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Understanding the Potential of PARO for Healthy Older Adults

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Abstract

As the population ages, there is an increasing need for socio-emotional support for older adults. A potential way to meet this need is through interacting with pet-type robots such as the seal robot, PARO. There was a need to extend research on PARO's potential benefits beyond cognitively impaired and dependently living older adults. Because independently living, cognitively intact older adults may also have socio-emotional needs, the primary goal of this study was to investigate their attitudes, emotions, and engagement with PARO to identify its potential applicability to this demographic. Thirty older adults participated in an interaction period with PARO, and their attitudes and emotions toward PARO were assessed before and after using a multi-method approach. Video of the interaction was coded to determine the types and frequency of engagements participants initiated with PARO. Overall, there were no pre-post interaction differences on these measures. However, semi-structured interviews suggested that these older adults had positive attitudes towards PARO's attributes, thought it would be easy to use, and perceived potential uses for both themselves and others. Participants varied in their frequency of engagement with PARO. A novel finding is that this active engagement frequency uniquely predicted post-interaction period positive affect. This study advances understanding of healthy older adults' attitudes, emotions, and engagement with PARO and of possible ways in which PARO could provide social and emotional support to healthy older adults. The results are informative for future research and design of pet-type robots.

Keywords

Aging; Active Engagement; Emotions; Human-Robot Interaction; PARO; Technology Acceptance

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[a]An additional research question was whether the way PARO was introduced (framed) to participants would influence their attitudes, emotions, and engagement. PARO was introduced as a pet, a robot, or a toy. There were no significant effects of framing so the data across groups were combined for this paper.

1 INTRODUCTION

1.1 Older Adults' Needs for Social Support

As the average life expectancy increases, the population of adults over 65 years old is growing (Colby and Ortman, 2015). By the year 2030, older adults (ages 65+) are expected to comprise more than 20% of the U.S. population (Colby and Ortman, 2015). This phenomenon is partially attributable to the "Baby Boomer" generation now coming of older age (Frey, 2010) and is expected to create a societal burden as a result of not having the resources necessary to care for these individuals (Knickman and Snell, 2002). Most older adults prefer to age in place, and preservation of autonomy can be beneficial to health (for a review, see (Mitzner et al., 2014)). Eighty percent of older adults currently live independently in their own homes (Houser et al., 2006). However, even if independence can be achieved, 28% percent of non-institutionalized older adults live alone (Administration on Aging, 2012), which can increase the risk of social isolation and loneliness (Victor et al., 2005). These measures of connectedness have been linked to higher rates of morbidity and mortality (Berkman and Syme, 1979; Steptoe et al., 2013). Not only do older adults' social network sizes tend to be smaller than younger adults' (Cornwell et al., 2008; McPherson et al., 2006), they are also more likely to *feel* lonely (Dykstra et al., 2005). This is concerning considering that feelings of loneliness predict death (Perissinotto et al., 2012), are highly related to depression (Jones et al., 1985) and that depression is predicted to be the second leading cause of death by 2020 (Murray and Lopez, 1997).

Older adults who maintain positive perceptions of their social connectedness are reportedly more resilient to declines in health (Cornwell and Waite, 2009). Thus, examining methods that aid older adults in reducing feelings of loneliness and maintaining positive perceptions of connectedness can benefit this population. Additionally, because the aging demographic will substantially increase the demand for care provision, it is especially critical to identify new (and perhaps non-human) methods for enabling older adults to maintain their well-being.

1.2 Potential for Robots as Therapeutic Tools

The use of robots in the home is one potential method for supporting older adults' needs. Although many robots have been developed to help compensate for age-related declines in physical health, less attention has been given to the development of robots that support social and emotional needs of older adults (Smarr CA, 2011). For instance, robots may provide a sense of social connectedness and emotional support for older adults whose social networks have decreased in size.

The potential for non-human socio-emotional support is evidenced by Animal-assisted therapy (AAT) studies, in which interacting with live animals had positive effects on peoples' well-being and quality of life (Ballarini, 2003; Banks and Banks, 2002; Odendaal and Meintjes, 2003). Building on this research, attempts have been made to replicate these effects using pet-type robots. Indeed, interacting with robotic pets such as the dog AIBO (Banks et al., 2008) and the cat NeCoRo (Libin and Cohen-Mansfield, 2004) had similar benefits as AAT. For example, after a 7-week period of interacting with AIBO, dementia patients residing in a day care center in Japan reported reduced feelings of loneliness (Kanamori et al., 2001). Additionally, nursing home residents of Maryland, USA who interacted with NeCoRo showed an increase in feelings of pleasure (Libin and Cohen-Mansfield, 2004).

Using robotic pets rather than live animals for therapy may be of particular interest for the older adult population for a variety of reasons, including: that a live animal may be difficult to take care of, especially for someone who has limited mobility or who travels frequently, and some older adult living environments do not allow pets. Despite the ability of AAT to improve well-being, older adults who do not want to or are unable to care for a live animal might find that a robotic pet is a suitable alternative. However, there may be limitations to using pet-type robots that were not designed for therapeutic purposes, such as a tendency for them to break (Tamura et al., 2004) or their not sufficiently promoting interaction (Shibata and Wada, 2010), but these potential limitations have not been empirically tested.

1.3 Potential for PARO

One robot that was specifically designed for therapy is the PARO, whose appearance, sounds, and behaviors were modeled after those of a baby harp seal (Shibata and Tanie, 2001). It is covered in fur, which is meant to promote engagement, is designed for long-term usage, and its function is solely to elicit positive emotions such as happiness and relaxation (Shibata et al., 2005). As such, PARO may have more therapeutic potential than the aforementioned pet-type robots, which were not specifically designed for therapy. Furthermore, users are likely to have pre-existing notions about the behavior of common household pets such as cats and dogs, and so their expectations may not be met when interacting with their robotic counterparts. In contrast, PARO's unfamiliar seal-like appearance may allow it to be more easily accepted (Shibata et al., 2012; Shibata and Tanie, 2001).

Previous studies using PARO have provided some evidence for its potential benefits (for a review, see (Shibata and Wada, 2010)). Introducing PARO into older adult care centers has been shown to increase reported happiness (Wada et al., 2004), activity (Wada et al., 2004), and social network size (Wada and Shibata, 2007). When assessing mood before and after interacting with PARO over the course of six weeks, older adults' moods tended to be more positive after interacting with PARO, and more negative when assessed again during the week after PARO was removed from the study location (Wada et al., 2004). Additionally, one study used an EEG technique that has been applied to screening for dementia in its early stages (Musha et al., 2002), and found some evidence that interacting with PARO improved cortical neuronal activity in certain individuals such that post-interaction activity indicated less impairment than pre-interaction (Wada et al., 2005a). These findings suggest that interacting with PARO could *potentially* have positive health benefits.

There are several limitations to the previous research investigating PARO's potential. First, earlier studies often did not operationally define "interaction" with respect to PARO nor did they measure it in quantifiable terms (Wada and Shibata, 2007). In fact, in some studies it was only mentioned that PARO was present in the room without reference to the types and/or number of interactions that were made between participants and PARO (Taggart et al., 2005; Wada and Shibata; Wada et al.; Wada et al., 2004). Others have reported only occurrences when PARO was spoken to and the duration of this speaking (Giusti and Marti, 2006). Only one study has systematically investigated healthy older adults' interaction types and interaction frequencies with PARO (Chang et al., 2014), referred to here as *active engagement*. This conceptualization of interaction is informative, as it captures those who choose to engage with PARO in different ways as well as how often they engage with PARO, rather than simply measuring how long the interaction period lasted. On a related note, few studies administered both quantitative and qualitative assessments to understand both objective engagement and subjective attitudinal acceptance (e.g., perceived ease of use and perceived usefulness), which are significant predictors of intention to adopt and future use, and therefore integral to successful human-robot interaction (Heerink et al., 2010a).

Past PARO research has focused primarily on understanding interactions with PARO in group settings, such as nursing homes or care-providing facilities. Due to the potential social influence effects present in these scenarios (De Graaf and Allouch, 2013), the findings might not necessarily translate to how people will interact with PARO one-on-one. It is important to also assess one-on-one interaction with PARO since this is a plausible scenario given older adults' desires to age in place. Furthermore, it is important to understand a broader range of users' interactions with PARO. PARO research thus far has focused primarily on individuals who were residing in dementia-care or assisted-living facilities (Giusti and Marti; Wada and Shibata; Wada et al.), even though PARO was designed to elicit positive feelings in all individuals. It is uncertain if the emotional health benefits of engaging with PARO would be observed for cognitively intact, independently living older adults. In sum, to fully realize the broad potential for therapeutic robots such as PARO for older adults, we need to understand healthy older adults' attitudes and emotions related to this robot as well as the nature of their engagement with it in a non-group environment.

1.4 Assessing Human-Robot Interaction

1.4.1 Models of Technology Acceptance—Models of technology acceptance have been developed to understand the factors that predict attitudes and intentions toward a technology, as well as technology adoption and use. These models include a variety of contributing factors, including perceived ease of use, perceived usefulness, social influence, and facilitating conditions (for a review, see (Holden and Karsh, 2010)). Although initially explored in the context of employee acceptance of an email system, two of these factors that are the strongest predictors in most models of technology acceptance (TAM; (Davis, 1989)) are also applicable to robot acceptance (Ezer et al., 2009; Heerink et al., 2010a; Stafford et al., 2010); namely, perceived ease of use and usefulness. Perceived ease of use is "the degree to which a person believes that using a particular system would be free of effort" ((Davis, 1989), p. 320). Perceived usefulness is "the degree to which a person believes that using a particular system would enhance his or her performance" ((Davis, 1989), p. 320).

How models typically quantify these constructs may not be indicative of acceptance of a robotic pet such as PARO. For example, assessing how it would "enhance performance" may be difficult for a person, given that it is designed to elicit positive emotions, not to enhance performance of an action or activity (Shibata et al., 2012), but this has not been empirically tested. Furthermore, some contributing factors would be difficult to measure due to the novelty of PARO, such as the social influence factor (whether the user thinks other people believe he/she should use the system) of the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Heerink et al., 2010a). Thus, to determine the relevance of these factors to a robotic pet such as PARO, a multi-method approach is likely necessary to understand whether older adults would think they could use it easily and perceive the potential utility for a given person (i.e., at different times or for certain mental, physical, or social conditions).

1.4.2 Active Engagement—Another relevant factor that may influence robot acceptance is engagement. In one study, a robot that was more socially interactive elicited more conversational expressiveness and higher ratings of social presence from people who interacted with it, which in turn was related to intention to use (Heerink et al., 2010b). Yet, there was no direct correlation between conversational expressiveness and robot acceptance, so it is unclear whether verbal engagement on its own is related to acceptance. PARO was designed to respond to speech and also to be touched as a live animal would be, so it is possible that these different types of engagement will relate to acceptance of this type of robot.

Another potential factor that may influence robot acceptance and continued use is the *amount* of engagement. For example, PARO was shown to be effective in reducing blood pressure for those who interacted with PARO, but the effect was directly related to the amount of engagement the participant had with PARO (Robinson et al., 2014). Thus the benefits of PARO might be dependent on an individual’s active engagement with it. How engagement is defined may impact interpretation of PARO’s potential benefits. For example, if engagement is operationalized as the number of minutes spent with PARO per day, two individuals who spend the same amount of time with PARO may have very different experiences (if one person is constantly petting PARO during this time and the other is simply in the same room with it) and may not receive similar benefits as a result. Despite this, previous studies have not investigated the specific types of engagements people exhibit with PARO or how frequently they engage. PARO will likely only benefit older adults if they actually engage with it, so there is a need to understand *active engagement: how* and *how often* people choose to interact with PARO.

1.4.3 Emotions—Emotions can predict the quality of an interaction and experience with a robot, such that those with initial positive emotions toward a robot rate the interaction more favorably (Broadbent et al., 2010). Emotions can be influenced by interactions with a robot, such that positive affect increases and negative affect decreases after interaction (Broadbent et al., 2010). Because PARO was specifically designed to elicit happiness, understanding peoples’ emotions before and after engaging with will inform the quality of the human-robot interaction. Beyond understanding specific pre-post emotions associated with PARO engagement, it would also be informative to identify perceptions of the contexts or conditions in which PARO might impact emotions (e.g., petting PARO would make me happy *if* I were lonely).

1.5 Overview of this Study

Older adults may be in need of social support and one potential means of providing this support is through the use of robots. PARO has been shown to have social and emotional benefits for older adults, particularly those in poorer health. However, little is known about the potential benefits for generally healthy, cognitively intact, independently living older adults or the underlying reasons why PARO could be beneficial. Thus, there was a need for a systematic investigation of factors that influence human-robot interactions in the context of therapeutic robots such as PARO.

This study investigated attitudes about, engagement with, and emotions toward PARO for healthy, cognitively intact, independently living older adults. The primary aims of this research were to determine older adults' attitudes and perceptions of benefits regarding PARO, how they engaged with it (if at all), and if the level of engagement with this robot impacted their emotions.

Based on the extant literature, we hypothesized that healthy older adults would have positive attitudes toward PARO, and would perceive it to be useful and easy to use. Additionally, we expected participants to actively engage with PARO given the opportunity and that this engagement would be emotionally beneficial. The results of this study provide insights into the potential for a robotic pet to be accepted by and beneficial to healthy older adults.

2 METHOD

The primary study variables were attitudes, perceptions of ease of use and usefulness, active engagement, and emotions. These were assessed at various points throughout the study, which consisted of a pre-interaction phase, an interaction phase, and a post-interaction phase (see Figure 3). They were examined quantitatively and qualitatively through questionnaires, semi-structured interviews, and video observations.

2.1 Participants

Participants were 30 independently living older adults (15 female), recruited from the Human Factors and Aging Laboratory Participant Registry at the Georgia Institute of Technology. Participants were compensated for completing the study. The full study protocol (H14014) was reviewed and approved by The Georgia Institute of Technology's Institutional Review Board (IRB) to ensure participant safety. Ages ranged from 67–80 years ($M = 72.17$, $SD = 3.69$). Detailed descriptive information about the participants is presented in Table 1. Participants were well-educated, with a slightly higher "high school and above" rate than the general population (West et al., 2014). Participants were cognitively intact, which can be inferred from the normal scores for older adults on the abilities tests (Czaja et al., 2006). The results of the Technology Experience Profile indicated that these participants were frequent users of technology. The results of the Robot Familiarity questionnaire indicated that overall, participants were somewhat familiar with certain robots, but inexperienced in terms of seeing or using them.

2.2 Materials

2.2.1 Ability Tests—Near and far vision was assessed using the Snellen visual acuity exam. The Reverse Digit Span test (Wechsler, 1997) was administered as a measure of memory span. The Digit Symbol Substitution task (Wechsler, 1997) was administered as a measure of perceptual speed. The Shipley Vocabulary test (Shipley, 1986) was administered as a measure of verbal ability.

2.2.2 Demographic, Health, and Technology Experience Questionnaires—Demographic, health, and technology experience information was collected using standardized materials developed by the Center for Research and Education on Aging and Technology Enhancement (CREATE; (Czaja et al., 2006)).

2.2.3 Interaction Demonstration Script—A script was developed and used for a demonstration of possible interactions with PARO. To avoid biasing by setting users' expectations (Paepcke and Takayama, 2010), this demonstration was kept brief, pointing out PARO's sensors, but not describing any technical specifications in detail. The script is presented in Table 2.

2.2.4 Perceived Ease of Use and Perceived Usefulness Questionnaire—Pre- and post-interaction attitudes toward PARO were assessed using the Perceived Ease of Use and Perceived Usefulness scales from the Technology Acceptance Model (TAM; (Davis, 1989)) as well as through single item questions in the pre-and post-interaction interviews (Table 5). TAM items were adapted to be relevant for this study (see Table 3). Participants indicated the extent to which they found these statements likely or unlikely (1 = extremely unlikely, 4 = neither unlikely nor likely, 7 = extremely likely). A meta-analysis of TAM constructs has indicated high reliability (Cronbach's alpha > .80) for both Perceived Ease of Use (α = .87) and Perceived Usefulness (α = .90) (King and He, 2006). For further validation of Perceived Ease of Use and Perceived Usefulness measures see (Davis, 1989) and (Campbell and Fiske, 1959).

2.2.5 Pet Experience Interview—Participants were given a short pet experience interview that asked "Do you currently have a pet?" and "If you were to get a new pet right now, would you rather get PARO or a live animal?", Participants were asked to elaborate on their "Yes" or "No" responses where applicable.

2.2.6 Positive Affect Negative Affect Schedule—Affective states were assessed pre- and post-interaction with PARO using the Positive Affect Negative Affect Schedule (PANAS; (Watson et al., 1988). This 20-item assessment consists of ten positive and ten negative emotions (Table 4). Participants indicated on a 5-point scale the extent to which they were feeling these emotions at the present moment (1 = very slightly or not at all, 5 = extremely). The "moment" internal consistency reliability (Cronbach's alpha) for Positive Affect is .89 and for Negative Affect is .85 (Watson et al., 1988). The correlation between PA-NA is −.15 indicating that they are separable constructs. The PA and NA components correlate as expected with measures of related constructs such as depression, anxiety, and psychological distress (PA correlates negatively with depression, NA correlates positively with depression, etc.) (Watson et al., 1988). For further validation of the PANAS see (Watson et al., 1988).

2.2.7 Pre- and Post-Interaction Interview—Participants received general questions about PARO pre- and post-interaction (Table 5). If necessary, participants were asked to elaborate on their responses to these questions. For example, if the participant indicated that they liked something about PARO, they were asked specifically what they liked about it.

2.2.8 Recording Device and Software—We used a Sony HDR-CX380 digital video camera to capture all participant verbalizations and engagements with PARO. The visual frame of the recording was set to ensure the video captured PARO, and the participant's head and upper body. Videos were uploaded using Sony PlayMemories Home software.

2.2.9 Robot Familiarity Questionnaire—The Robot Familiarity and Use Questionnaire asked participants to indicate how familiar they were with 13 different kinds of robots (e.g., autonomous car, manufacturing robot, research robot) on a 5-point scale with "1" being "not sure what it is" and "5" being "have used or operated this robot frequently" (Smarr et al., 2014). One item was adapted to include "PARO", as a check that participants had not heard of PARO prior to participation in this study (they all responded 1 or 2 to this item).

2.2.10 Robot: PARO—PARO (Fig. 1) was developed by Dr. Takanori Shibata of the Intelligent Systems Research institute of the National Institute of Advanced Industrial Science and Technology in Japan. It was designed as a "mental-commitment robot", that is, its function is solely to interact with people and elicit positive emotions (Shibata et al., 2012). PARO has tactile sensors on its endoskeleton, which is covered in soft fur to promote engagement. In addition to touch, PARO has sensors for light, sound, and posture. PARO is able to move its neck vertically and horizontally, its front and rear fins, and its eyelids (Fig. 2). Furthermore, PARO contains an internal temperature sensor that allows it to maintain a warm temperature similar to that of a live animal. PARO has both proactive and reactive behaviors, which were modeled based on those of a real baby harp seal. The proactive component consists of planning and generating behaviors, in addition to long-term memory capabilities based on positive and negative reinforcement. The reactive behaviors emerge as a response to sudden stimuli and also as a result of previous reinforcement. PARO also has a diurnal rhythm that provides the basis for its physiological behavior in the form of sleep and wakefulness (Shibata et al., 2012). Because PARO has these learning abilities, its memory was reset prior to each testing session to prevent each participant from having a different experience with PARO.

2.3 Procedure

Upon arrival at the Human Factors and Aging Laboratory at the Georgia Institute of Technology, participants were escorted to the testing room, where they would remain for the duration of the study. Participants were seated at a table in the middle of the testing room. The experimenter was seated at the adjacent side of the table on the left of the participant. After informed consent was obtained, participants completed the abilities tests. The experimenter then verbally introduced PARO under one of three framing conditions[a] (pet, robot, or toy) to which participants were randomly assigned. At this time, the experimenter asked for the participants' permission to turn the video camera on and bring PARO out. If permission was granted, the camera was turned on and PARO was brought into the room and placed on the table in front of the participant, but remained off. Next, initial reactions were assessed with a single open question, "What do you think about the PARO?" PARO was kept out of sight in the experimental room prior to exposure to ensure the initial reactions to PARO were captured in the video. The experimenter then administered the pre-interaction PARO interview, the Perceived Ease of Use and Perceived Usefulness questionnaire, and the PANAS in that order. Afterwards, PARO was turned on and the initial reaction question was asked again. Following this, the experimenter demonstrated possible interactions with PARO (see Table 2 for the interaction demonstration script), and then asked the participant if they would like to touch and/or hold PARO. The experimenter then left the participant in the room with PARO for ten minutes while the participant completed the Demographic and Health questionnaires. This short-term exposure period carried the potential for interaction, but had no specific experimental design. After this period, the experimenter returned to the room and the participant received the PANAS, the Perceived Ease of Use and Perceived Usefulness questionnaire, the post-interaction PARO interview, the Descriptors of PARO questionnaire, the Robot Familiarity questionnaire, the pet experience interview, and the Technology Experience Profile in that order. The participant was then debriefed and compensated. See Fig. 3 for the procedural flow of the study.

2.4 Analysis Overview

Time of assessment was a within-participant variable and was defined as pre- or post-interaction with PARO. The primary dependent variables were perceived ease of use, perceived usefulness, positive affect, and negative affect.

The interviews were professionally transcribed and MAXQDA analysis software was used to code responses to interview questions. We developed a coding scheme comprising three sub-schemes: (1) specific likes and dislikes mentioned about PARO; (2) yes, no and maybe responses to all applicable interview questions (Table 5), which were further probed to determine the reasons *why* participants provided these responses; and (3) the perceived *uses* of PARO (Table 6), the categories of which were determined based on thematic analysis (Braun and Clarke, 2006) and were additionally coded such that each perceived *use* also had a perceived *user*. Perceived use codes were mutually exclusive, but could have been mentioned in the same utterance. For example, a response such as "You could pet it, and that would calm you down" would be counted as both an interactive use (pet it) and an emotional use (calm you down). To ensure that the overall coding scheme was sufficiently detailed and reliable, two experimenters each coded two separate transcribed interviews (1 male, 1 female) and revised the specific details of coding scheme until sufficient reliability (>80% intercoder agreement) was obtained for each of these two transcriptions (81% and 86%). The remaining transcribed interviews were divided up for coding with Coder 1 coding 21 transcriptions and Coder 2 coding the remaining 9 (see (Mitzner et al., 2010; Prakash and Rogers, 2014) for other examples of this method).

We coded active engagement of participants with the PARO through a video analysis. Two coders developed the engagement types listed in Table 7 based on review of the interaction period from pilot data. All 30 videos were coded by two separate coders, after which Cronbach's alpha was calculated and the reliability was sufficient (α =.92) (Streiner, 2003).

3 RESULTS

A multi-method approach was used, with both pre- and post-interaction quantitative (PEU/PU, PANAS, etc.) and qualitative (interview) analyses. This enabled us to assess not only *if* there were pre/post differences in the quantitative measures, and if so, *why* there were differences. There were minimal pre-post differences in the quantitative assessments. Therefore, we focus on the results of the post-interaction attitudes and emotions (unless indicated otherwise) because those data assess how participants perceived PARO after it had been turned on and they had the opportunity to see how PARO could potentially be used.

3.1 Attitudes Toward PARO

3.1.1 What attributes about PARO were liked?—To determine what attributes of PARO participants liked or disliked, we asked two questions both before and after interaction. The first was, "Is there anything you like about PARO?" Next, "Is there anything you dislike about PARO?" Here, the pre- and post-interaction responses were combined, but repeated attributes were not counted. A word cloud was generated (Fig. 4) using wordle.net, which provides an easy-to-see differentiation of the likes and dislikes. Response frequencies ranged from 1 (e.g., docile, suspicious) to 19 (e.g., fur). In general, participants had positive attitudes toward PARO's attributes. There were 93 total mentions of positive attributes and 11 total mentions of negative attributes. Fig. 8 provides a list and frequency count for the top 5 positive and negative attributes mentioned. The most frequently mentioned "like" was "fur", with 19 of the 30 participants indicating that they liked PARO's fur. The most frequently mentioned "dislike" was "limited functionality", with 5 of the 30 participants indicating that they disliked that PARO did not seem to do much or was restricted in what it could do.

3.1.2 Perceptions of PARO: Usefulness, Ease of Use, Benefits, and Acceptance—Perceived usefulness scores were calculated by taking the mean of the six questionnaire items (Table 3). A paired t-test compared the perceived usefulness grand mean to the midpoint, 4.00, which corresponded with the response "neither likely nor unlikely". The grand mean for perceived usefulness was *not* significantly different than neutral $t(29)$, p=.83. Participants found it neither likely nor unlikely that PARO would be useful to them in their daily lives (Fig. 5). Likewise, a one-sample Wilcoxon signed-rank test (the nonparametric equivalent of a one-sample t-test) (Smarr et al., 2014; Wilcoxon, 1945) comparing the median of each individual perceived usefulness question to the midpoint, 4.00, did not yield any significant differences. Thus, the participants were neutral regarding each individual Perceived Usefulness item (Table 3).

Perceived ease of use scores were calculated by taking the mean of the six questionnaire items (Table 3). The paired t-test of the grand mean to the midpoint, 4 was significantly higher than neutral $t(29)$, $p<.001$. Participants found it slightly likely that PARO would be easy for them to use in their daily lives (Fig. 5). For perceived ease of use, the one-sample Wilcoxon signed-rank test comparing the median of each individual item to the midpoint, 4.00 yielded four significant items at the $p < .05$ level (Table 9), indicating that participants perceived these items as more likely than unlikely.

To further examine participants' overall perceptions of PARO after interacting with it, we coded responses to post-interaction interview questions regarding benefits, usefulness, ease of use, and desire to own (Table 10). Per the coding scheme described in section 2.4, responses were classified as "Yes", "No", and "Maybe" for each participant. Most participants (n=23) indicated that PARO would be beneficial to people. Slightly more than half (n=18) indicated that PARO would be useful to them. Almost all participants (n=27) indicated that PARO would be easy for them to use. Although participants were not told the price of PARO, it is possible that it could have been perceived as expensive and as such, been a barrier to acceptance. We wanted to gauge participants' acceptance attitudes that were not confounded by perceived cost. When asked, "If we offered to give you PARO to take home *for free*, would you want it?" most participants (n=24) responded "Yes".

To compare preferences for PARO vs. an actual pet, we asked participants, "If you were to get a new pet today, would you rather get PARO or a live animal?" One participant was not asked this question due to experimenter error. Of the remaining 29, 15 (52%) responded that they would rather get PARO, 13 (45%) responded that they would rather get a live animal, and one participant said he would first get a live animal and then get PARO to keep the animal company. Of the 30 participants, 5 of them (16%) currently had a pet, yet this did not appear to influence responses to the PARO vs. live animal question, as 2 of these participants responded "PARO", 2 responded "live animal", and 1 was the person who responded "both". The responses were further probed to determine *why* participants would prefer one or the other. Of the 15 who chose PARO, when asked why they made that choice, 10 of them (67%) gave responses related to PARO being easier to maintain than a live animal. For example, one participant said, "You don't have to feed him or clean his litter box or sweep up his hair from the rugs" and another said, "I don't want to take care of a live animal". Other less common responses were person-characteristics such as being allergic to animals or residence-characteristics such as not being allowed to have pets. Of the 13 who chose a live animal, when asked why they made that choice, 4 of them (31%) gave responses related to them being more interactive. For example, one participant said, "Because I know it's live. It would react differently than PARO, and…will almost talk to you" and another said "Because there really seems to be the potential for more interaction and also more mobility." Other less common responses were related to PARO's perceived high cost, or were age-related, with one participant saying, "I'm still in the age I think I'd like to get a live one."

3.1.3 Perceived Uses of PARO—We were interested not only *if* participants perceived PARO as being useful, but also *what* potential uses PARO could have, and *for whom* these participants believed PARO would be useful. A thematic analysis was performed to determine categories of uses. A description of the categories of potential uses determined by the coders is presented in Table 6.

Coders analyzed the transcripts and segmented each mention of a use for PARO, and then coded it using the aforementioned scheme (3.1.2). The codes for the uses were mutually exclusive, although it was possible that they were mentioned in the same sentence. For example, “You could pet it, and that would calm you down”, would be counted as separate potential uses (“Pet” = Interactive, “Calm you down” = Emotional). Results of the perceived uses for PARO coding can be seen in Fig. 6. Interactive uses were mentioned most frequently, with 32% of the perceived uses referring to PARO being used for interaction with a person (for further breakdown of interactive uses, see Fig. 7). Social Presence uses were mentioned 25% of the time, with participants providing responses such as “It would feel as if another presence was there” and “He could be a friend”. Emotional uses were mentioned 15% of the time, and included responses such as “I think he [PARO] would have a similar effect on just making people less anxious and calming them, and feeling—just improving their moods”. Another perceived use for PARO was general enjoyment (e.g., “it would be interesting to have around”), mentioned 12% of the time. Less frequently, people mentioned that PARO could be used as a social facilitator (e.g., “it would be an icebreaker”), as an ornament (e.g., “decoration on my bed”), or for security purposes (e.g., “[If someone was] trying to break in, I think he’d alert me to that”).

Because interactive uses were mentioned most frequently, these were divided further to determine the specific types of interactive uses participants perceived for PARO (Fig. 7). Of these, physical interactions (e.g., “I would probably touch it and rub it just to get it to move) and verbal interactions (e.g., “If you need to vent, vent to PARO”) were mentioned most often. In the case of unspecified interactions, participants said they would interact with PARO but were more general about how that interaction would take place (e.g., “Something to interact with”). Finally, 13% of the interactive uses were for learning purposes (e.g., “In a training as far as young children go, not to be afraid of small animals”).

3.1.4 Perceived Users of PARO—In addition to *what* the participants’ perceived PARO could be used for, we were also interested on whether they, being healthy and cognitively intact older adults, perceived PARO as being useful, and if not for themselves *for whom* did they perceived PARO as being useful? During the coding process, whenever an experimenter coded a “use” they also determined who the perceived “user” was, whether it be the participant himself or herself or another person. When discussing uses, participants mentioned themselves as the user 36% of the time. For 18% of the perceived uses, the coder could not determine who the specific user would be from the response. For example, one participant said “it could be motion in your home” as the use, which is talking about a use in a general sense and is not clear whether the user would be himself or herself or another person. Participants mentioned other people as their perceived users of PARO the remaining 46% of the time. Because “other people” were mentioned most frequently, we further divided responses to determine who specifically those perceived other users would be (Fig. 8).

3.1.5 Summary of Attitudes Towards PARO—In sum, these healthy and independently living older adult participants had generally positive attitudes towards PARO. When asked, they mentioned more “likes” than “dislikes.” Most mentioned that they thought it would be beneficial to people, that it would be easy to use, and that they would take it home if it were offered to them (for free). Participants tended to be neutral regarding PARO's usefulness on both the quantitative measure and the direct interview question. However, when they did mention specific uses for PARO, the most common responses were for some kind of interaction, whether it be physical, verbal, general interaction, or for learning. Of these uses, the specific users mentioned were most often other people, but they did perceive themselves as potential users over 1/3 of the time. Finally, over half of the participants (54%) said they would prefer PARO to a live animal.

3.2 Active Engagement with PARO

To determine whether participants chose to engage with PARO when the experimenter left the room, and if so, how they interacted with it, we developed an overall measure of active engagement. Using the aforementioned scheme (Table 7) to code the videotaped 10-minute interaction period, active engagement was classified by type and quantified for each participant. The resulting type and number of engagements is presented per participant (Fig. 9) and overall (Table 11).

The interactions that occurred most often were Words Spoken (*M*=78.90 *SD*=107.51) and Pet (*M*=27.83 *SD*=42.47). Although we specifically looked for them in our video analysis, there were no observed instances of Negative Interactions. The range between participants was 0–587 (M=129.8, SD= 138.8). Thus, there was high variability in the number of times participants chose to actively engage with PARO during the 10-minute interaction, but only one person chose not to engage with PARO at all.

3.3 Emotions and Engagement

Positive Affect (PA) and Negative Affect (NA) means were computed separately by averaging their respective items on the questionnaire. Paired t-tests were conducted comparing pre-interaction PA (*M*= 3.43 *SD*=1.12) to post-interaction PA (*M*=3.53 *SD*=1.20), and pre-interaction NA (*M*=1.15 *SD*=0.34) to post-interaction NA (*M*=1.03 *SD*=0.09). No significant differences were found for either comparison, indicating that overall, scores on these measures did not change after the interaction period with PARO. Thus, the presence of PARO alone did not impact emotions.

However, to determine whether the participant's activities during the interaction period (i.e., engagement frequency) influenced emotions, a two-step hierarchical linear regression was calculated to predict post-interaction affect based on pre-interaction affect and active engagement frequency with PARO.

For NA, the model predicting post-interaction NA with active engagement frequency did not yield significant predictors. Thus, active engagement did not significantly predict NA after the interaction period with PARO.

For PA, Model 1 was significant ($F(1,28) = 129.20$, $p<.001$), wherein PA-Pre contributed significantly to the regression model and accounted for 82.3% of the variation in PA-Post. Adding Engagement in Model 2 explained an additional 3.5% of the variation in PA-Post, and this R^2 change was significant ($F(2, 27) = 81.39$, $p<.001$). Thus, as Engagement increased by 1 standard deviation, PA-Post increased by .19 standard deviations (see Table 12 for model summary). Overall, those who chose to more actively engage with PARO during the 10-minute interaction period tended to be more emotionally positive after this time.

4 DISCUSSION

Aging is often coupled with major life events that impact social and emotional health, such as retirement, bereavement, and shrinking social networks. Given that the proportion of older adults in the population is growing rapidly, there is a need to ensure older adults receive adequate social and emotional support. One solution has been through the usage of pets as therapeutic tools. However, owning and taking care of a live animal is not always a viable option for older adults. Pet-type robots have the potential to provide some of the needs for older adults while avoiding some of the encumbrances of having a live animal. PARO is one such robot, and has been shown to benefit older adults with dementia in particular. Yet, older adults' socio-emotional needs are not restricted to this specific demographic. To fully realize its potential to promote successful aging for everyone, it is important to understand healthy and cognitively intact older adults' attitudes and emotions toward PARO, and their engagement with this robot.

The results of the present study indicate that in general, these healthy older adults liked PARO's attributes and perceived it as easy to use, however, they were neutral regarding its usefulness for themselves. A key contribution is that through semi-structured interviews, we were able to highlight and categorize response trends in the underlying reasons why PARO was perceived as useful (or not). Also, the multi-method approach enabled a comparison between qualitative and quantitative responses, which in some cases produced conflicting information. Given the opportunity, all but one participant did choose to actively engage with PARO, although the engagement frequency varied drastically per participant. This active engagement with PARO was assessed systematically in a controlled one-on-one environment, and was a significant unique predictor of positive affect, which is a novel finding. Hence, for those who chose to interact with PARO, it was objectively useful (in the form of an emotional boost) despite these individuals' subjective reports regarding PARO's usefulness,

4.1 Older adults' attitudes towards PARO and perceptions of benefits

In general, we found that the older adults we interviewed held positive attitudes towards PARO although some individuals did mention reasons why they did not think PARO would be useful to themselves and attributes they disliked about it. When asked what they liked and disliked, however, they reported "likes" much more frequently than dislikes. Many of the likes were related to PARO's unique physical appearance such as its fur, its white color, and in general, its 'cuteness'. The popularity of PARO's physical appearance has been previously shown (Wu et al., 2012), with some of the "favorite points about PARO" being its tactile texture, eyes, and face (Shibata et al., 2012). Thus for robots designed for social interaction, special attention should be given to appearance. With PARO, it makes sense that participants frequently mentioned liking its fur, because that is a typical and expected type of interaction with animals, even though seals are not common pets. It may be that PARO's inviting appearance overcame any potential uneasiness caused by interacting with an unfamiliar animal, with several participants mentioning that PARO was "unintimidating" and "non-threatening".

One possibility for participants being positive toward PARO could have been a social desirability bias: agreeable participants behaved and responded in a way that they thought was socially acceptable (Gallego-Perez et al., 2013; Van de Mortel, 2008). However, several methodological design steps were taken to reduce the potential for this type of bias to occur. Conducting the study in a one-on-one setting rather than in a group or public setting (which has been done extensively with PARO), eliminates this effect that may occur in trying to respond in a way that was deemed acceptable to the other participants (De Graaf and Allouch, 2013).

The remaining potential for a social desirability effect was limited to participants wanting to please the experimenter and as such, perhaps being more hesitant to say or do anything negative about/to it. Analysis of the multi-method data did not provide substantial evidence that a bias of this type occurred. All but one participant chose to actively engage with PARO in some way during the 10-minute interaction period, for which the experimenter was not present and the participant was not explicitly told that this period was meant for interaction with PARO. Had the participants held negative feelings toward PARO they likely would not have chosen to interact with it. Furthermore, responses to the interview questions that were not directly about liking or disliking PARO provided evidence that the participants were not hesitant to voice negativity towards it. Some indicated that it would not be useful to them and others said they would not take it home, even if it were free.

In addition to investigating participants' likes and dislikes of PARO, this study quantitatively and qualitatively addressed attitudes about PARO's potential usefulness and ease of use. Perceived ease of use was significantly greater than neutral, indicating that participants found it slightly likely that PARO would be easy for them to use. This is not surprising, as PARO requires users to simply turn it on and then engage with it as they please. Perceived usefulness was not significantly different than neutral, indicating that participants found it neither likely nor unlikely that PARO would be useful to them in their daily lives. There were no significant *changes* in perceived usefulness and perceived ease of use after the interaction period with PARO. Although methodological limitations of the present study (i.e., a one-time interaction) do not enable conclusions to be made regarding attitudes toward PARO over time, it is possible that the 10-minute interaction period was not a sufficient amount of time for participants to formulate and/or alter their opinions on PARO's potential usefulness and ease of use with respect to the PU/PEU quantitative items. Reassessment of these questionnaires after longer-term use might result in significant changes in either direction (e.g., Perceived usefulness of PARO decreases over time).

However, the qualitative measures showed that the majority of participants believed PARO *would* be useful to them (i.e., when asked this question in the post-interaction interview) and were interested in taking it home if it were offered to them for free. Specifying that they could take it home *for free* was by design, as the monetary cost of a technology is a concern that older adults have before they decide to use it (Beer and Takayama, 2011; Lee and Coughlin, 2015). Had this not been mentioned, variance in participants' perceived cost of PARO would not have been controlled for, and would have influenced the response to this question in an unpredictable way. This wording limits the interpretation of the responses as being intentional acceptance, because it could have been the case that many of the participants who responded "Yes" had no intention to use the robot but would take it home simply because it had no cost. Our finding that 20% of the people who *did not* say "Yes", however, is particularly informative because these were individuals that would not take PARO home even if it were free of charge. Identifying for those individuals what the robot would require for them to want to take it home would be enlightening in future research. Perhaps addressing some of the "limited functionality" concerns that participants had, for example, enabling PARO to take a person's blood pressure, would increase their acceptance of this technology.

Furthermore, over half the participants said that they would rather get PARO than a live animal, with many of them indicating this was response was due to it being lower maintenance than an actual pet. On its own, the finding that half the participants would prefer PARO over a live animal is not necessarily compelling. After all, forcing a choice between the two does not necessarily indicate that the person really wants either. The preference for PARO may have been a slight one. We were able to ask *why* participants preferred one or the other, and even though these were first time users of PARO, their responses were similar to reasons reported when actual owners of PARO were asked why they purchased the robot (Shibata et al., 2012). Reasons for choosing a live animal were more varied, but several people mentioned that PARO was limited compared to a live animal in terms of its interactivity. PARO might not have met these individuals' needs for reciprocity in a social companion (Lazar et al., 2016). Knowing the reasons why participants would choose one or the other are informative to designers of pet-type robots and interventions using such robots aimed at meeting older adults' socio-emotional needs.

In the present study, older adults' perceptions of usefulness were neutral on the quantitative assessment regarding PARO. However, the interview questions regarding usefulness unveiled a variety of perceived potential uses for PARO. It is possible that the Perceived Usefulness questionnaire lacks content validity when used as an assessment for acceptance of this type of robot. PARO was designed solely to elicit positive emotions in the user, and as such, questions such as "Using PARO in my daily life would allow me to accomplish tasks more quickly" are not applicable. Given that 12% of the perceived uses for PARO were simply for entertainment, a more appropriate questionnaire for future studies on PARO might be the Perceived Enjoyment questionnaire, which has been shown to have an effect on intentional acceptance (Heerink et al., 2008).

Nevertheless, participants mentioned a wide variety of uses and benefits for PARO in response to qualitative assessments, and over half responded, "Yes" when explicitly asked if they thought PARO would be useful to them. Of the perceived uses for PARO, interactive uses were mentioned most often, and specifically, participants mentioned that PARO would be used for physical interaction, verbal interaction, and as a passive presence in a given environment. The emphasis on physically interacting with PARO highlights the importance of making these types of robots tactilely appealing. One can imagine that perceived uses such as hugging and petting may have been mentioned less frequently if PARO did not have fur, however, this was not tested directly in this study. Future work could compare perceived usefulness of PARO between groups that interact with PARO with and without its fur to determine whether altering PARO's physical appearance impacts how people perceive it can be used.

Overall, socio-emotional uses comprised the vast majority of participants' perceptions about what PARO could do for themselves or for other people. This finding supports PARO's original design concept of a mental commitment robot, whose function was to engender and elicit feelings of happiness and relaxation (Shibata et al., 2005). The perceived usefulness component of the Technology Acceptance Model traditionally asks about usefulness for "self", so it is unclear how accurate these usefulness perceptions for "others" actually are. For example, one perceived user group that was frequently mentioned was children, yet it is entirely possible that children's usefulness perceptions of PARO for themselves would be discrepant from these older adults' perceptions of PARO's usefulness for children. The accuracy and predictive validity of perceptions of usefulness for others should be addressed further, as it is not yet well understood.

Although participants were able to envision a variety of uses for PARO, the finding that almost half of the perceived uses were explicitly mentioned as uses for "others" is informative. Many healthy older adults may not be open to having PARO as a companion for themselves, even if they are able to see a potential benefit of interacting with it. One possibility is that PARO's design invoked a negative age stereotype (Lazar et al., 2016; Neven, 2010) that dissuaded certain individuals from identifying themselves as potential users. Because the majority of the perceived "other" users were either children or non-healthy adults (e.g., cognitively impaired, lonely, socially isolated) it is likely that these healthy older adults did not identify with these population subsets and therefore were resistant to reporting that they themselves could use PARO. So even though it was the case that 'cute' and 'cuddly' attributes may increase PARO's likeability, they may also decrease how useful PARO is perceived by healthy older adults by activating negative age stereotypes or providing cues that they are not the intended users of this technology.

Additionally, while much emphasis in robotics is given to communication through natural language, the present results suggest that natural language might not be a requirement for therapeutic robots. What may be more important in human-therapeutic robot interaction is harmony between physical appearance and cognitive/interactive ability (Tapus et al., 2007). These participants still expressed interest in verbally interacting with PARO despite its lack of a natural language response. To illustrate, one participant said they would use it as a *"sounding board"*, and another said, *"Since I live alone sometimes when you just want to discuss some things and think things through, talk to PARO. PARO can't give you the answer, but at least it's someone who listens without responding…[PARO] won't be opinionated."* Forcing pet-type robots to have human-like communicative skills given their animal appearance might eliminate any potential benefits by inflating users' expectations beyond the robots' actual capability (Paepcke and Takayama, 2010)

Other perceived benefits of using PARO were that it would have a positive influence on emotions, could be used for entertainment, or could simply be displayed ornamentally around the home. The subjective responses regarding PARO's ability to improve emotional states were further supported by the objective finding that interacting with PARO predicted post-interaction positive affect. These results show PARO's potential versatility and ability to meet a variety of needs, with some participants indicating that they would interact with it often and bring it out in public, and others indicating that PARO could be used more passively, as just something to look at in the home.

Although these older adults tended to like PARO and perceived benefits for this robot, a few of the participants also identified potential barriers to acceptance of PARO. One barrier that was mentioned by a few participants was related to social norms (i.e., a worry about what others would think about them if they were seen using PARO). For example, one participant said, *"I think there is a point when, as we age, where talking to PARO would be quite understandable and acceptable…* [but] *If someone goes out and plays tennis three days a week and then goes home and cuddles with PARO, somebody's gonna go, 'looney tunes.'"* A response such as this one makes sense in the context of the aforementioned UTAUT model, that identifies social influence as a predictor of acceptance (Holden and Karsh, 2010). Other models identify anticipated support from family, peers, and the community as a factor that predicts technology adoption (Lee and Coughlin, 2015) Some older adults may feel using PARO is not socially acceptable unless there is some sort of loss in physical and mental abilities, and that PARO is not appropriate for healthy adults.

Indeed, when examining the specific "other" people that participants perceived PARO would be useful to, the most frequently mentioned users were those who have some sort of mental or physical impairment, or those who are socially isolated or lonely, a finding that corroborates previous evidence (Lazar et al., 2016). The characteristics of these "other users" could be considered to be facilitating conditions (a predictor in UTAUT), or specific contexts in which PARO could become useful. This further validated our rationale for using a multi-method approach. Had the semi-structured interview not been included, we would not have unveiled any information about how cognitively intact older adults perceived how PARO might be used by other people. This has implications for social robot design when considering that these now healthy older adults could at some point in the future be part of the user group for which they perceived PARO as being useful. For example, some participants mentioned liking the fur and the eyes, so even if they do not find PARO to be useful for themselves at the moment, that PARO has these attributes may influence their future acceptance of PARO.

Ideally, these types of robots would be designed to be useful in the present as well as the future. Some of the participants in this study did not perceive a present need for social support/companionship, even though they may have a future need for such support. If PARO were to be designed to have additional uses, it might be more viewed as more useful at different points in time. For example, a few of the older adults mentioned potential uses such as "Security" (i.e. that PARO could be used as an alarm for intruders) though that is not a capability PARO actually has. Perhaps if PARO did have an additional function, such as providing security, healthy older adults would want to own it at the present moment for that immediate utility, and then if they were to experience something such as bereavement and become more socially isolated, PARO's other attributes that were previously useless to that person would suddenly become more useful. An interesting question for future investigations might be to compare perceptions of PARO's usefulness between groups of different levels of physical impairment, mental impairment, and social isolation.

4.2 Older adults' active engagement with PARO

A methodological contribution of the present study was the development of a systematic and quantitative assessment of active engagement. This method is potentially applicable to all pet-type robots and also many other robots designed for social and therapeutic purposes. We found large individual differences in the total number of times cognitively intact older adults actively engaged with PARO, with some individuals engaged several hundred times, and one not engaging with PARO at all. However, for those who did engage with PARO, some trends in the types of engagements were identified such as speaking to and petting PARO. Our findings corroborate evidence that people tend to spend time speaking to PARO during interaction (Giusti and Marti, 2006), and that people engage both verbally and physically (Sabanovic et al., 2013) but none to our knowledge have quantified specific physical engagements such as petting and touching and investigated their emotional impact. Because these physical engagements occurred quite frequently during the interaction period, and overall engagement predicted positive emotions, an inviting physical appearance may be an important design consideration for this type of robot. Future studies should investigate what factors and/or personality traits predict engaging vs. not engaging with a robot, and also how older adults actively engage with PARO in the context of their own homes over time.

4.3 Influence of active engagement with PARO on emotions

Overall, there were no significant changes in emotion from pre- to post-interaction with PARO. The ten-minute interaction period on its own (i.e., without active engagement) may not have been long enough to elicit emotional changes. One interpretation of this finding is that the degree to which PARO has an emotional benefit depends on whether people actively engage with it. The practical implication is that in a care providing facility, for example, it may not be enough to simply place PARO in a common room and expect it to have benefits. Additional steps (e.g., a demonstration of PARO, designated interaction times) should be taken to facilitate engagement with this robot.

However, individual differences in active engagement frequency predicted post-interaction positive affect, such that people were more positive after the interaction period if they engaged with PARO more frequently during the interaction period, even when controlling for baseline positive affect. Previous studies have found that pre-interaction positive affect (PA) *toward the robot* can predict the quality of the interaction and post-interaction PA, which provided evidence that emotions can influence robot acceptance (Broadbent et al., 2010). In the present study, the PANAS was explicitly worded to refer to the participants' current perceptions of their emotions, not their emotions about PARO. Thus, these findings provide evidence regarding PARO's effect on emotions, not just about a person's future likelihood to purchase the robot. Furthermore, the brevity of interaction period strengthens this finding, given that the pre- and post-interaction PA assessments were only around 10 minutes apart, yet engagement frequency still significantly and uniquely predicted post-interaction PA.

4.4 Summary

This study provided insights into healthy older adults' perceptions of PARO's benefits, and PARO's actual emotional benefit for individuals who engage with it. Additionally, it exemplified the added value of implementing a multi-method approach in the social robot domain, as there were several discrepancies between the qualitative and quantitative data. There were also large individual differences in how people responded to PARO, with some being more negative toward it than others. However, the finding that many of these older individuals were positive toward PARO and open to interacting with it provides novel evidence that this type of robot may have practical uses for people who do not have a cognitive or physical impairment. Our findings suggest that PARO has potential to meet another type of need for which older adults are susceptible, namely the need for socio-emotional support. The implications of this finding is important given that lack of socio-emotional support is predictive of negative outcomes, such as mortality.

One limitation of this systematic approach, however, is that the study was conducted in a laboratory setting and the interaction period was brief, so we cannot make any statements about what older adults' attitudes, emotions, and engagement would be like with PARO in their own homes, or over a longer period of time. It is possible that the results obtained could change had the participants been exposed to PARO in a more natural context. There is evidence that the positive effects of PARO persist for at least a year (Wada et al., 2005b), but again, those findings were with dependently-living, cognitively impaired older adults. Additionally, a potential confound to the finding that engagement predicted post-interaction PA is that even though the time in which the experimenter was out of the room was invariant, the total possible engagement time was likely different across participants because they also completed questionnaires during this period. For example, some participants may have interacted with PARO more frequently if they completed their questionnaires faster, and some participants who completed their questionnaires quickly may not have engaged with PARO at all had they not had so much time in the testing room just waiting for the experimenter to return.

Despite these limitations, the findings provide evidence that healthy older adults perceive benefits for PARO in their lives and in the lives of others. Because perceived usefulness is a key predictor of technology acceptance, investigating the specific types of uses mentioned by these participants and who the perceived users were sheds light onto the potential factors to consider for increasing the likelihood of older adults' adoption of this technology. Many of these perceptions of usefulness revolved around perceived social and emotional benefits as a result of physical and verbal interaction with PARO. The participants in this study often mentioned that people who are experiencing mental or physical health problems or have a sub-optimal level of social interactions would be the ideal target for PARO. Although these are only *perceived* benefits, that they were mentioned most frequently by this demographic highlights that older adults may at least be open to receiving social-emotional support from a robot.

If social robots are to be used to meet this need, design of this technology should consider individual differences in attitudes towards these robots. In this study, the same exact attribute of PARO (e.g., eyes) was perceived as a positive attribute to one person and a negative to another person. One potential solution for this issue would be to allow for some customizability for users or different versions. With more task-driven robots (e.g., the Roomba), the physical attributes may be of less importance so long as the task is completed. In the realm of social robotics, where the goal of the robot is intertwined with the human-robot interaction, consideration of individual preferences, both physically and behaviorally, may be of particular importance. Additionally, design of pet-type therapeutic robots should consider creating an appearance that is friendly, unintimidating, and promotes physical and verbal engagement.

This study provided a critical first step towards understanding healthy older adults' attitudes towards and perceived benefits of PARO, their emotions before and after an interaction period with it, and how these emotions may be influenced by the extent to which they actively engage with this robot. Together, these results are practically relevant to robots that are designed for older adults, and provide insights into potentially informative future avenues of human-social robot interaction research.

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Highlights

- Healthy older adults had generally positive attitudes toward PARO
- Healthy older adults were neutral regarding PARO's usefulness
- Healthy older adults thought PARO would be easy to use
- Engagement type & frequency when interacting with PARO varied between participants
- Engagement frequency uniquely predicted post-interaction positive affect

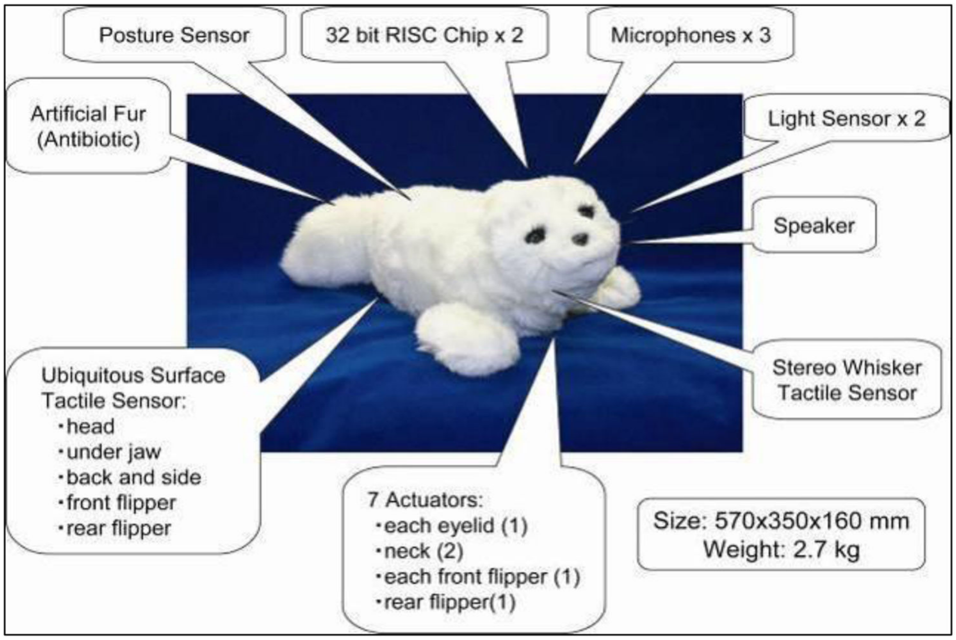

Fig. 1.
PARO’s sensors and specifications (Wada et al., 2004)

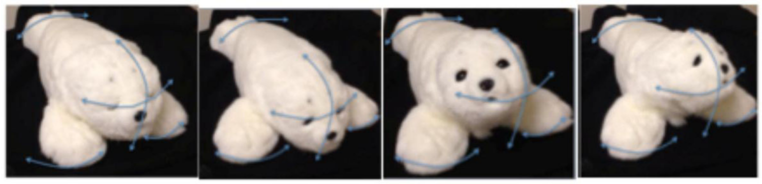

Fig. 2.
PARO’s range of motion

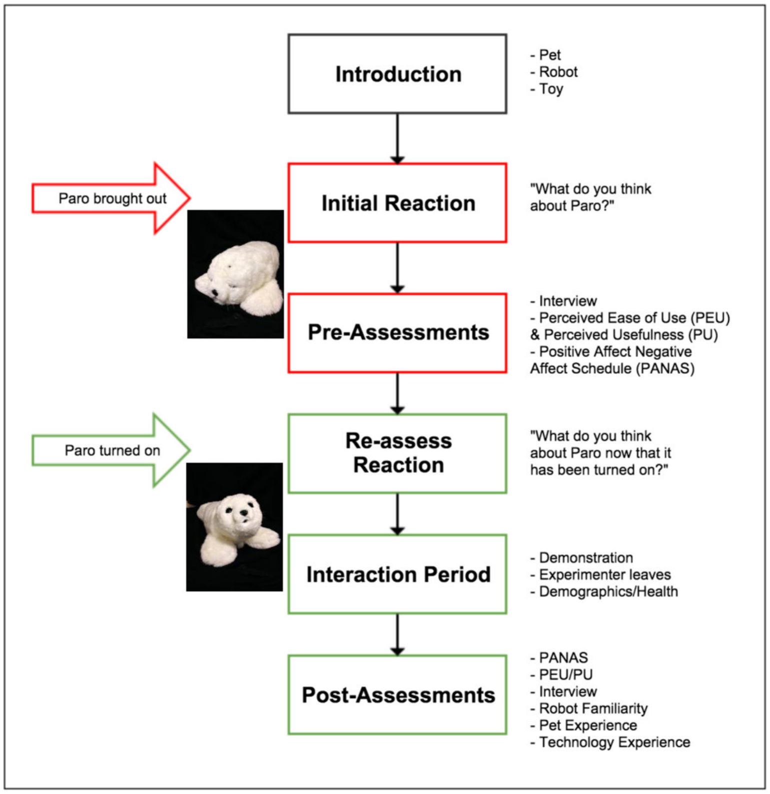

Fig. 3.
Experimental Procedure

Fig. 4.

Wordcloud (wordle.net) of specific likes and dislikes mentioned and table divided into total number of positive (likes) and negative (dislikes) mentioned. Larger font in the wordcloud indicates attributes mentioned more frequently. Words with black font were the “likes” mentioned. Words with gray font were the “dislikes” mentioned.

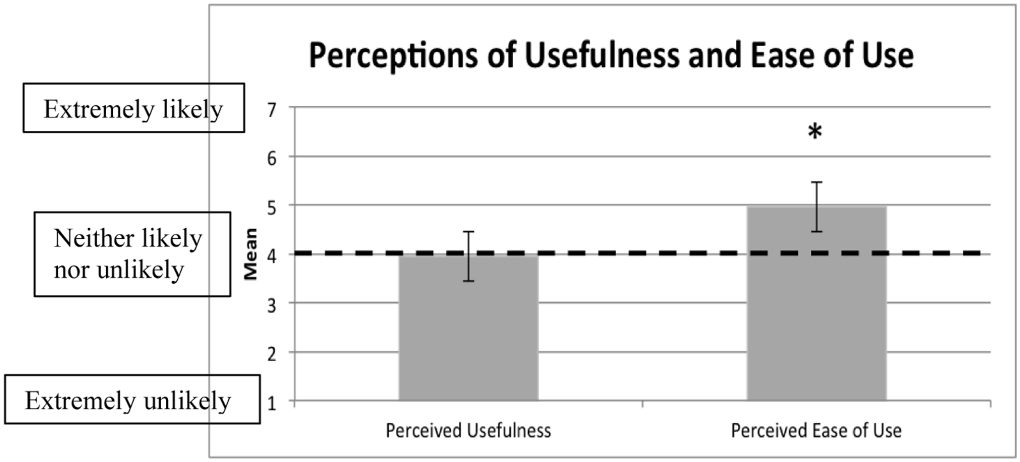

Fig. 5.

Results of the Perceived Ease of Use and Perceived Usefulness Questionnaire[a]. The thick dotted line on the "4" midpoint corresponds to the response "Neither unlikely nor likely" regarding perceptions of PARO's usefulness and ease of use, respectively. The asterisk indicates a significant difference from the midpoint for that factor. The error bars are standard errors.

[a]Partial results of the Perceived Ease of Use and Perceived Usefulness Questionnaire were reported in McGlynn, S.A., Kemple, S.C., Mitzner, T.L., King, C.-H., Rogers, W.A., 2014b. Understanding Older Adults' Perceptions of Usefulness for the Paro Robot, Proceedings of the Human Factors and Ergonomics Society Annual Meeting. SAGE Publications, pp. 1914-1918..

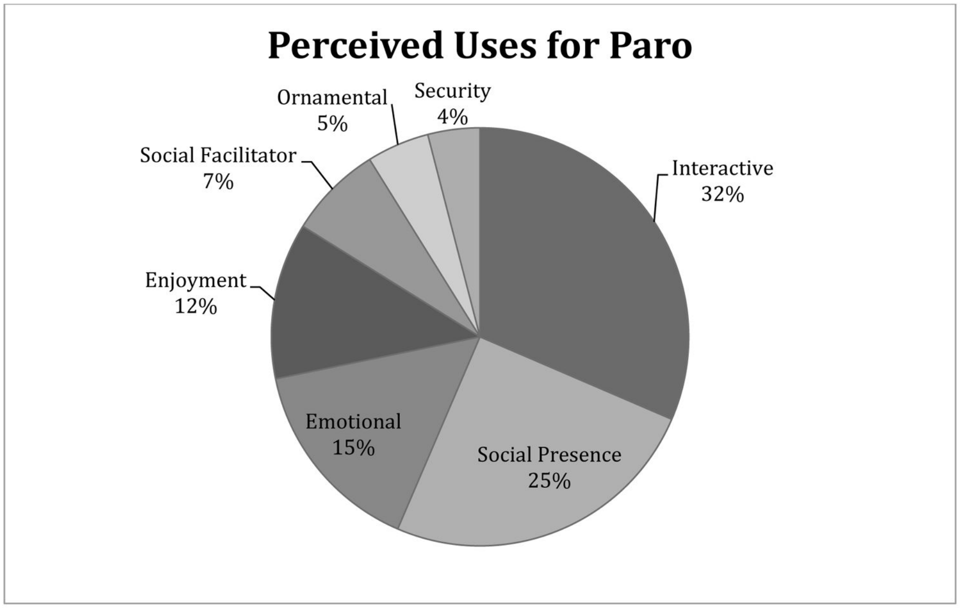

Fig. 6.
Perceived Uses for PARO. Interactive uses were mentioned most often, followed by social agent, emotional, enjoyment, social facilitator, ornamental, and security.

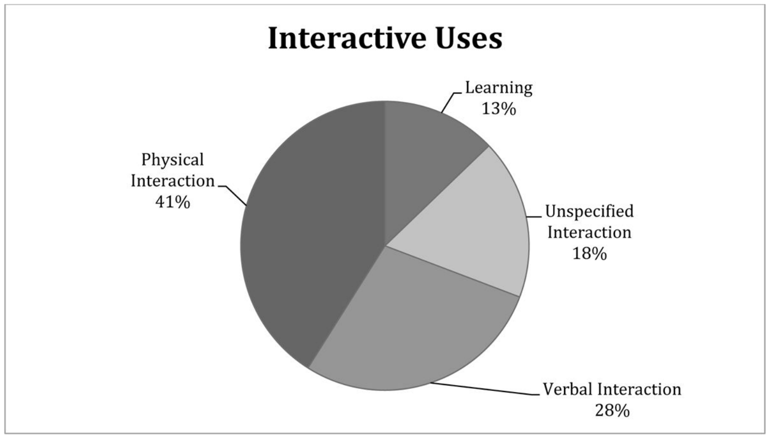

Fig. 7.

Interactive uses of PARO mentioned by participants. Physical interactions were mentioned most frequently, followed by verbal interactions, unspecified interactions, and interactions for learning purposes.

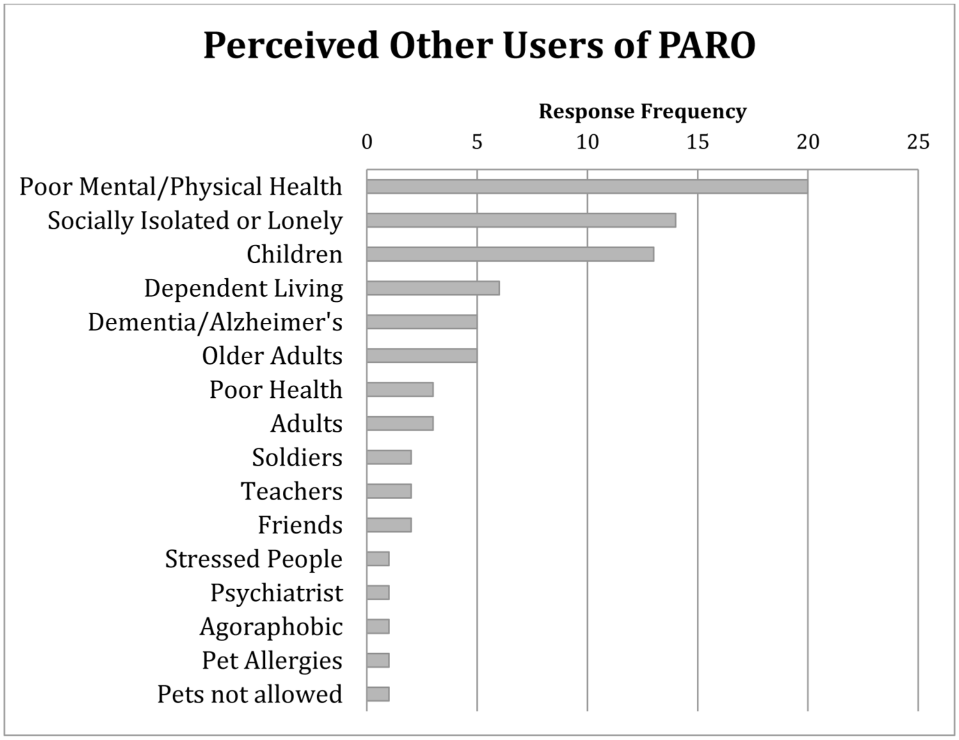

Fig. 8.
Perceived "other" users of PARO.

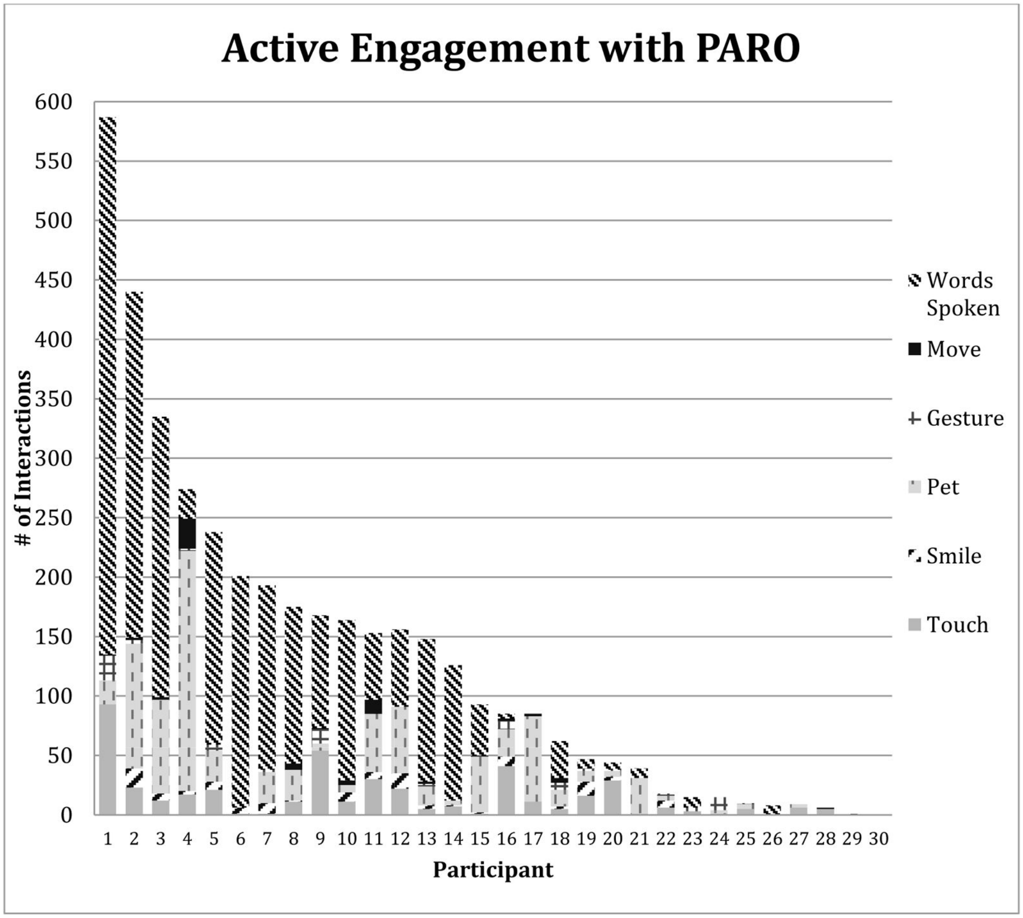

Fig. 9.

Active Engagement with PARO per participant. Total number of interactions for each engagement type listed for each of the participants, ordered from most total interactions (left) to least total interactions (right)

Table 1

Participant Descriptive Information

Factor	Measure	M (or %)	SD	Range
Abilities[a]				
	Digit Symbol Substitution	51.67	14.67	27–88
	Reverse Digit Span	7.53	2.53	1–12
	Shipley Vocabulary	33.63	4.33	24–40
Education (%)				
	High School Graduate	10.00		
	Vocational Training	10.00		
	Some or in-progress college/Associate's degree	23.33		
	Bachelor's degree	20.00		
	Master's degree	33.33		
	Doctoral degree	03.33		
Ethnicity (%)				
	White Non-Hispanic	60.00		
	Black Non-Hispanic	40.00		
General Health				
	In general, would you say your health is: (1 = poor, 3 = good, 5 = excellent)	3.73	.87	2–5
Technology Experience Profile (TEP)[b]				
	Within the last year, how much have you used the following technologies: (36 items; 1 = Not sure what it is, 3 = Used once, 5 = Used frequently; 180 possible points)	136.27	18.09	36–180
Robot Familiarity[c]				
	Indicate your familiarity in terms of hearing about them, using them, or operating them before today: (1 = Not sure what this is; 2 = Never heard about, seen or used it; 3 = Have only heard about or seen this robot; 4 = Have used or operated it only occasionally; 5 = Have used or operated this robot frequently)	2.65	.52	1–5

[a](Shipley, 1986; Wechsler, 1997)

[b](Czaja et al., 2006)

[c](Smarr et al., 2014)

Table 2

PARO Interaction Demonstration Script

Interaction Demonstration	"The PARO can sense light through its eyes. PARO is more active during the daytime when it is light out, and less active at night. It responds when you touch its flippers (*experimenter touches*), back and head (*experimenter touches*), stomach (*experimenter touches*), and whiskers (*experimenter touches*). It also responds to sound and can distinguish between voices."

Table 3

Perceived Usefulness and Perceived Ease of Use adapted from Davis (1989)

Perceived Usefulness Items	Perceived Ease of Use Items
I would find PARO to be useful in my daily life.	My interaction with PARO would be clear and understandable.
Using PARO would enhance my effectiveness in my daily life.	I would find PARO to be flexible for me to interact with.
Using PARO in my daily life would increase my productivity.	I would find PARO easy to use.
Using PARO would make my daily life easier.	It would be easy for me to become skillful at using PARO.
Using PARO would improve my daily life.	I would find it easy to get PARO to do what I want it to do.
Using PARO in my daily life would enable me to accomplish tasks more quickly.	Learning to operate PARO would be easy for me

Table 4

Positive and Negative Affect Schedule Items (Watson et al., 1988)

Positive Affect	Negative Affect
Interested	Distressed
Excited	Upset
Strong	Guilty
Enthusiastic	Scared
Proud	Hostile
Alert	Irritable
Inspired	Ashamed
Determined	Nervous
Attentive	Jittery
Active	Afraid

Table 5

Interview questions Pre- and Post-interaction with PARO[a]

Pre-Interaction Questions	Post-Interaction Questions
Have you ever heard of PARO before?	If we offered you PARO to take home with you right now would you want it?
Do you like anything about PARO?	Do you like anything about PARO?
Do you dislike anything about PARO?	Do you dislike anything about PARO?
Do you think that PARO could be beneficial to people?	Do you think that PARO could be beneficial to people?
Would you be interested in having PARO?	Would you be interested in having PARO?
How would you use PARO if you had it?	How would you use PARO if you had it?
Do you think that PARO would be useful to you?	Do you think that PARO would be useful to you?
Do you think that PARO would be easy for you to use?	Do you think that PARO would be easy for you to use?
	If you were to get a new pet today, would you rather get PARO or a live animal?

[a]Questions listed in this table are those included in the analyses presented in this paper. The full set of study materials are available from the authors.

Table 6

Coding Scheme for Perceived Uses of PARO

Code	Description
Emotional	Any mention of a use where the use would impact the user's current mood or emotional state of mind
Enjoyment	Any general mention that using PARO would be fun or entertaining
Interactive	Any mention of a use that would be an interaction between a person and PARO
Ornamental	Any mention of PARO being used as display or decoration
Security	Any mention of PARO being used as an alarm or to detect potential hazard
Social Facilitator	Any mention that PARO could be used to stimulate conversation or interaction between people
Social Presence	Any mention that PARO could be a companion, friend, or pet, or that PARO would simply *be there* for a person

Table 7

Coding Scheme for Active Engagement with PARO

Interaction Type	Description
Gesture	Motion directed at PARO that does not make contact with it (e.g., waving to PARO)
Move	The participant intentionally moves the animal on the table from its original position.
Pet	The participant contacts PARO similarly to how a person would touch a live animal that generally consists of some kind of motion (e.g., stroking, scratching).
Touch	The participant intentionally contacts PARO in a way that is not what is considered a "Pet" or "Move" above (e.g., touching the whiskers, tapping PARO's face).
Speak	The number of occasions when the participant talks directly to PARO.
Words Spoken	The total number of words spoken.
Negative Interaction	Hitting, raising voice, or any other interaction meant to harm PARO physically or verbally.
Other	Any seemingly meaningful interaction with PARO that did not fall into one of the categories above (e.g., singing to PARO, kissing noises).

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Table 8

Top 5 Positive and Negative Attributes of PARO Reported

Rank	Positive	Frequency	Negative	Frequency
1	Fur	19	Limited Functionality	5
2	Color	15	Size	2
3	Cute	12	No Tax Benefit (Cost)	1
4	Design	7	Not Real	1
5	Friendly	6	Suspicious	1

Table 9

Results of the Wilcoxon signed-rank test for the quantitative post-interaction PEU questions (See Table 3).

Item	Mean	Standard Deviation	Median	Range	N	p
It would be easy for me to become skillful at using PARO.	4.20	2.11	6	1–7	30	.002 *
I would find PARO to be flexible for me to interact with.	4.60	2.04	5	1–7	30	.223
My interaction with PARO would be clear and understandable.	4.73	1.86	5.5	1–7	30	.044 *
I would find PARO easy to use.	5.36	1.83	6	1–7	30	.002 *
I would find it easy to get PARO to do what I want it to do.	4.53	2.05	5.5	1–7	30	.326
Learning to operate PARO would be easy for me.	5.63	1.67	6	1–7	30	<.001 *

* Median was significantly different than the midpoint, 4.00

Table 10

Percentage of participants out of 30 that provided the responses indicated for each of the questions presented.

Question:	Response		
	Yes	Maybe	No
Do you think PARO would be beneficial to people?	76%	21%	3%
Do you think PARO would be useful to you?	60%	3%	37%
Do you think PARO would be easy to use?	90%	7%	3%
If we offered to give you PARO to take home for free, would you want it?	80%	7%	13%

Table 11

Active Engagement with PARO overall.

Engagement Type	Total	% of Total	Mean	Range	SD
Words Spoken	2367	61%	78.9	0–452	107.5
Pet	835	21%	27.8	0–202	42.5
Touch	438	11%	14.6	0–93	19.8
Smile	111	3%	3.7	0–16	4.5
Gesture	80	2%	2.7	0–21	4.7
Move	64	2%	2.1	0–25	5.0

Table 12

Summary of Hierarchical Regression Analysis for Variables Predicting Post-Interaction Positive Affect (N = 30).

	Model 1			Model 2		
Predictor	***B***	***SE B***	***β***	***B***	***SE B***	***β***
PA-Pre	.97	.09	.91*	.91	.08	.91*
Engagement				.002	.001	.19*
R^2		.82			.86	
F for change in R^2		129.79*			81.39*	

Note: PA-Pre and Engagement were centered at their means