outcome measurements. The intervention and control activity took place in a space screened from view of staff so that they were not aware of participant intervention sequence order.

RESULTS

Eighteen residents from a dementia-specific, secured, long-term care unit participated in the study. The randomization proved successful, as no significant differences were noted in participants' characteristics between the first PARO and control groups ($p < 0.05$). The average age of participants was 85.3 ($SD = 8.4$ years). Forty-seven percent were married and 53% were

widowed or divorced. The mean Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) and Test of Severe Impairment (Albert & Cohen, 1992) scores were 7.4/30 (severe dementia) ($SD = 5.0$) and 13.4/24 (severe dementia) ($SD = 5.3$), respectively. More than half of the participants (66%) had a history of disruptive behavior. As a result of the small sample, it was not possible to compare participants across the range of MMSE scores.

The nature of the outcome measures and the high level of participant cognitive impairment resulted in a large amount of missing data. Furthermore, missing data analysis revealed that these data were not completely missing at random. In view of this and the small sample, data imputation was considered to be inappropriate for the purpose of statistical analysis. Outcome measures were examined according to the effect and clinical significance of the PARO intervention.

The effect of the PARO intervention was assessed using the standardized difference in means (Cohen, 1988) of both the reading and PARO groups following intervention (Table 1). A standardized difference in means of 0.3, 0.5, and 0.8 are considered to have a small, moderate, and large effect, respectively. PARO was found to have a

positive moderate to large influence on the QOL-AD (0.6 to 1.3) and OERS-Pleasure (0.7). The PARO group had higher QOL-AD and OERS-Pleasure scores when compared to the reading group. Small to moderate effects were found for RAID People with Dementia (0.4) and Proxy (0.3 to 0.4) versions. Staff indicated that participants in the PARO group displayed less anxiety than those in the reading group, which was confirmed by video analysis. In addition, moderate to large negative influence on OERS-Anxiety (0.5 to 0.7) and OERS-Sadness (0.4 to 0.6) were found. Scores for OERS-Anxiety and OERS-Sadness were found to be higher in the PARO than reading group.

Clinical significance of the PARO intervention was examined based on two criteria: (a) difference in pre- and postintervention scores exceeding the Reliability Change Index (RCI); and (b) postintervention score falling within the normative range. Although several alternative and advanced formulae exist for calculating RCI, outcomes of these formulae are akin (Maassen, 2000). Hence, the simpler method of Jacobsen and Truax (1991), which provides a degree of control over regression to the mean and measurement error, was used. In addition, Wise (2004) contended that a change of one stan-

dard deviation on a given measure is comparable to a large effect size and should be considered as clinically significant. Given the lack of a universally agreed benchmark on clinical significance, a pragmatic approach was adopted where a clinically significant change is considered to be one that surpasses the RCI on a given measure by a minimum of one standard deviation. Therefore, the RCI was computed using the differences in pre- and postintervention scores divided by the standard error of the difference to establish a cut-off change score for clinical significance at 95% confidence (i.e., 1.96 standard deviation).

As reflected in **Table 2**, the PARO intervention had a positive, clinically meaningful influence on QOL-AD, in which an increase in QOL-AD scores for participants was found after the PARO intervention. On the other hand, a negative clinical change was observed on AWS, in which participants in the PARO group were found to display increased behaviors of wandering.

DISCUSSION

Residents living in nursing homes may have limited opportunity to engage in meaningful activities and, in particular, activities that are focused on a positive emotional response. The experience of positive emotions is an important component of QoL. However, dementia may impede the ability of a person to pursue pleasurable moments (Schreiner, Yamamoto, & Shiotani, 2005). Therefore, structured activities have an important role in improving QoL. Research suggests that when residents are actively engaged, they report improved QoL and reduced depression (Mitchell & Kemp, 2000). The current study provides important preliminary support for the idea that robots may present a supplement to activities currently in use and could enhance the life of older adults as therapeutic companions, and in particular, for those with moderate to severe cognitive impairment.

KEYPOINTS

Moyle, W., Cooke, M., Beattie, E., Jones, C., Klein, B., Cook, G., & Gray, C. (2013). **Exploring the Effect of Companion Robots on Emotional Expression in Older Adults with Dementia: A Pilot Randomized Controlled Trial.** *Journal of Gerontological Nursing*, 39(5), 46-53.

- 1 Loneliness, anxiety, and depressed mood are common features of dementia.
- 2 Robotic animals, which provide companionship, may be an alternative psychosocial intervention for older adults with dementia.
- 3 Introduction of PARO improved quality of life and improved pleasure.
- 4 Further research, using a larger sample and more emphasis on observation measures, is required to confirm these findings.

The findings are consistent with previous research on robotic companions and people with dementia. Libin and Cohen-Mansfield (2004) explored the use of a robotic cat compared to a non-robotic (stuffed toy) cat. They found both the robotic and toy cat held participants' interest. However, more importantly, sessions with the robotic cat resulted in a significant increase in pleasure and interest. Kanamori, Suzuki, and Tanaka (2002) reported that the introduction of a robotic dog (AIBO) showed statistically significant improvements in speech, emotional words, and satisfaction index postintervention in individuals with dementia. Furthermore, there was a statistically significant decrease in patient loneliness between baseline and post-test (20th session). One study (Sellers, 2006) compared the effect of visitation by (a) a person with a live dog, (b) a person accompanied by a robotic dog (AIBO), and (c) a visitor alone. The live dog and AIBO interventions stimulated resident social interaction beyond that of the visitor alone. However, the AIBO resulted in residents spending more time looking at the AIBO. Shibata, Wada, Saito, and Tanie (2004) compared PARO with a placebo PARO (programmed on repetition and not response) with 23 older people (none with dementia). The intervention involved 1 hour of group interaction

with the PARO, 4 days per week for 3 weeks. The Profile of Mood States was used at baseline and postintervention to measure mood. No difference was found between placebo and PARO groups, although both interventions were reported to improve mood.

Although the findings suggest PARO could enhance the life of older people as therapeutic companions, the cost of PARO should be taken into consideration when deciding to introduce PARO into a care facility or in research. PARO cost approximately \$5,027 U.S. each (<http://www.japantrendshop.com/paro-robot-seal-healing-pet-p-144.html>), excluding postage. Furthermore, PARO need to be returned to Japan or Denmark for repairs, and the cost of return postage and repairs, as well as time taken to repair, can limit their availability. However, the number of people living with dementia in residential care is increasing as the population ages. There is evidence that these residents have limited stimulation, which reduces their QoL and increases loneliness, depression, and dementia-related behaviors. Care for people displaying such behaviors is complex, poses challenges for staff, and often results in the use of costly pharmacological treatment. Such treatment increases physical dysfunction as a result of sedation, and extra pyramidal symptoms can contrib-

ute to an increase in falls, which add further to the burden of care. There is a need to develop and evaluate interventions that specifically focus on opportunities to enhance stimulation, engagement and mood, and reduce agitated behaviors. If PARO can successfully improve each of these areas, then this will contribute to their cost effectiveness.

LESSONS LEARNED

The intervention did not pose any major challenges and was readily accepted by participants. The facilitator training and clear protocol manual helped overcome any potential obstacles with training and facilitation of the intervention. Family were willing to have their family member involved in the research, as they viewed PARO as “cute” and of low risk for harm. Positioning of the intervention within the facility was challenged by limited space within the facility, and the dedicated space had no barriers, such as doors, which may have encouraged some participants to walk away from the intervention group. We found nine participants with one PARO to be too many to encourage continual engagement and interest. The introduction of two PARO to the group allowed interested participants to interact with other participants through the discussion about PARO. We recommend PARO is used with individuals or in small groups of up to three residents. As previously indicated, the researchers used a standardized protocol and a trained facilitator to engage residents with PARO through the four key procedural areas outlined in the protocol. The intervention therefore relied on the facilitator introducing PARO and working individually as well as within the group to build the activity and engagement. The research did not compare PARO with and without a facilitator; however, the researchers’ observations suggest PARO activity requires facilitation rather than PARO being left with a resident.

LIMITATIONS AND IMPLICATIONS

The current research was limited primarily by the sample size and the large amount of missing data, which occurred as a result of the severe cognitive impairment of participants, reducing the opportunity to explore the impact of PARO on participants’ expression of behaviors. Future studies need to build on this research with larger samples and a greater emphasis on observation measures to take account of severe cognitive impairment reducing self-report. In addition, future research also needs to consider the potential for a companion effect of a robot versus a non-robotic animal and the contribution of companion robots to communication and social interaction. Additional research is needed to determine the efficacy of this approach as an individual activity versus a group activity. Furthermore, qualitative studies of the acceptability of robots as companions are also warranted.

CONCLUSION

There is a need to invest in trialing interventions such as PARO robots, which may reduce dementia-related behaviors (e.g., agitation) that make the provision of care challenging as well as costly due to the increased use of staff resources and pharmaceutical treatment.

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