PARO Robot Affects Diverse Interaction Modalities in Group Sensory Therapy for Older Adults with Dementia

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***Abstract*—We evaluated the seal-like robot PARO in the context of multi-sensory behavioral therapy in a local nursing home. Participants were 10 elderly nursing home residents with varying levels of dementia. We report three principle findings from our observations of interactions between the residents, PARO, and a therapist during seven weekly therapy sessions. Firstly, we show PARO provides indirect benefits for users by increasing their activity in particular modalities of social interaction, including visual, verbal, and physical interaction, which vary between primary and non-primary interactors. Secondly, PARO's positive effects on older adults' activity levels show steady growth over the duration of our study, suggesting they are not due to short-term "novelty effects." Finally, we show a variety of ways in which individual participants interacted with PARO and relate this to the "interpretive flexibility" of its design.**

Keywords—social robot; assistive robotics; therapy; dementia; human-robot interaction.

I. Introduction

This paper presents the evaluation of PARO, a socially assistive robot resembling a baby seal, in the context of multi-sensory behavioral therapy (MSBT) for older adults with varying levels of dementia in a nursing home context. PARO has been applied in both institutional and domestic spaces as a therapeutic companion robot for the elderly. It has been commercially available in Japan since 2005 and in the United States and Europe since 2009. Many short- and long-term studies have documented PARO's successful implementation in different types of eldercare contexts in Japan, though few studies as of yet explore PARO's use in the US [1].

We observed a therapist using PARO as part of an MSBT activity for older adults in a US nursing home for seven consecutive weeks. MSBT is widely used for people with dementia as a method of presenting controlled sensory stimulation of the visual, auditory, olfactory, and tactile systems to keep their sensory systems active [2]. As a multimodal sensory stimulus in group therapy sessions, PARO engaged participants through sound and movement, the tactile quality of its soft fur covering, and its relatively compact size that allows participants to hold, hug, and pass it around the table.

As MSBT aims to provide participants with stimulation and increased activity levels, our analysis focused on evaluating participants' level of engagement with their social and physical environment in therapy sessions. We documented an increase in activity levels in particular interaction modalities (visual, physical, and verbal) and noted that the robot's use had a socially mediating effect on participants. We add to existing research on the therapeutic and social effects of PARO (e.g. [3,4,5]) by performing behavioral analyses of the particular interaction modalities that are affected and constitute greater engagement by our participants. Our study thus provides empirical evidence of the therapeutic mechanisms related to using PARO with cognitively impaired older adults, and contributes to the robot's effective use in such applications.

Additionally, we noticed variability in participant interactions with PARO, suggesting that assistive robots need to accommodate multiple ways in which users interact with and make sense of them. We suggest that the "interpretive flexibility" [6] in PARO's design supports the engagement effects shown and discuss its importance in designing SARs for cognitively impaired users.

II. Background

A. SARs in eldercare

Socially assistive robots (SARs) are designed to help people through social, rather than physical, interaction [7] and produce therapeutic outcomes for target populations. As the older population in many developed countries rises, eldercare has become a major application domain for SARs [1].

SARs are expected to play both functional and affective roles in the lives of older adults. Clara [8] uses social cues to encourage patients performing physical and cognitive exercises and can provide information on the patient's progress to caregivers. Care-O-bot supports independently living elders by delivering meals and drinks [9], and Pearl is a safety monitor and daily activity assistant for seniors with mental impairment [10]. Robots can also act as communication devices (e.g. [11,12]) and companions to relieve loneliness (e.g.[13,14]).

Research has shown that robots can successfully be included in therapeutic regimens for the elderly. Their effects can include positive health impacts, decreased stress and improved mood, decreased loneliness and better communication with others [1]. Challenges in existing SAR evaluations include the predominance of studies performed in Japan and potential novelty effects. Our study focuses on examining the behavioral mechanisms behind PARO's therapeutic efficacy, addresses novelty effects, and extends studies with the robot to the US.

B. PARO's therapeutic and social effects

PARO is a zoomorphic therapeutic robot that has primarily been studied in interactions with older adults with varying levels of cognitive impairment. Findings suggest that PARO can have a positive effect on the emotional states and stress levels of users, as measured via EEG readouts [15] and urine hormone levels [3]. Wada et al [16] have developed guidelines describing how caregivers should present the robot to elders to achieve therapeutic effects.

Researchers have also found that PARO can act as a social mediator for the elderly. In a three-month-long study during which PARO was placed in a public space in a care home, [3] found the robot's presence correlated with a continuous increase in the density of the participants' social networks. Kidd et al. [5] verified PARO's effect of increasing social activity in a US nursing home. Social mediation has also been reported in studies of group activities with PARO similar to our own [4], but the mechanisms by which it occurs have not been systematically studied. Our study adds empirical evidence for the interaction modalities PARO affects in older adults in group activities.

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C. Interpretive flexibility in robot design

Dr. Shibata, PARO's designer, describes that "it is not necessary for PARO to have all the functions, the interaction can enlarge the number of functions." [1] This suggests that "interpretive flexibility"—the ability of a technology to "sustain diverging opinions" from different user groups [17]—is at the foundation of PARO's design.

Researchers have shown that a technology's "interpretive flexibility" can enable its application and success in diverse contexts. [6] suggest that interpretive flexibility allows users to experience a "feeling of flow" while using a system and claim that it is particularly necessary for robots meant to have a socially mediating role in interaction. Turkle's studies of one-on-one interactions between users and PARO suggest that people interpret PARO in different ways depending on their personal attitudes toward technology, their psychological state, and prior social experiences [18].

Our results suggest that participants and the therapist both took advantage of PARO's interpretive flexibility and were able to accommodate their different interests, needs, and understandings of the robot in therapy sessions.

III. Method

We evaluated PARO in a seven-week-long observational study conducted in a senior living community in Bloomington, IN. Our participants were recruited from the facility's rehabilitation wing and all had some level of cognitive impairment, from minor to severe. We obtained written consent from the participants' legally approved representatives before the study began.

A. Participants

10 participants (P1 through P10) were initially enrolled in the study. However, three individuals were excluded from the final analysis due to non-

[1] Talk at the Japan Society in New York, June 2007.

participation (P1, P7, and P10, see Fig 2A in Results), which was defined as being present/awake at ≤1 session out of the total seven sessions. This left an effective sample size of 7 participants.

The participants had varying levels of physical and cognitive impairment. Only one participant could walk without a wheelchair. Three participants were more socially interactive and could engage in fluid conversation (P3, P5, P9). All participants had memory impairments, including not remembering PARO from one session to the next (P3, P5). Four participants were less active overall and fell asleep easily in the sessions. Most participants needed the therapist's assistance to communicate with others.

B. *Study setup*

Our PARO activity was adapted to regular weekly MSBT sessions held in the facility. Participants interacted with one PARO once a week in 30-45 minute group MSBT sessions mediated by a therapist. The participants generally gathered around a table, with the therapist engaging them one by one and encouraging them to interact with PARO (See Fig 1). One pilot session performed before the study allowed the therapist to get used to the robot, and helped us test the observational coding scheme we used to capture interactions in real time.

The study ran for a total of seven sessions from mid-July through the end of August. The activity was open-ended. All participants did not attend every session, and occasionally had to leave early due to personal reasons. Attendance at each session (defined as participants being present *and* awake) was approximately 5 or 6 participants. As a result, our analysis emphasizes average group effects.

Figure 1. The therapist presents PARO to nursing home residents in a sensory group context.

PARO's effects on participants' behaviors were investigated on two co-occurring levels (primary vs. non-primary), based on the subject's relative role in the interaction with PARO at the time they displayed a particular behavior. The therapist passed PARO around to participants multiple times during a session, with participants interacting with the robot for a few minutes at a time. Participants to whom PARO was passed could pick up and hold the robot, or leave it on the table in front of them. During this period, we considered the participant the primary interactor (**PR**). All other participants other than the primary were considered non-primary (**Non-PR**) for the duration of the turn. This distinction is important to our study, since we are interested not only in PARO's direct stimulatory effect on primary participants, but also in its ability to stimulate activity and interaction even when participants are not in direct contact with PARO. As all participants were gathered around a table, Non-PRs were at most a few feet away from PARO.

C. *Data collection*

Three researchers attended each weekly MSBT session to observe and videotape interactions. Two researchers coded participants' activities on site using a predefined scheme; one coder noted the frequency of all the behaviors (continuous and non-continuous) performed by the primary interactor (PR)—the person interacting directly with PARO at any given time—while the other coder tracked the behaviors of all other participants (Non-PR). The coding of Non-PRs noted the incidence of their continuous behaviors (e.g. sleeping, looking) every few minutes when PARO was switched from one PR to the next to account for their duration. Non-continuous behaviors, such as speaking, were coded each time they were performed by a Non-PR. We coded the video interactions by noting the frequency and duration of each behavior of visible participants.

Both onsite and video-based coding tracked the interactions between the primary and non-primary interactors and PARO, other participants, the therapist, and occasional visitors. Onsite coders took note of visual (look), verbal (speak, sing, make other noise: e.g. cooing) and physical (pet, hit, hold, kiss, take or offer PARO) interactive behaviors participants performed to PARO and other people. Video coding used the same codes and focused on time-based tracking of physical interactions with PARO, and verbal interactions with PARO, the therapist, and other participants, since there were few physical interactions among participants.

IV. Results

There was wide variability in behavioral interactions across participants in terms of the types of interactions and their amounts (See Fig 2B). This suggests that the "interpretive flexibility" of PARO's design allowed users to make sense of and respond to its behaviors in variable ways.

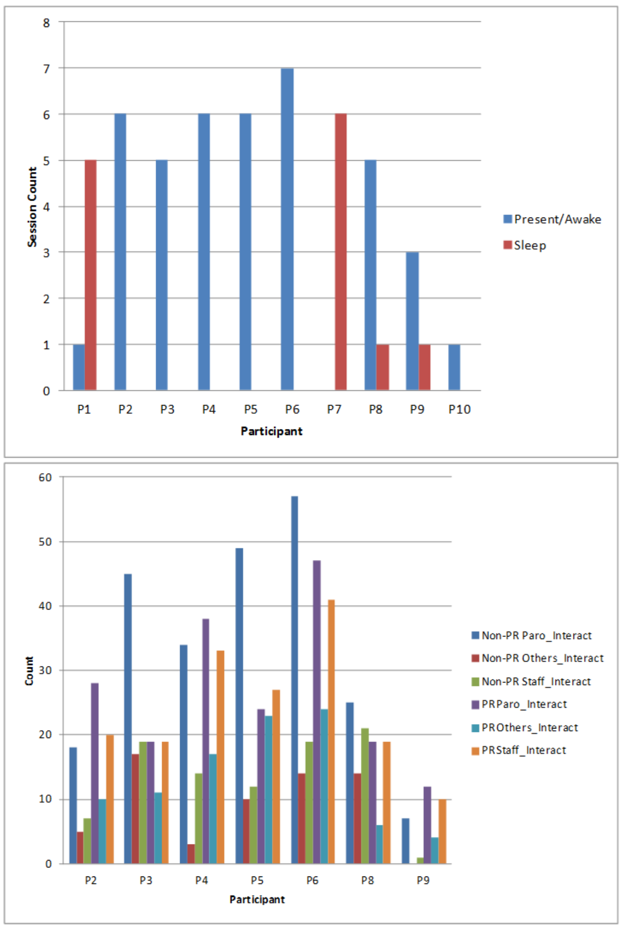

Fig. 2 Inter-individual behavioral diversity in terms of 2A) Participants being present and awake, and 2B) Participants' various interaction modalities

Figure 3 shows the total amount of per-session interactions, calculated as the *count of interactive behaviors* during the session scaled for session sample size (so that all sessions are directly comparable). In general, there was consistent growth in interactions over time, although the data show some noise from session to session. This is to be expected with our population, as their daily physical and mental health status significantly affected their interactions. Growth was evidenced in individuals' interactions as both the primary and as the non-primary interactor. In previous studies, such growth has been correlated with improved neural functioning measured via EEG [15] and reduced stress hormones [3]. Importantly, this steady growth over time counters the interpretation that the results are due to simple "novelty effects," unless novelty effects can be more complex and long-term.

Behavioral coding of interaction videos shows that the *duration of interaction* also increased over the course of the study. Fig.4 shows an increasing trend in the average duration of participants' verbal and physical interactions across sessions.

Fig. 3 Interaction counts over time

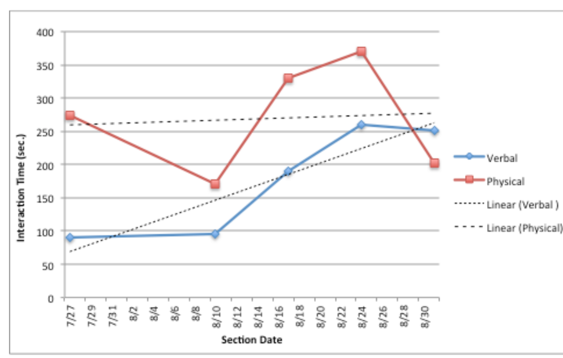

Fig. 4 Average interaction times over sessions (sec.)

The details regarding each behavioral category are shown in Table 1 through pre/post percentage growth from the baseline (7/20/2012) to the final (8/31/2012) interaction session. All categories show growth in the number of interactions; however, given the small sample size, only the *Non-Primary Interactions with PARO* were found to be significant using a traditional statistical *t*-test

(p=.001, df=8). More specifically, most of growth can be accounted for as follows:

1) **Non-Primary:** visual behaviors (towards PARO) and vocalization behaviors (towards PARO, other participants, and staff)
2) **Primary:** visual and vocalization behaviors toward other participants

TABLE I. INTERACTION GROWTH FROM BASELINE TO FINAL

		Baseline	Final	% Growth
Non-PR	Paro_Interact	9.8	57.4	586%
	Others_Interact	12.6	21	167%
	Staff_Interact	8.4	26.6	317%
PR	Paro_Interact	25.2	33.6	133%
	Others_Interact	11.2	28	250%
	Staff_Interact	21	36.4	173%
	Non-PR Total	30.8	105	341%
	PR Total	57.4	98	171%

The significant takeaway is that the growth found in our analysis provides evidence of *particular modalities* of social interaction that PARO affects, which *differ in PR and Non-PR participants*. With non-primary participants, PARO served as a critical focal object in the room (evidenced by the growing incidence of looking at PARO) that correlated with vocalizations toward both PARO and other people present. For primary interactors, PARO appeared to enhance engagement with other participants, as evidenced by the greater increase in verbal interaction (toward PARO and others) than physical interaction (with PARO). In other words, even when the participant was directly holding or facing PARO, the principle effect over time was an increase in their interaction with other people. This indicates that PARO provides not only direct benefits through interaction with the robot itself, as previously shown [3,15], but that it provides indirect benefits through social interaction with people. Video analysis provides additional support for our conclusion, showing that interaction with PARO increased the duration of verbal communication with PARO and interaction with other participants.

V. DISCUSSION

Our evaluation of PARO in the context of MSBT with nursing home residents with varying levels of cognitive impairment suggests that the robot can effectively provide therapeutic benefits for this population. Participants showed higher levels of engagement with their environment and other people, being increasingly attentive and interactive as the study progressed. It is particularly encouraging that even participants who were not directly interacting with PARO displayed increasingly attentive behavior toward both the robot and others in the environment through the duration of the study. This novel finding suggests that PARO's effect goes beyond its direct impact on the person interacting with it, enabling indirect cognitive engagement as well.

It is also important to note that the most significant increase in activity for primary interactors was not with PARO itself, but with the other people around them. This result contradicts the assertion that companion-type robots will alienate older adults from their environment [18]. Our results suggest that SARs need not distract from human interaction, but can help the elderly engage more actively with others.

A further significant result is the steady increase of these effects throughout the duration of our study, suggesting that they are not merely due to the robot's novelty, as has been suggested in reviews of SARs research (e.g. [1]). The steady increase in activity we documented in our study suggests that PARO has a cumulative socially mediating role when used in group therapy, motivating participants to interact more with each other as well as the robot and making such engagement habitual through repetition. One possible explanation for these effects could be that the sensory stimulation provided by PARO during the interaction carried over to participants' interactions with others. The effect was not due to people's increased exposure to each other, as our participants had attended sensory group together before PARO was introduced.

We also suggest that PARO's "interactive flexibility" scaffolds diverse individual interactions in this context that make it useful for dementia therapy. PARO had a positive effect on the activity levels of participants who were interacting with it directly, as well as those who were observing others interacting with the robot. While we have not yet systematically analyzed the transcripts of dialogue during the session, we did note that participants discussed not only issues regarding how PARO works and what it is, but also reminisced about their family members, previous pets, and other life experiences as they were interacted with the robot. These varying interpretations show PARO's meaning is adaptable to various users and situations.

Our future work will involve more detailed analysis of the video data collected and of related transcripts to understand how the positive effects reported here were achieved, including studying change on the individual level and producing guidelines for PARO's use in MSBT therapy. We would also like to compare PARO's use in different therapeutic situations (e.g. one-on-one, groups of 2-3 participants), and to focus on how the interpretive flexibility in its design plays a role in the robot's adaptation to different users and contexts of use. Opportunities also exist to extend the use of SARs like PARO to other populations suffering deficits in cognitive engagement with their environment, such as elderly patients with clinical depression.

CONCLUSION

In this paper, we showed that the seal-like robot PARO has both direct (interacting with PARO) and indirect (engagement with other people and the environment) effects on the activity levels of older adults with cognitive impairment. PARO provides such benefits via *particular* modalities that vary between primary and non-primary interaction. While participant activity levels increased overall, significant changes were seen in indirect engagement by participants (e.g. looking at and talking to others interacting with PARO) as well as in engagement between primary interactors and other people present. These effects showed steady growth over time, countering their interpretation as simple "novelty effect". Finally, our results suggest that the interpretive flexibility of the robot may allow for its adaptation to use by individuals with varying needs and levels of cognitive impairment.

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