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Understanding Older Adults' Perceptions of Usefulness for the Paro Robot

Sean A. McGlynn¹, Shawn C. Kemple¹, Tracy L. Mitzner¹, Chih-Hung King², and Wendy A. Rogers¹

¹Georgia Institute of Technology, Atlanta, GA

²DTI Robotics, US, Inc.

Abstract

There is a growing proportion of older adults in the population. Normal aging brings about difficulty in maintaining autonomy as well as an increased need for social support. Animal-assisted therapy and pet-type robots may be a solution to this problem. However, older adults' living situations cannot always accommodate live animals and there are design limitations associated with many of the current pet-type robots. Paro's design addresses some of these issues, but perceptions of Paro's usefulness remain largely unexplored in the normally aging older adult population. The focus of this paper was to address perceived usefulness of the robot Paro as well as potential influencing factors of perceived usefulness. In this study, 30 healthy older adults (ages 67-80) completed questionnaires and answered interview questions regarding perceived usefulness and perceived ease of use of Paro before and after they interacted with it. The data revealed that the participants were neutral regarding perceived usefulness of Paro in their daily lives. However, most participants indicated specific uses for themselves and others, which raised concerns regarding the applicability of the Perceived Usefulness measure in this context. Furthermore, most participants said that they would want to own Paro, and perceived it as being beneficial to other people. Data analysis is ongoing, but initial findings and potential response trends have been identified and discussed. Our results provide insights into healthy older adults' thoughts toward and acceptance of this robot, as well as potential influencing factors of its acceptance.

INTRODUCTION

As the population of adults over 65 continues to grow and the average life expectancy increases, there is a rapidly expanding need for support for older adults (Administration on Aging, 2012). Limitations in physical and cognitive capability that are associated with aging can make aging in place difficult. Advances in robotics have opened the door for a number of opportunities, including providing support for individuals as they age and potentially enabling them to remain in their homes despite age-related limitations (Mayhorn, Rogers, & Fisk, 2004). It is imperative that a systematic, human-centered approach be taken when designing these robots, to ensure that they can be used by and are useful for older adults. Considering the effects of normal aging (i.e., visual, haptic, and auditory declines) in the design of robots should facilitate older adults' ability to interact with and accept this technology (Beer et al., 2012).

There is growing interest in the application of robotics for physical assistance for older adults (i.e., ambulation, fetching items; Smarr, Fausset, & Rogers, 2011). There is also potential for robots to provide support for cognitive and emotional difficulties experienced by some older adults (i.e., social isolation, loneliness, stress). The few attempts to use commercially available robots in the way that animal-assisted therapy has been employed have been promising, but offer much room for improvement (Filan & Llewellyn-Jones, 2006). This study assessed older adults' acceptance of Paro (Figure 1), a baby harp seal mimic robot that was developed solely for therapeutic purposes (Shibata & Tanie, 2001).

Previous studies on Paro have focused mainly on its potential to alleviate symptoms associated with dementia (Wada, Shibata, Musha, & Kimura, 2008). This study explored whether Paro would be accepted by normally aging older adults and their justification for acceptance or non-acceptance. Specifically, we addressed older adults' perceived usefulness and perceived ease of use of Paro.

Older Adults' Needs for Social Support

By 2030, older adults are expected to comprise nearly 20% of the U.S. Population (Administration on Aging, 2012). Many older adults prefer to age in place, and evidence suggests that this preservation of autonomy can be beneficial to health (for a review of the literature see Mitzner, Chen, Kemp, & Rogers, 2014). However, the normal decline in cognitive and physical functioning that comes as a result of aging often makes maintaining autonomy a challenge (Fausset, Kelly, Rogers & Fisk, 2011; Greiner, 1996). Even if independence can be achieved, living alone can increase the risk of social isolation and loneliness, which have been linked to higher rates of morbidity and mortality (Cornwell & Waite 2009). Although social network size decreases with age and social isolation is linked to negative health outcomes, research suggests that older adults who maintain positive perceptions of their social connectedness are more resilient to these declines in health (Cornwell & Waite, 2009). Given that 80% of older adults in the United States live independently in their own homes (Houser, Fox-Grage, & Gibson, 2006), there may be a great need of providing social support and companionship to this demographic.

The use of robots in the home is one possible solution to support older adults' needs for assistance. Most robots that are being developed to aid older adults are designed to compensate for normal age-related declines in physical capability. Less attention has been given to extending the application of robots to alleviate the cognitive and emotional issues that can emerge with aging, when in fact, older adults may need this type of support as well as support for physical tasks (Smarr et al., 2011).

Pet Therapy: Animals and Robots

Pet therapy or Animal-Assisted Therapy (AAT) has been used in a variety of contexts and has shown positive effects on well-being and quality of life (Ballarini, 2003). For example, patients who received AAT sessions either once or three times per week scored significantly lower on the UCLA Loneliness Scale, as compared to patients who received no AAT (Banks & Banks, 2002). Research has also found that interaction with pet dogs lowers blood

pressure and increases neurochemicals associated with relaxation and bonding (Odendaal & Meintjes 2003).

However, owning a pet is not a realistic option for everyone. Pets can be expensive, time-consuming, and physically demanding. For an older adult experiencing weakness or pain, having to bend over to feed a cat or taking a dog for a walk several times a day may not be feasible. Additionally, long-term care facilities are prone to the spread of diseases (Yoshikawa 1995), and so owning a pet may even be prohibited for older adults living in these environments.

Pet robots may be a viable substitute to owning a live animal, as they are likely to be allowed in more environments, and do not require the space, time, or physical effort that live animals do. There is also some evidence that pet robots are capable of eliciting similar health benefits as dogs and cats. Dementia patients showed decreased levels of stress-related hormones after 1-hour interactions with Sony's robot dog, AIBO, and reported reduced loneliness after 20 sessions over a 7-week period (Kanamori et al., 2001). In addition, interactions with NeCoRo, a robotic cat, were shown to increase feelings of pleasure in nursing home residents (Libin & Cohen-Mansfield, 2004).

Initial findings on the benefits of pet robots as therapeutic agents are intriguing, but much of the literature on pet robots has focused on the effects in patients with dementia. Furthermore, the robots used for testing are often not designed for therapeutic purposes and thus, tend to break or do not sufficiently promote interaction with participants (Shibata & Wada, 2010). Therefore, there is a need to extend this research to normally aging adults, as well as to use robots that are more appropriately designed for human interaction.

Potential for Paro

Paro is a robot designed by Dr. Takanori Shibata of the Intelligent System Research Institute of Japan's National Institute of Advanced Industrial Science and Technology. Its appearance, sounds, and behaviors were modeled after those of a baby harp seal, and its function is solely to elicit positive emotions such as happiness and relaxation (Shibata, Wada, Saito, & Tanie, 2005). In this sense, it offers the potential for more meaningful interactions than those elicited by robots used in previous studies, which were not specifically developed for therapeutic purposes. Its unfamiliar, baby seal-like appearance allows users to interact with it without pre-existing notions that occur with robots modeled after common pets such as dogs and cats, and thus, it is more easily accepted (Shibata, Kawaguchi, & Wada, 2012; Shibata & Tanie, 2001).

Paro has been used to assist older adults in care centers and shown to increase happiness and activity, decrease symptoms of depression and dementia, and even decrease stress levels in both the older adults and the centers' nursing staff (Wada, et al., 2004). In addition, nursing home residents interacted with Paro more readily than with a resident dog (Robinson, MacDonald, Kerse, & Broadbent, 2013). In normally aging adults, perceptions of Paro have shown to be influenced by prior pet experience as well as by gender (Shibata et al, 2012). To fully realize the potential for future therapeutic robots in the aging population, we must first

gain a better understanding of the factors affecting acceptance of this relatively new form of technology.

Technology and Robot Acceptance

There are a variety of factors that influence technology acceptance (Sun & Zhang, 2006). Peoples' initial positive emotions and attitudes toward robots before interaction influence the quality of interaction and experience (Broadbent et al., 2010). Perceptions of robots have been shown to be important for predicting acceptance of robots and other technologies (Heerink, Kröse, Evers, & Wielinga, 2010; Stafford et al., 2010). The Technology Acceptance Model (TAM) has shown to be an effective model of predicting technology acceptance (Davis, 1989). This model identifies perceived ease of use and perceived usefulness as key factors in accepting technology (Davis 1989). In the original model, perceived ease of use was defined as "the degree to which a person believes that using a particular system would be free of effort." Perceived usefulness was defined as "the degree to which a person believes using a particular system will enhance his or her job performance." (Davis, 1989, p. 320). Although originally studied in the context of employee acceptance of an electronic mail system, research has also identified perceived ease of use and perceived usefulness as predictors of robot acceptance (Ezer, Fisk, & Rogers, 2009; Smarr et al., 2014). To fully understand Paro's potential benefits to older adults, investigation of this population's acceptance of this robot is needed, in addition to examination of possible factors that increase or decrease the likelihood of acceptance.

Overview of this Study

The main objective of this study was to investigate healthy older adults' acceptance of the Paro robot. Specifically, did healthy older adults perceive Paro as being useful to them? Did they perceive Paro as being beneficial to others? Furthermore, what reasons were provided as justification for these perceptions of usefulness or non-usefulness for themselves and for others? A better understanding of factors influencing acceptance of pet-type robots will help provide designers of this technology with a blueprint of human-centered considerations to maximize adoption of these devices. We also investigated whether or not framing Paro differently influenced perceptions of usefulness and ease of use. This framing stimulus was provided by introducing Paro to participants in one of three ways; as a pet, a robot, or a toy. It was hypothesized that introducing Paro under these different frames would be an influencing factor in users' attitudes toward this robot. However, for the purposes of this paper, the main focus was on the results of quantitative and qualitative perceived usefulness assessments.

METHOD

Participants

Participants were 30 older adults (15 female, 15 male; aged 67-80, $M=72.17$, $SD=3.69$) recruited from the Human Factors and Aging Laboratory database. Participants reported being in good to very good health (1=poor, 3=good, 5=excellent; $M=3.73$, $SD=.87$) and were diverse with respect to race/ethnicity (60% White/Caucasian, 40% Black/African

American). The education level of the participants varied, with 60% reporting holding a Bachelor's degree or higher.

Ten participants were assigned to each framing group, with an equal proportion of males and females in each. There were no significant differences between groups regarding demographics, health, or ability test scores.

Stimuli

Paro has tactile sensors on its endoskeleton, which is covered in soft fur to promote interaction. 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. 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).

Materials

Introduction Script.—A script was developed and used for the introduction of Paro under each of the three framing conditions. The 'frame' was stated by the experimenter four times during this introduction, and then not again for the remainder of the study.

Perceived Ease of Use and Perceived Usefulness Questionnaire.—Pre- and post-interaction attitudes toward Paro were assessed by adapting the Perceived Ease of Use and Perceived Usefulness scales from the TAM to be relevant for this study (e.g., "I would find Paro useful in my daily life," "I would find Paro easy to use"). Participants indicated the extent to which they found these statements likely or unlikely, with "1" being "extremely unlikely" and "7" being "extremely likely." Sufficient reliability has been attained for measures of both perceived ease of use ($\alpha = .91$) and perceived usefulness ($\alpha = .97$) (Davis 1989).

Pre- and Post-Interaction Interview.—Participants were asked eight questions about their opinions and perceptions of Paro pre-interaction and eight questions post-interaction. For example, "Have you ever heard of Paro before?"(pre) and "Do you like anything about Paro?"(pre/post)

Other materials.—We also administered several other measures and questionnaires that were not included in this paper: ability tests, technology experience, pet experience, robot familiarity, Descriptors of Paro, and the Positive and Negative Affect Schedule (PANAS). Analysis of these items will also be addressed in future works.

Procedure

The primary focus of this paper is on the results from the Perceived Ease of Use and Perceived Usefulness Questionnaire, and selected interview questions related to perceived usefulness. However, the following describes the full experimental procedure (Figure 2).

After informed consent was obtained, participants completed the abilities tests. The experimenter then verbally introduced Paro under one of the three framing conditions (pet, robot, or toy) to which participants were randomly assigned. The camera was then turned on and Paro was brought into the room but remained off. Next, the initial reaction question was asked and pre-interaction assessments were administered. Afterwards, Paro was turned on and the reaction question was asked again. Following this, the experimenter demonstrated possible interactions with Paro, 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. After this period, the experimenter returned to the room and administered the post-interaction assessments. The participant was then debriefed and compensated.

Design

The experiment used a 3 (framing condition) $\times$ 2 (time) split-plot design with the framing condition as the between-subjects factor and time of assessment as the within-subjects factor. The dependent variables were Perceived Ease of Use and Perceived Usefulness.

RESULTS

Perceptions of Usefulness for Paro: Self and Others

To determine whether framing condition (pet, robot, toy) or time of assessment (pre-/post-interaction) affected participants' perceived usefulness of Paro, a framing (3) $\times$ time (2) analysis of variance (ANOVA) was conducted. There were no significant main effects of framing condition or time, and there was no significant interaction effect. Therefore, the remaining analyses were conducted on the sample as a whole (not separated by framing group) and focused on post-interaction perceptions of usefulness, after Paro had been turned on and participants had interacted with it.

Perceived usefulness scores were calculated by taking the mean of these six items in the Perceived Ease of Use and Perceived Usefulness Questionnaire, which generated scores between 1-7 (1 = extremely unlikely, 4 = neither, 7=extremely likely). The mean score was not significantly different than neutral ($p=.827$), suggesting that participants found it neither likely nor unlikely that Paro would be useful to them ($M=3.71$, $SD=1.86$).

Perceived usefulness was also assessed via interview questions. We identified three of these questions as being particularly relevant to usefulness. These questions and the response proportions can be seen in Figure 3.

Responses were categorized as “Yes”, “No”, and “Other”. “Other” pertained to conditional responses such as “I might if I knew more about it” or “Maybe if I were lonely.” If necessary, participants were asked to elaborate on their responses. Example responses are

shown in Table 1. Bolded words correspond to possible response trends that warrant further analyses, and will be explained in the discussion.

Perceived Ease of Use of Paro

Perceived ease of use scores were calculated in the same manner as the aforementioned perceived usefulness scores, but instead used the six Ease of Use items from the questionnaire. The mean scores both pre- ($M=4.87$, $SD=1.43$) and post-interaction ($M=5.03$, $SD=1.58$) were significantly greater than neutral (*Pre*; $t(29)p<.01$, *Post*; $t(29)p<.01$) suggesting that participants found it slightly likely that Paro would be easy to use both before and after interacting with it.

To determine whether framing condition or time of assessment affected participants' perceived ease of use for Paro, a Framing (3) $\times$ Time (2) ANOVA was conducted. There were no significant main effects for framing condition or for time. A significant Framing $\times$ Time interaction was found for this measure $F(2, 27)=5.18$, $p=.01$, $\eta^2=.28$, suggesting that mean differences in pre- and post-interaction perceived ease of use scores depended on which framing condition participants were nested in.

To explore this interaction, post-hoc comparisons were conducted. After conditioning on frame and comparing across time, paired t-tests revealed a significant mean difference between pre-interaction ($M=4.62$, $SD=1.25$) and post-interaction ($M=5.92$, $SD=.70$) perceived ease of use scores for participants in the robot group, such that mean perceived ease of use scores were higher post-interaction at the .05 alpha level ($t(10)p=.022$). However, this effect was not significant after a Bonferroni correction was applied ($05/3$) = .016.

DISCUSSION AND FUTURE DIRECTIONS

This study's main focus was on healthy older adults' perceived usefulness of Paro and the reasoning behind these perceptions. In addition, perceived ease of use of this robot was examined. Also investigated was whether framing the Paro as a robot, toy, or pet would influence perceptions but there were minimal effects of the framing manipulation.

The quantitative perceived usefulness scores revealed that healthy older adults found it neither likely nor unlikely that Paro would be useful to them in their daily lives after interacting with it. However, the response proportions (Figure 3) to post-interaction interview questions regarding usefulness somewhat contradicted this finding. Thus, it is possible that the Perceived Usefulness component of the questionnaire lacked content validity in this setting. Because Paro was designed to be socially-assistive rather than task-oriented, questions such as "Using Paro in my daily life would allow me to accomplish tasks more quickly" are not applicable. For future studies on socially-assistive robots, a more appropriate measure might be the Perceived Enjoyment questionnaire, which has also been shown to influence technology acceptance (Heerink, Ben, Evers, & Wielinga, 2008).

Responses to these interview questions were probed to determine *why* participants perceived Paro as useful or not. This revealed potential *facilitators* (e.g., soothing, improving moods) and *barriers* (e.g., meaningless, no need) toward acceptance of Paro. Another trend was that

Paro's usefulness was perceived as being conditional on a person being in a certain state of mind (e.g., "feeling down and low") or living situation (e.g., "nursing home", "isolated"). In the ongoing analyses of these data, these interview data will be further investigated to address the following questions:

- 1) What are the *facilitators* and *barriers* towards acceptance of Paro?
- 2) *Who* in particular do healthy older adults believe could benefit from using Paro?
- 3) What specific *benefits* are perceived for themselves and others?

Previous studies on Paro have shown its ability to aid persons experiencing age-related declines. The main finding of this study is that *healthy* older adults perceive uses and benefits for Paro as well. A better understanding of these perceptions will provide insight into Paro's potential to provide companionship and social support for older adults.

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Figure 1:

Paro, the robotic baby harp seal mimic (Wada, Shibata, Saito, & Tanie, 2004)

Figure 2:
Experiment Procedure

Q1			Q2			Q3		
Do you think that Paro would be useful to you?			Do you think that Paro would be beneficial to people?			If we offered to give you Paro to take home for free, would you want it?		
Yes n=16 (53%)	No n=10 (33%)	Other n=4 (13%)	Yes n=27 (90%)	No n=1 (3%)	Other n=2 (6%)	Yes n=25 (83%)	No n=4 (13%)	Other n=1 (3%)

Figure 3.
Response proportions to three selected usefulness questions.

Table 1.

Example responses to three post-interaction interview questions.

	Example Responses		
	“Yes”	“No”	“Other”
If we offered to give you Paro to take home would you want it?	“...this is something that if I was feeling down and low , there would be a soothing aspect to me.”	“It seemed basically just meaningless . It just didn’t seem to really respond like even a cat would do.”	“If I could figure out how to get him to respond to me if I have a crisis.”
Do you think that Paro could be beneficial to people?	“...in the same way that they have animals who they bring to nursing homes ...just making people less anxious and calming them...just improving their moods .”	“I don’t know how [it would be]”	“...perhaps you have some sort of mental quirks, that you’re so isolated that you don’t have any interaction with human beings.”
Do you think Paro would be useful to you?	“It would be interesting to have around and you’d find yourself talking to it.”	“I simply have no need ”	“Not without knowing more about what its function could actually do for me”