Beer, J. M. & Takayama, L. (2011). Mobile Remote Presence Systems for Older Adults: Acceptance, Benefits, and Concerns. Proceedings of Human-Robot Interaction Conference: HRI 2011, Lausanne, CH, pp. 19-26.

Mobile Remote Presence Systems for Older Adults: Acceptance, Benefits, and Concerns

Jenay M. Beer
School of Psychology
Georgia Institute of Technology
654 Cherry St.
Atlanta, GA 30332
jbeer@gatech.edu

Leila Takayama
Willow Garage
68 Willow Rd.
Menlo Park, CA 94025
takayama@willowgarage.com

ABSTRACT

While much of human-robot interaction research focuses upon people interacting with autonomous robots, there is also much to be gained from exploring human interpersonal interaction through robots. The current study focuses on mobile remote presence (MRP) systems as used by a population who could potentially benefit from more social connectivity and communication with remote people — older adults. Communication technologies are important for ensuring safety, independence, and social support for older adults, thereby potentially improving their quality of life and maintaining their independence [24]. However, before such technologies would be accepted and used by older adults, it is critical to understand their perceptions of the benefits, concerns, and adoption criteria for MRP systems. As such, we conducted a needs assessment with twelve volunteer participants (ages 63-88), who were given first-hand experience with both meeting a visitor via the MRP system and driving the MRP system to visit that person. The older adult participants identified benefits such as being able to see and be seen via the MRP system, reducing travel costs and hassles, and reducing social isolation. Among the concerns identified were etiquette of using the MRP, personal privacy, and overuse of the system. Some new use-cases were identified that have not yet been explored in prior work, for example, going to museums, attending live performances, and visiting friends who are hospitalized. The older adults in the current study preferred to operate the MRP themselves, rather than to be visited by others operating the MRP system. More findings are discussed in terms of their implications for design.

Categories and Subject Descriptors

J.4 [**Computer Applications**]: Social and Behavioral Sciences – *Psychology*. H.5.2 [**Information Systems**]: Information Interfaces and Presentation – *User Interfaces*.

General Terms

Design, Experimentation, Human Factors

Keywords

Human robot interaction, mobile remote presence, older adults

1. INTRODUCTION

The question of robot acceptance is relevant to older adults, particularly as many robots and systems are being designed to help older adults maintain independence and live in their homes longer. Older adult's perspectives upon such technologies may influence the way in which they interact with and use the system. Additionally, by understanding the user's needs, designers can develop user-centered and user-friendly systems.

Qualitative research methods, such as needs assessment interviews, provide the means by which to better understand user's perceptions and willingness to use technology. The goal of the present research was to understand (1) older adults' views on what a mobile remote presence system may be used for; (2) older adults' perceived benefits and concerns about the system; and (3) criteria for older adults to accept using the system.

1.1 Robots for Older Adults

Technological advancements are making domestic robots viable commercial products, aiding individuals in completing tasks they cannot or do not want to perform (e.g., iRobot's Roomba vacuum). Robotic systems have the potential to assist older adults perform tasks they need or want help with as they age. Older adults prefer to age in place [10]; that is, they prefer to age in their home settings, and may be amenable to having robots in their homes. Robotic systems may assist older adults in maintaining their independence, reducing healthcare needs, providing everyday assistance, and promoting social interaction.

Many service robots currently designed for physically assisting older adults, particularly focusing upon activities of daily living and instrumental activities of daily living, such as medication management, emergency monitoring, and feeding [12, 16, 23]. Other domestic robotics projects for the older adult population focus on systems with social capability. These types of robots are intended to take part in collaborative activities, such as acting like a social partner [5, 13-15, 18, 26].

In contrast, a different approach is to use robotic systems to foster social interaction *between people*. In particular, mobile remote presence (MRP) systems are designed to be teleoperated, and used to improve communication between individuals. Such systems are currently in development and some have been designed for older adults in home and healthcare settings [1, 9, 20, 27].

Although robotics and remote presence systems are being designed for older adult use, acceptance of such systems is still a relatively open question. When designing MRP systems there is a need to understand older adult users' perception of a system in their home or healthcare settings. A common assumption is that older adults do not accept new technology. It is true that older

adults generally have less experience with technology, which may be related to computer anxiety [4]. With robotics in particular, it might be assumed that older adults may not be as accepting as their younger adult counterparts because they are concerned about the system being difficult to learn [6].

On the other hand, older adults have demonstrated a willingness to use technology, as long as it assists them in living independently [25]. Older adults, surveyed about their acceptance of new technologies in the home, demonstrated a positive attitude toward technological aids in a domestic setting, but that acceptance was associated with the specific problem they have to cope with [11]. Likewise, acceptance of domestic robots has been suggested to depend on the older adults' perception of their own health status (physical and cognitive), with a greater appreciation for the utility and application of a domestic robot in the home as health capabilities are at risk of declining [3]. In fact, in a large-scale survey, older adults have demonstrated an interest in using robots in the home, particularly if the system is performance-directed (i.e., assists with critical tasks in the home) [7]. A number of research studies have shown that if the benefit outweighs the cost of use, then older adults *are* willing to accept and adopt technology [2, 19, 25].

1.2 Related Work

Previous work in ubiquitous computing has conducted needs assessments with older adults, focusing on issues that surround cognitive decline [21]. Using 45 household interviews and seven focus groups, the researchers discussed social networks with older adults, identifying several social needs: reciprocity, diversity, and extensiveness. They also identified several social barriers: difficulty following conversations, forgetting names and faces, and fears of imposing. These studies were conducted to inform the design of ubiquitous computing systems to support social connectedness for older adults, but they can readily apply to identifying needs for robotic systems, too.

More directly related to human-robot interaction, Forlizzi et al. [8] used ethnographic methods to explore how robotic technologies might support older adults to remain active and independent longer. Focusing on the place of existing products in the ecology of people, products, and activities, they observed 17 older adults' activities and interactions with products and conducted semi-structured interviews in private residences in the Pittsburgh and Chicago metropolitan areas. One of their major findings was that many products in the home represent different values for older adults than they do for younger adults (e.g., cell phones take the place of cars for maintaining social contact with others). Communication and social interaction were particularly important activities to support. Forlizzi, et al. [8] recommended the following design guidelines for future robotic technologies: (1) fit the aging ecology, (2) support migrating values, and (3) be functionally adaptive. This ethnographic study was a source of inspiration for the current study, which sought to support communication and social interaction for older adults. The current study also aimed to focus more directly upon mobile remote presence (MRP), not robotic technologies or products in general.

More specifically related to mobile remote presence, Boissy et al. [1] used focus groups with six healthcare professionals and six older adults with disabilities. These researchers identified potential uses for such technologies, including (1) improving safety for patients and their sense of safety, (2) helping family caregivers with providing medical care and using specialized equipment, and (3) improving communication between patients (in their own homes) and healthcare professionals, overcoming social isolation. They also identified concerns of patients regarding privacy, cost, and utility, which are discussed in the context of the current study's results.

2. STUDY DESIGN

In contrast to these previous works, the current study focused on mobile remote presence for older adults, who actually experienced using a functioning MRP prototype. We did not target healthcare contexts (e.g., [20]) or people with cognitive decline (e.g., [21]) or disabilities (e.g., [1]). Instead, we focused upon social and medical contexts with older adults who had no apparent disabilities or decline.

Each participant in the current study interacted with a visitor who operated the MRP, and each participant also operated the MRP system in order to visit a person. As recommended by Rogers and Mynatt [24], the assessment of the current system is "based upon user needs assessment with a commitment to training users to effectively interact with the systems" (p. 26).

The current study focused upon the following research questions: From the perspective of older adults, (1) what could MRPs be used for? (2) what concerns would need to be addressed? (3) how and why would MRPs be accepted and adopted? To assess these research questions, the data collected from this study were analyzed to determine older adults' opinions of the system (i.e., perceived benefits and concerns), suggestions for use cases, and recommendations on system design.

3. METHOD

3.1 Participants

The participants included 12 community dwelling older adults (5 men and 7 women), ranging from 63 to 88 years of age (M = 73.38, SD = 7.38). Older adults were recruited from local community senior centers and were compensated monetarily for their participation. All participants reported living independently in a house, senior housing, apartment, or condominium. They were generally well educated; all participants reported some college education or higher, with many reporting having a Master's degree (42%). The majority of the participants reported living with someone else (83%). Self-reports of the participants' health status are presented in Table 1.

Each participant was given a technology experience questionnaire (adopted from Czaja, et al. [4]). Each participant was assigned a score, based upon the mean of their responses in a self-report usage of 16 common place technologies (e.g., cell phone, keyboard, fax machine). For this Likert-type scale, 1 indicated no experience, whereas 5 indicated daily experience. The mean technology score was 3.5 (SD = 0.8), suggesting moderately-high technology experience. Similarly, each participant received a robot experience mean score. For this experience scale, 5 robot categories were presented (e.g., vacuuming robot, manufacturing robot); 1 indicated no experience, whereas 5 indicated extensive experience with the robot. The mean robot experience score was 2.3 (SD = 0.4), suggesting moderately-low robot experience.

Table 1. Self Reported Health Characteristics

Health Characteristics	*N*=12
General Health	
Excellent	17%
Very Good	33%
Good	42%
Fair	8%
Poor	0%
Health Problems Limiting Daily Activities	
Never	50%
Seldom	42%
Sometimes	8%
Often	0%
Always	0%

3.2 Remote Presence System

The mobile remote presence (MRP) system used in the current study was an alpha prototype of the Texai project (see Figure 1). The system consists of a touch screen on a mobile base; it stands 5'2" tall. The touch screen is surrounded by a microphone, web camera, and speakers. The base has an active caster with two passive wheels, a computer, and a large battery that lasts approximately eight hours on a single charge. This MRP prototype was developed to support a remote co-worker, who lives in Indiana, but works in a research and development company in California. The MRP system is different from traditional video conferencing (e.g., Skype) in that it allows the user to control navigation and webcam angle to enhance one's sense of *remote presence*. Similar MRP systems have been studied in the past, focusing on workplace contexts (e.g., [17, 22, 28]). One related project focused on home healthcare [20].

3.3 Semi-Structured Interview Procedure

The participants were interviewed individually in a private room. They first completed a study agreement form that described the general aspects of the study as well as their rights as volunteer participants. Next, they completed a general demographics and technology experience questionnaire.

After the moderator provided an introduction and overview of the study, the participants watched an instructional video that demonstrated the basic functions of the system, as well as how to use the web-based user interface designed to operate the system.

Participants completed two study sessions where they served as (a) a pilot user who operated the MRP system (see Figure 2) and (b) a local user who encountered a visitor in the MRP system (see Figure 3); the sessions were balanced for order across participants. During both sessions, the participants were constantly monitored by the experimenter, who was trained to press the run/stop button if an unlikely safety-risk were to occur.

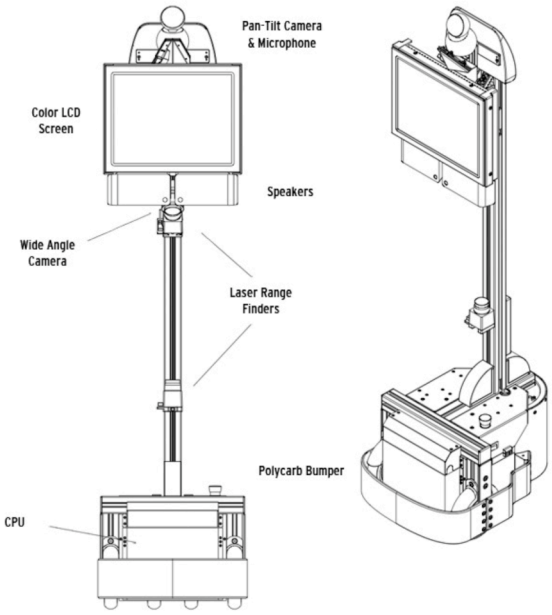

Figure 1. The Mobile Remote Presence (MRP) system where the older adults could not see or hear it.

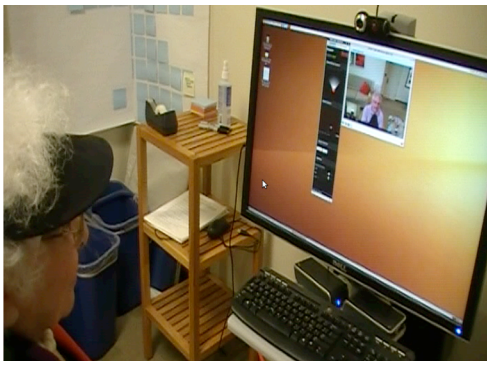

Figure 2. Pilot session: Study participant operating the MRP system

Figure 3. Local session: Study participant being visited via the MRP system

During the pilot user session, the participants were allowed to control the remote presence system via the web-based UI. The system was located on the opposite side of the office building,

Using the web interface, participants were instructed to drive the system down a short hallway, through a door, and into a seating area. During this time, the experimenter was present to assist the participant in navigation if needed (e.g., avoiding obstacles). In the seating area, the participants socially interacted with a secondary researcher. The secondary researcher mediated the conversation by only discussing an approved set of neutral topics (e.g., "Where are you from?" or "How long have you lived in the area?"). The interaction lasted 5-10 minutes, upon which the older adult logged out of the web-based user interface.

During the local user session, the secondary researcher piloted the system and drove it into the interview room. Again, the secondary researcher interacted with the participant and mediated the conversation by only discussing an approved set of neutral topics. The interaction lasted 5-10 minutes, upon which the secondary research drove the system out of the interview room.

After each type of interaction, the moderator interviewed the participant. In total, the interview lasted approximately two hours (an hour for each session), including a break that was offered between sessions.

The semi-structured interviews were developed to assess the older adults' perceived benefits and concerns about the system, their willingness to use the system, and their general opinions about the system. The interview questions consisted of eight major sections, which were split between the piloting condition and the local user condition. These sections were chosen to elicit discussion and to encourage participants to discuss a wide range of applications. Table 2 provides example interview questions from each of these sections.

Table 2. Sample questions from structured interview

	Pilot User Condition
Contacting Others	Who might you want to contact with the system?
Health Care	Imagine that a friend is recovering at a health care facility and that you could use this system to contact them...
Contacting Doctor	Imagine that a health care professional can use the system to contact you...
Attending Events/Locations	What types of events or locations would you like to attend via the system?
	Local User Condition
Contacting Others	Who might you want to be contacted by with the system?
Health Care	Imagine you are recovering at health care facility, and other could use the system to contact you...
Contacting Doctor	Imagine you could use this system to contact a health care professional...
Health Staff	What types of tasks could the staff at an assisted living center use this system for?

The interview questions followed a specific order of progressions, depending on the session. However, the script was structured to allow the moderator the freedom to pursue other topics that arose during discussion.

4. RESULTS

After the twelve interviews were transcribed, we developed a coding scheme to analyze the participants' responses. We identified themes in the data based on patterns of participant answers to the structured interview questions. A well-defined coding scheme provided a structure with which to sort and summarize the data in an objective manner and enable two independent raters to classify a section of text as fitting with a specific descriptor in the coding scheme.

The resulting coding scheme included 388 dimensions on which participants' interviews were coded on. Two researchers, a primary coder and a secondary coder, coded the transcripts using text analysis software MAXQDA10. The percent agreement between the primary and secondary coder was 91%. The primary and secondary coders then reviewed disparate codings and modified the coding scheme for clarification. The remaining interviews were analyzed by the primary coder only.

4.1 Opinion of system

For each major section, the participants were asked their general opinion of the system. The majority of mentioned opinions were positive (66%), some were mixed (28%), and a few of the mentioned opinions were negative (6%).

The older adults' positive opinions of the system were also reflected in their discussion of benefits vs. concerns of the system. Overall, the older adults discussed significantly more benefits (n = 174) than concerns (n = 124), χ^2 = 15.4, p < .0001. Of the concerns mentioned, older adults discussed significantly more concerns as a local user (n = 75) than a pilot user (n = 49), χ^2 = 5.45, p < .02. Overall, these participants suggested a preference for controlling the system themselves, rather than letting someone else controlling it; this preference may explain the difference in the frequency of mentioned concerns for being the local user.

Participants were asked who they would want to contact via the system (both as a pilot or a local user). Participants most commonly mentioned family, more specifically their children or grandchildren (see Figure 4). The second most commonly mentioned group was friends (33%). Despite the previous focus on previous work on medical contexts, the older adults in the current study did not mention doctors or medical staff very often (6% doctors); this may have been due to their relatively good self-reported health levels.

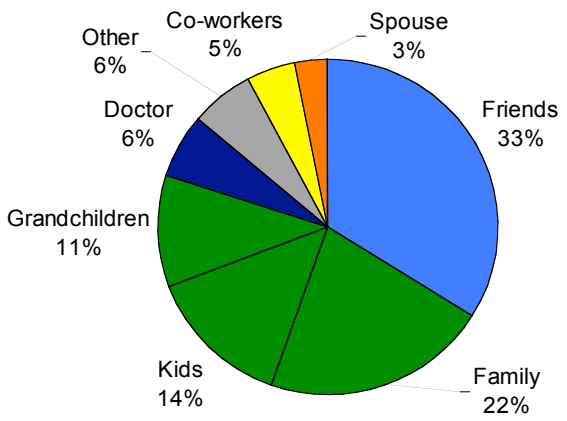

Figure 4. Who older adults would contact with the system (% times mentioned)

4.1.1 Perceived benefits of the system

For each section of the interview, the older adults were asked in an open-ended format what benefits they perceived in using the system. The participants' reported benefits were then coded (based upon the predefined coding scheme) and tallied across the entire interview script. Table 3 lists the top 5 commonly mentioned benefits.

Table 3. Most commonly mentioned benefits (*N*=174 codes)

Benefit	% of times mentioned
Visualization	25%
Reduce travel time / safer travel	14%
Socialization / reduce isolation	13%
Convenience	9%
Health diagnosis	9%

Visualization was the most commonly mentioned benefit, comprising of 25% of the total mentioned comments. In other words, being able to see the person on the other side of the MRP system was perceived as a major benefit. As one older adult explained "…there are situations when it's important to look at people's faces when you're presenting ideas to see what the feedback is... It adds another dimension to just the linguistic exchange."

The older adults were also concerned about having to someday give up their drivers' licenses. They observed that the remote presence system could allow them to stay in contact with friends and family without having to drive long distances or in inclement weather.

Additionally, the system's potential to promote socialization and reduce social isolation was identified as a potential benefit. In particular, the older adults recognized this benefit in healthcare applications. One older adult referred to a friend who was recovering at a health care facility, "…they don't get to see anybody, so I think it would be very helpful to an inmate, let us say or a patient, not an inmate, to have a visitor." This is consistent with previous findings in robotics [1], ubiquitous computing [21], and computing technologies, more broadly [24].

In addition perceived benefits, participants were asked in each section whether they would be willing to use the system. Every participant (n=12) mentioned that they would be willing to use the system for daily or weekly activities, depending on the application.

4.1.2 Perceived concerns about the system

For each section of the interview, the older adults were also asked in open-ended format what concerns they perceived about using the system for that particular application. The participants' reported concerns were then coded (based upon the predefined coding scheme) and tallied across the entire interview script. Table 4 lists the top 5 commonly mentioned concerns.

Table 4. Most commonly mentioned concerns (*N*=124 codes)

Concern	% of times mentioned
Etiquette refusing / ending call	18%
Privacy	15%
Less personal / lack of face-to-face contact	13%
Misuse / overuse	12%
Difficult to use	9%

Based on these data, etiquette was a primary concern for older adults. Etiquette was largely discussed in terms of the older adult as a local user. They were concerned about refusing a visitor (i.e., not "picking up" when a friend or family member wants to visit via the MRP system) as well as ending an ongoing interaction with people visiting via the MRP system. This concern about proper etiquette is consistent with earlier findings that being imposing was a major concern among older adults in the context of social barriers [21]. Etiquette was discussed in terms of developing social rules for proper and polite use of the system, "It's a lot easier to hang up [the telephone] on somebody gently than it would be if they could see that you didn't want to talk to them...we'd have to learn a whole new set of skills on how to keep a distance when it's needed." Etiquette was also commonly discussed in terms of privacy. The concern for privacy was most commonly mentioned when discussing managing visitors if the older adult was recovering in a health care facility.

The system's perceived limitations as being less personal, or lacking physical face-to-face contact with others, was particularly mentioned when discussing health care applications (including the use by assisted living staff members). It was clear that while the older adults recognized the benefit the system may have in these applications, it should be used to supplement in-person health care, not replace it. As one older adult said, "Well, I think people contact is very important and I wouldn't want them to use it excessively. In other words, it's more important that they see the patient and they have a relationship but use it to help them." This is consistent with previous findings that MRP healthcare systems should supplement, but not replace, healthcare professional or family member visits [20].

4.2 Use cases: Off-site events and locations

After piloting the system, the participants were asked to brainstorm events or locations they would like to visit via the remote presence system. Table 5 depicts the top 5 mentioned desired destinations for older adults using an MRP system; percentages refer to the number of participants who mentioned each particular use case.

Half of the participants (50%) expressed interest in driving the system outside. Whether this included a stroll through a park or a busy city, participants expressed interest in exploring new places from the comfort of their own home.

Also mentioned were attending concert performances and sporting events. In this application, the older adult may view the performance with the rest of the audience, but could also turn/rotate the system in order to "personalize" the viewing experience (i.e., more control than viewing the performance on television). One participant described using the system to attend concerts, "You could situate it the way you want kind of that you'd get a feeling of participation, being there better than a TV. This is just my personal opinion, and you would have better seats <laughs>." Museums and theater performances were other destinations that older adults identified as places they would like to visit via the MRP system.

Table 5. Mentioned use cases (*N*=12 people)

Event / Location	% of people who mentioned use case
Outside	50.0%
Performances (concerts)	41.7%
Sporting events (i.e., audience)	41.7%
Museums	33.3%
Performances (theater)	33.3%

4.3 Product Design

4.3.1 Appearance and ease of use

Most of the older adults (67%) reported that it was easy to operate the MRP system. However, upon reviewing the video recordings of the participants driving, it became clear that the older adults' driving performances were not without troubles. In particular, they behaviorally demonstrated difficulty controlling the speed and direction of the system. This difficulty seemed to be commonly related to the use of the mouse and the web-based user interface. One participant said, "You're not only having to watch the red ball [that was used to drive the MRP system], but you have to watch where you're going and your speed and looking out for things. So it was a lot to do, especially just controlling it with the mouse." When asked how to improve the system's driving design, 50% of the older adults recommended different driving controls (alternatives to a computer mouse) due to issues with fine motor movement and mapping the controls to the system's video feed.

When asked about the appearance of the system, 75% of participants disliked, were indifferent, or had mixed opinions. The most common complaint was that the system was "too machine-like," particularly if used in a home setting.

4.3.2 Know before use

Finally, participants were asked what they would like to know about the system before they purchased or used it. (See Figure 5).

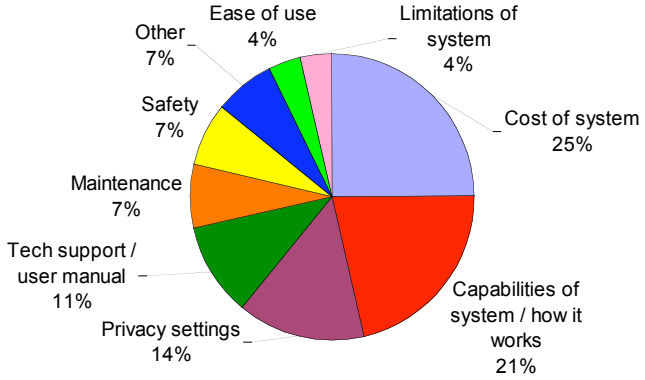

Figure 5. What the older adults would want to know before using the system (% times mentioned)

They most commonly mentioned the cost and whether purchasing the system for their home would be financially feasible, which is consistent with the concerns regarding who would pay for such services identified in previous work [1]. The rest of the comments had to do with the system's functionality. In particular, older adults wanted a high level understanding of how the system works. This was mentioned in terms of understanding the capabilities of the system (21%), but also having access to technical support or a user manual (11%). Finally, privacy settings were mentioned (14%), particularly with regard to having the capability to refuse a call and monitor who has access to the MRP system; the preservation of privacy was the top issue identified by Boissy, et al. [1].

5. DISCUSSION

Mobile remote presence systems have the potential to help older adults maintain independence longer. However, without first assessing older adults' opinions and willingness to use such systems, designers risk developing systems that may not be adopted by the intended population. Qualitative research studies, such as interviews, provide the appropriate methodology to conduct needs assessments. Findings from needs assessment studies may help the designer to understand user requirements, attitudes, and acceptance, thereby promoting the design of better user-centered systems. Unlike previous studies that used pictured robots [1], existing product ecologies [8], or social networks [21] as a focus of analysis, the present work focused on experience with an actual mobile remote presence system. The older adult participants interacted with the remote presence system and made responses to interview questions with the specific system in mind.

5.1 Overview of Benefits and Concerns

Overall, the older adults' opinions of the MRP system were positive in nature. This was further supported by the participants' identification of significantly more benefits than concerns about using the system. It is well supported that older adults are willing to adopt technology if the benefit of using it is clear [25]. Based upon these current findings, the benefit of using this system was clear to the older adult participants, and each participant expressed

a willingness to use it. The findings from this study suggest that independently-living, healthy older adults are generally willing to use a mobile remote presence system such as the Texai prototype in both social and medical contexts. In summary, the participants recognized that visualization, reducing travel, and socialization were primary benefits of using this system. However, etiquette of managing calls, privacy, and a lack of face-to-face contact were potential causes for concern.

5.2 Implications for design

The applications discussed in the interview (i.e., home or healthcare environment) are very different from the workplace, which the system is currently primarily used for. The potential to use this system in home or healthcare applications, as discussed in the interview, should be kept in mind when determining design choices based on the data. For example, although the MRP system's "machine-like" appearance may be acceptable for the workplace, the older adults did not care for it, mentioning they would like it to look more homely with softer edges. Keeping the live streaming video display of the MRP pilot is also important for maintaining the ability to see one's visitor when being visited via an MRP system or to be seen by others when piloting, which was the top benefit mentioned in this old adults needs assessment.

On a similar thread, the older adults' concerns about etiquette is a challenging interaction design consideration. Again, this concern may be different in nature for home or healthcare settings compared to the workplace. As mentioned in these interviews, using the system to communicate with family and friends requires a very different social interaction compared to interacting with co-workers. Additionally, the participants expressed that the social "rules" required for a remote presence system may be very different from those social rules required for a telephone. In other words, it may be more difficult to say "goodbye" or refuse a call politely when the user can see the other person. It is recommended that the system be designed to allow the *local* user control over accepting and refusing MRP system visits. Allowing the local user this control will help to mitigating potentially rude behaviors as well as protect local users' privacy. Social norms are bound to form around such technologies, which may be more or less out of a designer's control, but at least some issues around control of one's privacy are critical for the future design of such MRP systems in home and medical settings.

Although prior work has explored the use of MRP systems for enabling family members and medical staff visit older adult patients, the current study has found that older adults prefer to control the MRP system themselves, too. This preference to control the MRP system suggests a different set of use cases for older adults that have not been previously explored in depth. For example, many of the older adults in the current study expressed the desire to go outside, visit new places, attend live performances, and visit museums. This suggests that tourist destinations, concert performance halls, and museums might actually be the types of places where MRP systems should be placed, rather than only putting them in older adults' homes or in hospitals. Enabling MRP systems to function outdoors is yet another challenge that could promise the set of fruitful use cases in the future.

Finally, older adults expressed a need for other control options, rather than just the graphical user interface with the mouse. Although older adults suggested that the system controls and display seemed easy to use, in practice the mouse was challenging to use due to difficulties with fine motor control. Multiple control options, such as steering wheels, keyboard control, and joysticks might be potential alternatives to controlling the system. Additionally, older adults suggested that tutorials or user manuals describing how the system works may facilitate adoption and improve the ease of use of the system.

5.3 Limitations and Future work

Conducting needs assessments and user studies should be an iterative practice in the design process. Although the current study provides insight to this user population's requirements for adopting this system, it is critical for future work to be conducted to ensure that future designs are effective.

First, although the use of a tangible system was a strength of this study, it has yet to be determined the generalizability of these findings to other robotic systems. Technology acceptance may vary according to both the system and user characteristics.

To generalize to a variety of MRP systems, it is important for other MRP platform designers to conduct similar needs assessment studies. Different variations on prototypes of these MRP systems may be necessary for exploring specific system-level dimensions, e.g., MRP system height, speaker volumes, monitor sizes, industrial design styles. The implementation of a variety of user controls, such as steering wheels, keyboard control, and joysticks has yet to be experimentally evaluated. The ease of use for each of these types of controls may vary by age group, hand-eye coordination, etc.

In terms of user characteristics, future work should be conducted with other age groups, cultures, geographic regions, etc. The current study included a particularly health set of older adults, who live in a technophillic culture, the Silicon Valley, so it is important to also explore different types of communities to broaden the scope of this area of research. Comparing a variety of cohorts could assist a designer in developing a remote presence system for a more diverse user group.

In terms of methods, it would be ideal if future work could also provide long-term experience with a MRP system applied to the situations that older adults intend to use them, enabling longitudinal studies and ethnographic studies that can use observations, not only interviews, to learn about how older adults could and would actually use MRP systems.

6. ACKNOWLEDGMENTS

Thanks go to the study volunteers, who made this research possible, and to Bob Bauer for his assistance in conducting the experiments. A special thanks go to Professors Arthur D. Fisk and Wendy A. Rogers as well as the Willow Garage Texai Alpha project team for their support of this project.

7. REFERENCES

[1] Boissy, P., Corriveau, H., Michaud, F., Labonte, D. and Royer, M.-P. 2007. A qualitative study of in-home robotic telepresence for home care of community-living elderly subjects. *Journal of Telemedicine and Telecare* 13, 79-84.

[2] Caine, K.E., Fisk, A.D. and Rogers, W.A. 2007. Designing privacy conscious aware homes for older adults. In *Proceedings of HFES*.

[3] Cesta, A., Cortellessa, G., Giuliani, M.V., Pecora, F., Scopelliti, M. and Tiberio, L. 2007. Psychological

implications of domestic assistive technology for the elderly. *PsychNology Journal* 5, 3.

[4] Czaja, S.J., Charness, N., Fisk, A.D., Hertzog, C., Nair, S.N., Rogers, W.A. and Sharit, J. 2006. Factors predicting the use of technology: Findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychology and Aging* 21, 333-352.

[5] Dautenhahn, K., Woods, S., Kaouri, C., Walters, M., Koay, K.L. and Werry, I. 2005. What is a robot companion--Friend, assistant or butler? In *Proceedings of IROS*, IEEE, 1488-1493. DOI=10.1109/IROS.2005.1545189

[6] Demiris, G., Rantz, M.J., Aud, M.A., Marek, K.D., Tyrer, H.W., Skubic, M. and Hussam, A.A. 2004. Older adults' attitudes toward and perceptions of 'smart home' technologies: A pilot study. *Informatics for Health and Social Care* 29, 87-94.

[7] Ezer, N., Fisk, A.D. and Roger, W.A. 2009. More than a servant: Self-reported willingness of younger and older adults to having a robot perform interactive and critical tasks in the home. In *Proceedings of HFES*, 136-150. DOI=10.1518/107118109X12524441079382

[8] Forlizzi, J., DiSalvo, C. and Gemperle, F. 2004. Assistive robotics and an ecology of elders living independently in their homes. *Human-Computer Interaction* 19, 25-59.

[9] GeckoSystems 2010. Gecko System Markets: Consumer Family.

[10] Gitlin, L. 2003. Conducting research on home environments: Lessons learned and new directions. *The Gerontologist* 43, 5, 628-637.

[11] Giuliani, M.V., Scopelliti, M. and Fornara, F. 2005. Elderly people at home: Technological help in everyday activities. In *Proceedings of RO-MAN*, IEEE, 365-370.

[12] Hansen, S.T., Andersen, H.J. and Bak, T. 2010. Practical evaluation of robots for elderly in Denmark: An overview. In *Proceedings of HRI*, ACM, Osaka, Japan, 149-150. DOI=http://doi.acm.org/10.1145/1734454.1734517

[13] Heerink, M., Krose, B., Evers, V. and Wielinga, B. 2006. The influence fo a robot's social abilities on acceptance by elderly users. In *Proceedings of RO-MAN*, IEEE, 521-526.

[14] Heerink, M., Krose, B., Wielinga, B. and Evers, V. 2008. Enjoyment, intention to use and actual use of a conversational robot by elderly people. In *Proceedings of HRI*, ACM, Amsterdam, The Netherlands, 113-119. DOI=http://doi.acm.org/10.1145/1349822.1349838

[15] Heerink, M., Krose, B., Wielinga, B. and Evers, V. 2009. Measuring the influence of social abilities on acceptance of an interface robot and a screen agent by elderly users. In *Proceedings of British Computer Society Conference on HCI*, 430-439.

[16] Helal, A. and Abdulrazak, B. 2006. TeCaRob: Tele-care using telepresence and robotic technology for assisting people with special needs. *International Journal of ARM* 7, 3, 46-53.

[17] Jouppi, N.P. 2002. First steps toward mutually-immersive mobile telepresence. In *Proceedings of CSCW*, ACM, New Orleans, LA, USA, 354-363. DOI=http://doi.acm.org/10.1145/587078.587128

[18] Kidd, C.D., Taggart, W. and Turkle, S. 2006. A sociable robot to encourage social interaction among the elderly. In *Proceedings of ICRA*, IEEE, 3972-3976.

[19] Melenhorst, A.S., Rogers, W.A. and Bouwhuis, D.G. 2006. Older adults' motivated choice for technological innovation: Evidence for benefit-driven selectivity. *Psychology and Aging* 21, 190-195.

[20] Michaud, F., Boissy, P., Labonte, D., Corriveau, H., Grant, A., Lauria, M., Cloutier, R., Roux, M.-A., Iannuzzi, D. and Royer, M.-P. 2007. Remote assistance in caregiving using telerobot. In *Proceedings of ICTA*.

[21] Morris, M., Lundell, J. and Dishman, E. 2004. Catalyzing social interaction with ubiquitous computing: A needs assessment of elders coping with cognitive decline. In *Proceedings of CHI*, Vienna, Austria, 1151-1154. DOI=http://doi.acm.org/10.1145/985921.986011

[22] Paulos, E. and Canny, J. 2001. Social tele-embodiment: Understanding presence. *Autonomous Robots* 11, 1, 87-95.

[23] Pollack, M.E., Brown, L., Colbry, D., Orosz, C., Peintner, B., Ramakrishnan, S., Engberg, S., Matthews, J.T., Dunbar-Jacob, J., McCarthy, C.E., Thrun, S., Montemerlo, M., Pineau, J. and Roy, N. 2002. Pearl: A mobile robotic assistant for the elderly *AAAI Workshop on automation as caregiver*.

[24] Rogers, W.A. and Mynatt, E.D. 2003. How can technology contribute to the quality of life of older adults? in *The technology of humanity: Can technology contribute to the quality of life?*, Mitchell, M.E. Ed. Illinois Institute of Technology, Chicago, IL, 22-30.

[25] Sharit, J., Czaja, S.J., Perdomo, D. and Lee, C.C. 2004. A cost-benefit analysis methodology for assessing product adoption by older user populations. *Applied Ergonomics* 35, 81-92.

[26] Taggart, W., Turkle, S. and Kidd, C.D. 2005. An interactive robot in a nursing home: Preliminary remarks *CogSci workshop: Towards social mechanisms of android science*.

[27] Tsai, T.-C., Hsu, Y.-L., Ma, A.-I., King, T. and Wu, C.-H. 2006. Developing a telepresence robot for interpersonal communication with the elderly in a home environment. *Telemedicine and e-Health* 13, 4, 407-424.

[28] Venolia, G., Tang, J., Cervantes, R., Bly, S., Robertson, G., Lee, B. and Inkpen, K. 2010. Embodied social proxy: Mediating interpersonal connection in hub-and-satellite tams. In *Proceedings of CHI*, ACM, Atlanta, GA, 1049-1058. DOI=http://doi.acm.org/10.1145/1753326.1753482