Situated Analysis of Interactions between Cognitively Impaired Older Adults and the Therapeutic Robot PARO

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Abstract. In order to explore the social and behavioral mechanisms behind the therapeutic effects of PARO, a robot resembling a baby seal, we conducted an eight-week-long study of the robot's use in a group activity with older adults in a local retirement facility. Our research confirms PARO's positive effects on participants by increasing physical and verbal interaction as evidenced by our behavioral analysis of video recorded interactions. We also analyzed the behavioral patterns in the group interaction, and found that the mediation of the therapist, the individual interpretations of PARO by different participants, and the context of use are significant factors that support the successful use of PARO in therapeutic implementations. In conclusion, we discuss the importance of taking the broader social context into account in robot evaluation.

Keywords: PARO, Older Adults, Dementia, Socially Assistive Robot.

1 Introduction

PARO, a socially assistive robot resembling a baby seal, has been commercially available since 2005 and is widely used as a social companion of older adults in institutional as well as domestic contexts. Studies in institutions all over the world (e.g., Japan [1], US [2], and Australia [3]) provide evidence of its therapeutic effect improving users' emotional status (e.g. [4]) and reducing stress levels (e.g., [1]). Evaluations of PARO have also shown that its use can increase social interaction among older adults. Most existing studies focus on examining PARO's effect in experimental settings or using quantitative measurements (e.g., [3]). While such studies substantiate PARO's therapeutic effects – i.e., show that PARO *works* – they give little information about the mechanisms producing the effects – i.e., *how* PARO works. The study we present corroborates PARO's positive effects on participants' activity levels, but focuses on describing observational findings regarding the specific behavioral, contextual, and personal factors that contribute to these effects.

In order to explore the behavioral, social, and contextual factors that support PARO's therapeutic effects, we conducted an eight-week-long observational study of ten older adults with dementia participating in Multi-Sensory Behavioral Therapy (MSBT) in a local eldercare institution. MSBT is widely used for people with dementia, and involves controlled sensory stimulation in a relaxing environment

aimed at keeping the sensory systems of cognitively impaired people active.[5]. In this work, we adapted the concept of MSBT by using PARO as a source of multimodal sensory stimuli – it makes seal-like vocalizations, has visible movement, and is covered with soft hair that encourages touch. We explored how older adults interacted with PARO and the therapists and other participants in the group, and used quantitative and qualitative approaches to study not only the incidence of particular behaviors but also their meaning. Our study shows increasing activity among participants both in terms of incidence and duration, and suggests that mediation by therapists, environmental factors (e.g. change in venue, composition of the group), and participants' variable interpretations of PARO, are crucial mechanisms supporting PARO's therapeutic efficacy when used by older people with dementia.

2 Background

2.1 PARO's Use in Eldercare

PARO (see Fig.2) is a socially assistive robot developed by Japan's National Institute of Advanced Industrial Science and Technology (AIST). The built-in tactile, balance, and light sensors and microphones under its soft fur enable PARO to sense touch, sound, and changes in position (e.g. hugging), and the motor system and speakers allow PARO to react to human interaction with physical movement (e.g., wagging its tail) and vocalizations simulating a baby seal. PARO is categorized as a socially assistive or therapeutic robot and is often used in a manner similar to pet therapy and as a companion for children and older adults, especially seniors with dementia.

Numerous clinical studies of PARO discuss its positive psychological, physical, and social effects on older adults, including improving the mood of participants [4] and decreased stress levels after using PARO [1]. PARO's social effects have been substantiated by showing that seniors in a living center who had free access to PARO in a public space had increased contact with each other while the robot was present [6]. Moyle et al's [3] experimental study of PARO in a group setting showed using PARO could reduce agitation and anxiety caused by dementia.

Studies investigating the behavioral mechanisms of therapy using PARO have been more limited. Shibata [7] documents a variety of participant behaviors during sessions with PARO, including stroking, speaking, singing, and smiling to PARO, and communicating with caregivers. Existing studies have identified nurturing and sharing the robot among participants in group activities as significant emergent behaviors in interactions with PARO [2] Taggart [2] and Shibata [7] have documented cases in which PARO incited users to reflect on their personal history and emotional charged issues. Wada [8] has developed guidelines for using PARO therapeutically as a result of systematically filtering and categorizing observations of PARO's implementation in nursing institutions. While these guidelines suggest best practices, they focus on case studies and successful one-time observations, rather than providing a more comprehensive picture of situated interactions between older adults and PARO.

Our study contributes to existing evaluations of PARO with a systematic analysis of the robot's implementation in an MSBT group to understand the interaction mechanisms that lead to success and failure of PARO's use with older adults.

2.2 Socially Situating Human-Robot Interaction

Research in Human-Robot Interaction (HRI) suggests that interactions between humans and robots depend not only on the robot's capabilities, but also on the behaviors of human actors, the social and physical context, and daily routines. Forlizzi [9] suggests that robotic technologies designed for older adults are part of a "product ecology," which includes other people, technologies, and the environment, and need to fit this context. Sabanovic [10] suggests that HRI studies need to take the broader social context into account to evaluate the meaning and consequences of robots. These conceptual points are supported by empirical studies. Mutlu's [11] study of an assistive robot used in a hospital showed that the physical environment, social/emotional tenor, and the organizational structure and workflow of the space significantly affected people's evaluations of robot coworkers.

Takanori Shibata, PARO's creator, describes PARO's design as underdetermined -- "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 [12]—is at the foundation of PARO's design. Other HRI researchers have also noted interpretive flexibility plays an important role in the way users make sense of robots. Alač [13] suggested HRI is constituted through the interpretative actions of human participants. Shibata [7] described various cases in which older adults and caregivers adapted PARO in different ways to suit their needs. Taggart et al. [2] also described PARO as an "evocative object," provoking different reactions from different people.

Our study shows that the physical environment, and the emotional status and behaviors had a significant impact on the interaction between participants and PARO, as well as the activity within the group. Our participants also used PARO's interpretative flexibility to develop various ways of using PARO to meet their needs.

3 Study Design

3.1 Field Site and Participants

Our study was conducted in a local retirement community in Bloomington, IN, which provides both long-term and short-term care for older adults. Ten participants joined our research sessions. All of them were over 65 years old and had mild to severe dementia. Two were male and the rest were female. Most participants were in wheelchairs; only one could walk with limited assistance. The participants varied in terms of their social interactivity – some were eager to interact with others, while

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

those with severe dementia had difficulty speaking and often fell asleep during sessions. Participants with severe dementia were sometimes confused about their whereabouts and displayed anxiety. Since participation in the sessions was voluntary, participants did not attend all sessions; we usually had six to seven participants in each session and only three participants showed up consistently throughout the study.

3.2 Methods

To get a comprehensive understanding of the interactions among participants, and between participants, PARO and the therapist during sessions, we performed both on-site coding and video recorded the sessions for more detailed coding later on. Results of on-site coding were published in a prior paper [14], so this paper focuses on the video data. We ran two pilot sessions and eight study sessions from July 27th to September 14th, 2012. Due to technical issues, we lost video data for August 3rd so that date is excluded from our. Each therapy session lasted around forty minutes.

Video Coding. Due to limitations of the camera's perspective, which focused on the participant who was directly interacting with PARO and did not include much of the interactions of other participants, coding focused on physical (e.g., petting, holding, kissing) and verbal interactions (e.g. talking, singing), without taking interpersonal gaze into account. The coders attended to three categories of behavior: "Interaction with PARO," "Interaction with other participants," and "Interaction with therapist." Physical interactions were mainly with PARO. Verbal interactions were limited and most of them occurred around PARO, though codes include verbal interaction with therapists, other participants, and other people (e.g., family members, researchers). Video analysis measured the duration and incidence of behaviors.

Observational Field Notes and Post-interview. Besides coding the videos, we also took observational notes about the details of interaction which helped us find repeating behavioral patterns and interpret the meanings behind certain behaviors. We also conducted interviews with the therapists participating in the therapy sessions before and after the study. The therapists kept PARO in the retirement community for the duration of our study and could use it freely, so interviews focused on their general experiences with PARO. Furthermore, since the reported study is part of more long-term observation of the retirement institution, we use insights from continuing observation to interpret the context and meaning of the patterns found in this study.

4 Results

4.1 Overall Increase in Interactivity

In a previous publication reporting on the results of on-site behavioral coding [14], we showed that there was a consistent growth in the frequency of both the Primary (directly interact with PARO) and Non-Primary (not in direct contact with PARO) participants' interactions over the course of the study. Our analysis of the video-

recorded interactions similarly shows an increase in the average duration of physical and verbal interactions with PARO over the course of the study (see Fig.1). Since sometimes verbal and physical interactions are exclusive of each other, we also added the duration of the two to get a more comprehensive view of the interaction. In Figure 1, the total duration of both physical and verbal interaction has a more obvious upward trend than physical or verbal interaction taken separately. There is also a slight decrease in interaction durations for the last two sessions. In interviews, the therapists mentioned that the mental and emotional status of participants had a significant impact on interaction during the research sessions. Both the general atmosphere and the activity_levels of participants were low on 8/10, 9/7 and 9/14, with many participants sleeping, which may explain the decline in interaction. Finally, the average duration of physical interaction is always higher than verbal interaction, in line with the diminished verbal capabilities of some of the participants.

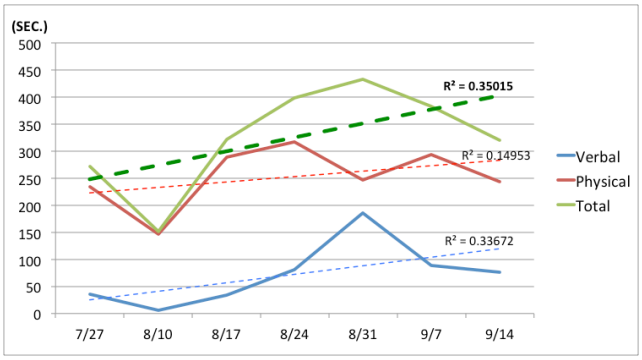

Fig. 1. Average duration of verbal and physical interactions.

4.2 Mediation by Therapist

During our study, the therapist had full control over the conduct of the activity so that it would be most beneficial to participants. The two participating therapists were provided with Wada's Guidelines for Using PARO [8] prior to the study. The therapist ended up changing the way she ran the activity throughout the study, which allowed us to see the effects of a variety of social and physical arrangements of the group. In the beginning of our study, the therapist seated participants around a small table with PARO at the center, which made it difficult to reach for some residents (Fig. 2A). In this configuration, we found PARO did not engage the participants, even though some of them had interacted with it in the pilot study. Some of them looked at PARO without reaching for it, and others simply ignored it. After this session, the therapist started mediating the interaction by encouraging participants to interact with PARO. She passed PARO from one participant to the other, accompanying the robot and scaffolding its use. This led to participants interacting with PARO one-on-one, often with the help of the therapist, or sometimes sharing it with another person (Fig. 2B). During a session, each participant was offered to interact with PARO at least once and the more engaged elders had multiple chances to interact with the robot.

Fig. 2. (A) Initial interaction setting. (B) Therapist mediated interaction.

To begin the PARO interaction, the therapist put PARO in front of the resident or on their lap. When two or three people wanted to interact with PARO simultaneously, PARO was set up on the table between them or the people were moved closer together. When PARO was near the targeted participant, the therapist encouraged interaction by petting or stroking the robot in front of them and initializing conversation about PARO, saying things like "Do you remember it?" "Isn't it cute?" "What do you think about it?" Besides mediating interaction with the targeted participants, sometimes the therapist shifted to others in the group and talked to them about PARO from a distance. When the interaction was mediated in this way, participants were more willing to communicate with each other and interact with PARO. These results are in line with Wada's [8] findings on the need for caregivers to scaffold PARO's use in particular ways for it to have a therapeutic effect, but differ in relation to Wada's statement that the handler's facilitation is required because PARO is unable to move by itself. In our observation, the mediator's role was much more important. Although PARO raised participants' interest and became a topic of conversation, older adults still had trouble initiating and continuing conversation without mediation by the therapist due to their cognitive and physical impairments.

4.3 Effects of Social and Physical Environment

Aside from therapist mediation, we found that the environment significantly affected the residents' social interactions with PARO and with other people in the room. Normally, the MSBT activities were held in a closed room, but two sessions were held elsewhere. The session on August 17th was outside in the shadow of the building on a sunny day, while the session on August 24th was in the lobby. In both sessions, there was increased social interaction among participants. For example, participant P4 and P9 were both generally highly interactive with PARO, but they interacted with PARO individually most of the time. In the trial in the lobby, P9 moved next to P4 and shared PARO with her in the middle of the session. They would look at each other while both of them interacted with PARO, and conversed about PARO when PARO was passed to another participant. P3 usually had very short conversations with other people, if any. In the outdoor session, she spontaneously and continuously talked to P9 while she or P9 held PARO in their arms. P3 had sat next to P9 more than three times in previous sessions, but with they had not communicated.

The social composition of the group also had significant impact on the interactions. P10 only attended our study on August 31th. She is active, talkative, and humorous, and her presence had a positive overall effect on the group. Her humorous conversations with PARO and the therapist caught other participants' attention and caused them to laugh and engage with each other. The frequency of participants' spontaneous conversation with their neighbors was higher at this session than at any of the others and uncharacteristically involved multiple people.

4.4. Individual Interaction Styles

Our observations showed that participants made sense of PARO and defined its social roles in different ways that were related to their individual needs and personal histories. Following are three cases showing different interaction styles we observed.

P5 had memory problems caused by mild dementia, but was capable of fluent conversation with people. She enjoyed staying in the lobby and looked forward to talking to other residents' families when they visited them in the lobby. In our study, she spent most of her time observing the researchers and events in the space. She did not initiate interaction with the robot, but would become extremely animated in interaction with it when the therapist asked her to participate. She talked to the therapist a lot about PARO, even showing appreciation for its cute appearance. She also talked to PARO sometimes, while attending to people's gaze (including therapist and researchers) at the same time, as if looking for social assurance. Her interactions with PARO seemed to mostly revolve round conversation with the therapists; soon after PARO was passed to another resident, she would lose interest in the robot and started observing the surroundings again.

P8 had severe dementia and had trouble conversing with people. She was often confused and anxious, asking "What should I do?" or " Did I do the right thing?" In our MSBT sessions, P8 usually slept, and watched the therapist when she was awake. She was friendly to PARO when the therapist gave it to her, even if she rejected PARO previously. For example, in one session when the therapist came to P8 and told her "You are going to visit him (PARO)," P8 said "No." Later, when the therapist put PARO in her arms, she treated it in a friendly way, holding, petting, and exploring PARO's movement as she described it to the therapist. P8's interactions with PARO were usually encouraged by the therapist and she reacted very positively to the therapist suggestions and social cues. On one occasion when she rejected holding PARO with a negative facial expression, the therapist laughed and said, "What is that look on your face for?" P9 then kissed PARO instead of holding it.

P9 was very excited to interact with PARO from the beginning, and she is the only person that had a consistently increasing trend in both physical and verbal interactions. She has very mild dementia and converses easily and fluently. She remembered PARO throughout the sessions. In the early stages of the study, P9 was nervous about physical contact with PARO. When the therapist put PARO on her lap, she looked surprised by the robot's movements, but did not reject it. As she got more familiar with PARO, she was always extremely happy when the therapist presented PARO and eager to interact with it. Previously a singer, she also developed a practice of singing to the robot in addition to talking and petting PARO. Because the therapist tried to let all participants have an equal chance to interact with PARO, she could not

interact with PARO as long as she wanted. When PARO wasn't with her, her gaze would follow PARO and she laughed or smiled to the participant who had PARO. Because of her interest of PARO, she often shared PARO with other participants or other participants sometimes had conversations about PARO with her.

These three cases show that PARO can be used by participants as a way to attract other people's attention, as a part of interacting with the therapist and following her suggestions, and as an engaging social companion on its own, depending on the participant's personality and interaction capabilities.

4.5 Post-interview with therapists

We conducted interviews with two therapists in the nursing institution after the study was completed. One of them was the MSBT session coordinator in our study, while the other was her supervisor. They mentioned that it's difficult to identify steady progress in PARO's effect on the residents because their reactions to PARO depended on their daily emotional and physical status. Interviews with participating therapists helped us develop more informed interpretations of our observations, and also suggested that one-on-one interaction with PARO was more effective for older adults with cognitive impairments such as those in our participant pool.

The therapists used PARO in another MSBT group, and also sometimes let residents have individual PARO interaction time. For example, one resident did not want to get up in the morning so they had her interact with PARO to give her more motivation to leave her bed. Another case involved a resident with agitation and anxiety problems caused by her dementia. When the housekeeper changed her sheets, she usually became angry and screamed. The caregiver gave her PARO before changing her sheets to calm her down. In general, the therapists felt that this type of one-on-one interaction was a more successful way to use PARO in this institution.

5 Discussion

The situational analysis of cognitively impaired older adults interacting with PARO reported in this paper supports prior findings of PARO's therapeutic effects, particularly an increase in both the physical and verbal interaction in the group. In addition, our findings suggest more attention should be paid to broader social structures, such as staff mediation, the social and physical context, and individual needs, that support the success of socially assistive robots in everyday use. We also showed that PARO's underdetermined design encouraged interpretive flexibility, with individual users and the therapist adapting the robot to their needs.

The observed patterns of therapist mediation, the importance of social and physical context, and differing individual interpretation of PARO's role emphasize the importance of studying human-robot interaction holistically across individual, group, and broader institutional frames. While most studies of PARO's use focused solely on the individual participants and PARO (e.g., [1][3][4]), our observations show specific ways in which a broader set of social, environmental, and personal factors contribute

to the successful use of PARO in therapeutic settings. The guidelines developed by Wada [8] provide caregivers with suggestions for using PARO with individuals, but do not extend to specifying details about the social and physical contexts of use. We found the physical setting and placement of PARO and participants affected interactions, and key individuals (e.g. therapist, talkative elders) could change group dynamics. While substantiating PARO's effects in open-ended interaction can be challenging due to the numerous contextual factors researchers must take into account, more qualitative studies of PARO's use can provide a clearer picture of the interplay of different contextual factors in robot-mediated therapy.

Understanding the various ways in which therapists mediate interactions with PARO is also a crucial aspect of future studies. The therapist in our study adopted multiple methods of generating interaction in the group, including asking questions, showing the interaction with PARO, and directing participants' attention to others interacting with PARO, switching between different mediation methods based on the personal needs of each participant and the group dynamics. The described research suggests that PARO's use and therapeutic results must include the mediation and scaffolding given by therapist or other people to the interactions with the robot.

We observed that PARO's underdetermined design allowed for a diverse set of practices and meanings to evolve around its use, depending on the social context or personal needs of those interacting with it. Leaving space for interpretive flexibility to occur may therefore be a useful design guideline for assistive robots, since it can help counterbalance the limited technological abilities and situational awareness of robots, and accommodate the varied abilities of users. PARO's underdetermined design may also explain its successful use in more than 30 countries around the world [7], which we will focus on in future studies.

6 Conclusion

Prior PARO studies showed the robot's positive therapeutic effects and increased social interactions, but included very little information about how those effects were achieved. Our study of PARO focused on understanding the social, behavioral, and environmental factors that support PARO's function in the context of MSBT with cognitively impaired older adults. We suggest extending the focus of study to the physical and social contexts of PARO's use and taking advantage of interpretive flexibility to design therapeutic robots for different contexts. In the future, we plan to have extensive study to understand PARO use in different settings and focuses on the broader social and cultural contexts.

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