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“Commanding Your Robot” Older Adults’ Preferences for Methods of Robot Control

Jenay M. Beer¹, Akanksha Prakash¹, Cory-Ann Smarr¹, Tracy L. Mitzner¹, Charles C. Kemp², Wendy A. Rogers¹

¹School of Psychology, Georgia Institute of Technology, Atlanta, GA

²Department of Biomedical Engineering Georgia Institute of Technology, Atlanta, GA

Abstract

Home robots have the potential to assist older adults in maintaining their independence. However, robots deployed in older adults’ homes will be required to interact with untrained, novice users. The way untrained users, such as older adults, provide commands or control the robot (i.e., “method of robot control”) will likely impact the ease of use and adoption of the robot. The current study explored older adults’ preferences for controlling robots. Twelve independently-living older adults (ages 68–79) observed a functioning personal robot in a home setting, and were interviewed about their opinions regarding specific methods of robot control (i.e., laser pointer, physical manipulation, and devices). The older adults perceived advantages and disadvantages of these specific methods, including ‘specificity in command’, ‘accurate robot performance’, ‘limitations in their own physical capability’, and ‘challenges in using control device.’ The older adults also completed a questionnaire measuring their willingness to use 10 different types of methods of robot control. These data revealed that older adults were willing to use a variety of methods. Although older adults were limited in their spontaneous ideas about robot control (i.e., limited to voice command), once exposed to other options they were willing and open to a variety of control methods

INTRODUCTION

A current trend in robotics is the development of robots designed to be deployed in a home setting. Unlike other robots (e.g., military, space, healthcare), home robots will be expected to be usable by untrained users. “Method of robot control” refers to the way in which a human provides input commands to a robot. The appropriate application of a control method is dependent on the users’ capabilities, the task being performed, the environment in which the robot is operating in, as well as the robot’s capabilities. Because home robots have the potential to aid older adults to age-in-place (Lawton, 1990) and maintain independence, appropriate control methods for older adults must be understood to ensure home robots are easy to use and readily adopted.

Different methods of robot control may be appropriate for varying types of home robots and tasks. For instance, robots that are teleoperated may receive human input from interfaces such as one- and two-handed controllers, a computer mouse, or a keyboard (e.g., Takayama, Marder-Eppstein, Harris, & Beer, 2011). Conversely, semi-autonomous robots may receive

human input from shared control methods, such as demonstration (Billard, Calinon, Ruediger, & Schaal, 2008), direct physical interfaces/manipulation (Chen & Kemp, 2011), gesture recognition (Charles et al., 2009; Gielniak, & Thomaz, 2011), laser pointers (Nguyen, Jain, Anderson, & Kemp, 2008; Kemp et al., 2008), or voice command (Hyun, Gyeongho, & Youngjin, 2007). With so many control methods being developed, how should designers determine which to use?

One way to assess control preferences is to ask users.

Some studies have found that users prefer voice control (Kahn, 1998); in particular older adults hold this preference (Ezer, 2008). However, speech recognition software has limitations in understanding and interpreting language (e.g., Roy et al., 2000). Spoken language is often riddled with inconsistencies, incomplete sentence structures, and fillers such as “um” and “ah”. Furthermore, voice control may not be appropriate for all home tasks, such as providing a robot with specific navigation instructions, or teaching it a task requiring fine motor control. To date, older adults’ willingness to use control methods other than voice commands has not been thoroughly investigated.

A robot designed for the older adult population is only useful if older adults’ accept and adopt the technology into their home environment. Acceptance is an important variable to consider with regard to predicting technology use (Davis, 1989), and influencing the nature of the human-robot interaction (Broadbent, Stafford, & MacDonald, 2009; Young, Hawkins, Sharlin, & Igarashi, 2009). Furthermore, robot designers should be mindful of users’ acceptance, because radical technologies, such as home robots, are not as readily accepted as incremental innovations (Dewar & Dutton, 1996; Green, Gavin, & Aiman-Smith, 1995).

The widely supported Technology Acceptance Model (TAM; Davis, 1989) proposed two main variables that affect acceptance: perceived usefulness and perceived ease of use. Older adults are more likely to accept new technology, if they perceive it to be useful (Melenhorst, Rogers & Bouwhuis, 2006). Additionally, the method of controlling the robot will likely impact perceived ease of use. Users’ behavioral adoption of technology can be predicted by their attitudes and intentions (Fishbein & Ajzen, 1975). We conducted a needs assessment to explore older adults’ opinions on methods of robot control.

Goals of Current Research

Because technology adoption can be predicted by user’s attitudes (Fishbein & Ajzen), the goal of the current study was to investigate older adults’ preferences for methods of robot control. Unlike previous works, we did not ask participants to imagine a home robot (e.g., Ezer, Fisk, & Rogers, 2009).

Instead, the current study focused on potential methods for controlling home robots by older adults, who actually observed and interacted with a robot in a home environment.

Specifically, our research aimed to:

- Understand older adults’ preferences and perceived advantages/disadvantages of controlling a robot.

- Assess older adults' willingness to use control methods.
- Consider the implications of findings for older adults' adoption of methods of robot control.

We used a combination structured interview and questionnaire to provide a rich set of qualitative and quantitative data. Each participant interacted with a home-based robot. A mobile manipulator robot was used to represent a personal robot with a wide range of capabilities. Participants were interviewed about their opinions on three specific methods of robot control, and then completed a questionnaire assessing their willingness to use a larger variety of methods.

METHOD

Participants

We interviewed 12 independently living older adults, a large sample size for qualitative research (Maykut & Morehouse, 1994). The participants (6 female, 6 male; aged 68–79, $M=72.6$, $SD=3.9$) were recruited from the community. Participants were diverse with respect to race/ethnicity with half White/Caucasian and half Black/African American.

Participants also varied in their reported education level, with half reporting holding a bachelors degree or higher.

To assess participants' experience with robots, we administered a questionnaire measuring different aspects of robot familiarity as well as the frequency of using 13 different types of robots (e.g., surgical robots, manufacturing robots, entertainment/toy robots). Overall participants were somewhat familiar with, yet inexperienced using robots.

Materials and Apparatus

Demographics Questionnaire. Prior to the structured interview, demographic, health, and technology experience were collected using standardized questionnaires developed by the Center for Research and Education on Aging and Technology Enhancement (CREATE; Czaja et al., 2006).

Methods of Robot Control Questionnaire. After the structured interview, participants' willingness to use a variety of control methods was assessed via a questionnaire. They indicated their general preference for using 10 different methods of robot control using a scale ranging from 1 (not at all willing) to 5 (completely willing). The 10 control methods were chosen based on the current state of control techniques developed in the robotic community (see Agah, 2001).

Robotic Platform. The robot was the PR2 (Personal Robot 2) developed by Willow Garage, Inc which is a commercially available human-sized mobile manipulator currently used by a number of robotics researchers. This robot has an omni-directional wheeled base with two 8 DOF arms/grippers, a telescoping spine, and a pan-tilt head that carries two stereo camera pairs and a LED texture projector. The PR2 is capable of autonomously navigating around a typical home/office environment, and manipulating objects using its grippers.

Aware Home Research Facility. The interviews took place in the Aware Home Research Facility, which is a unique 3- story, 5040 square foot laboratory designed to simulate an authentic home environment (www.awarehome.gatech.edu/).

Procedure

The participants were interviewed individually in a private room in the Aware Home Facility. They first completed an informed consent form that described the general aspects of the study as well as their rights as a participant. Next they completed demographic, technology, and robot experience and attitude questionnaires.

After an introduction, the participants viewed the PR2 for the first time, and were asked about their initial preference for controlling this type of robot. Next, three robot demonstrations were shown, in which the robot delivered a medication bottle to the participant, turned off a light switch, and picked up and organized objects on a table (Figure 1). The robot autonomously performed these demonstrations, and no method of control was demonstrated to the participants to reduce bias. Participants were interviewed after each demonstration.

Following the three demonstrations, participants were again asked about their general preference for robot control. Then they were interviewed for their opinions on three specific types of robot control. These methods of control were chosen because they represent methods currently being used and developed (e.g., Chen & Kemp; 2011; Kemp et al., 2008; Nguyen, Jain, Anderson, & Kemp, 2008).

Laser pointer: command or control the robot by using a laser pointer to point to an object and the robot will fetch it.

Physical manipulation: command or control the robot by physically moving the robot's arms and grippers to show it what to do. It will respond to how a person moved it and will learn based on that movement.

Device: command or control the robot from a device; this could include a computer, remote control, joystick, handheld touch screen, or touch screen mounted on the robot.

RESULTS

We transcribed verbatim each of the twelve interviews. We identified themes based on patterns of responses to the structured interview questions. These themes were used to develop a well-defined coding scheme. This 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. For this paper, this coding scheme was applied only to data pertaining to methods of robot control.

Two researchers, a primary coder and a secondary coder, coded three transcripts using text analysis software MAXQDA10. The percent agreement between the primary and secondary coder was 96.7%. 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.

Interview Data

Preferences for Control. At two points in the interview script, participants were asked to indicate their preferred method of robot control (“how would you want the robot to know what to do?”). The interviewers provided no information to participants regarding what types of control were available for this robot. Instead, participants were encouraged to think of any method of control they would prefer. This question was asked at the beginning of the interview, after the participants viewed the robot stationary positioned in a room but prior to seeing the robot perform any of the demonstrations. The question was asked again after the participants had observed the robot complete the three home tasks.

The majority of participants (75%) indicated for the initial control question that they would prefer to give the robot verbal commands. A few participants mentioned other methods, such as a one-handed remote. After seeing the robot perform tasks, their responses stayed relatively the same, with most participants (83.3%) maintaining their preference for voice control. However, a third of the participants’ preferences either were expanded on or became conditional; for instance, one participant stated that she initially thought voice control was the best option, but after seeing the robot “I can’t imagine how I would tell which light to turn off, but . . .”. She also stated that a remote might be a better option for navigation. Some of the participants’ changes and modification in their preferred method of control suggests exposure to a robot may influence preferences for control as a function of task or context.

Participants were also asked about robot feedback after a command is given (“how would you like to know that the robot understood what to do?”). Half the participants indicated they would prefer visual feedback from the robot (e.g., a nod, blinking light). Surprisingly, a third of the participants mentioned no feedback is needed, where the robot’s behavior of “just doing the task” would be an indication that it understood the command.

Advantages / Disadvantages of Control. Most participants indicated that voice command was their preferred method of robot control. However as outlined earlier, voice control is a difficult method to implement, and may not be ideal for all tasks. Therefore, we prompted participants with three commonly researched non-voice control methods: laser pointer, physical manipulation, and devices. Participants were asked to discuss their perceptions of the advantages and disadvantages for each method of control. Tables 1 and 2 depict the categories of advantages and disadvantages that emerged from the data. Example quotes are also provided.

The participants’ perceived advantages and disadvantages were control method specific. For instance, five of the participants mentioned that a benefit of using a laser pointer is the specificity in the command they could give to the robot.

Additionally, participants perceived a laser pointer as a simple, preprogrammed method. Other comments included “If you couldn’t speak, then I think the laser would be a good way.” However, one disadvantage that was specific to the laser pointer was some older

adults' concern of shaky or unstable hands. Proximity to the device as well as proximity to the items the older adult might want to point at with the laser was also mentioned. One older adult mentioned that if the laser pointer was lost, "It'd be nice for the robot to be able to find it for you if you lost it." Finally, communication challenges were mentioned. For example, older adults expressed concern of whether the robot would be able to interpret their command, if they were simply pointing at an object (e.g., would the robot know to move it, fetch it, or use it in some way).

Physical manipulation was not positively regarded. In fact, a third of the participants indicated that they could see no advantage in the method, even as a teaching tool. The majority of the participants (68%) suggested that manipulating the robot's arms to show it what to do would be physically challenging for many older adults. Some older adults recognized that this might be a time-consuming method, and not worth the effort if they could do the task themselves. One participant stated "I can't see no advantages of doing that, because see if it's a robot, robots are supposed to be able to do the things that you want to do. But you gotta physically take and put your hands on it, that's kinda like defeating the purpose". The primary advantage the older adults identified for this method was the specificity of the command by showing the robot exactly how to do something.

When asked about devices, a third of older adults would specify one type of device (e.g., one-handed remote control) and simply state "I'd like that," without explanation as to why they might like it. Their lack of detail might suggest responses based on preexisting preference or experience with such devices, or they may have difficulty articulating the reasons for their preference. Nonetheless, the idea of controlling a robot using a device was not perceived to be without disadvantages. The primary disadvantage identified by many older adults (41.6%) was a human performance limitation based on potential difficulty using the devices, as well as errors or device malfunctions. One comment was, "that's my ignorance of not knowing how to use it [control device]. If someone taught me how to use it, then I'd be able to use it too."

Remotely Controlling Robot. Participants were asked what their initial reaction was to a person remotely located from their home controlling the robot. None of the participants had a positive reaction. Instead, the participants either had negative or mixed/conditional views. For example, one participant explained, "the degree of comfortableness or uncomfortableness with that is contingent on who did you give that information to [control the robot]?" If in a situation where remote control was necessary, some older adults indicated they would allow their children or healthcare professionals to do so.

Questionnaire Data

The Methods of Robot Control Questionnaire, administered after the interview, assessed older adults' openness to using a variety of robot control methods. As shown in Table 3, all 10 control methods yielded a mean of 3.0 (somewhat willing to use) or higher. This suggests that the older adults, in general, were open to the idea of using a wide range of methods to control a home robot.

DISCUSSION

The primary finding from this investigation is that older adults are open to using a variety of methods of robot control. There is a misperception that older adults are afraid or unwilling to use technologies, yet research suggests this is not the case (Olsen, O'Brien, Rogers, & Charness, 2010). Our data provide confirmatory evidence that although older adults may be initially limited in their imagined control methods (i.e., to ideas of voice control), after interacting with a robot and learning about a variety of control methods (via interview and questionnaire) they were relatively open to different methods.

The interview data revealed that older adults' perceptions of advantages and disadvantages were device specific. For instance, the laser pointer was viewed as an easy to use method with high specificity in command. However, physical manipulation yielded few advantages, and some participants viewed physical manipulation as "defeating the purpose" of having a robot. Finally, using devices to control the robot had mixed responses, with advantages/disadvantages depending heavily on individual preference for those devices.

A trend across all control methods was related to human performance limitations. Whether the limitation was physical (e.g., strength to move robot's arm), knowledge/skill based (e.g., knowing how to use a touch screen), or perceptual (e.g., seeing the object that the user intends to point laser beam onto), participants were concerned about their own limitations. We asked participants to consider their current living situation as well as "down the road." Older adults recognized that in the future they may have more difficulties, making certain control methods difficult to use. Hence, different control methods might be more feasible at different points in older adults' life. For example, physical manipulation may be more feasible for early older adulthood, rather than later older adulthood.

This study provides insights into older adults' preferences and willingness to control home based robots. However, it is important to note that our sample comprised healthy independently living older adults, and preferences may differ for older adults with lower functioning. Furthermore, the primary goal of this study was to investigate older adults' preferences and attitudes, which predict adoption (Fishbein & Ajzen, 1975). Future considerations should investigate behavioral adoption and usability of such methods, as attitudes will likely shift with experience. Nonetheless, overall older adults were open to the idea of controlling a home robot and potentially willing to use a variety of methods. The present data provide details about the nature of their concerns that must be considered during design and deployment.

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Figure 1.
PR2 autonomously completing three demonstrations: (a) medication bottle delivery, (b) turning off light switch, and (c) picking up and organizing objects.

Table 1**Advantages of Control Methods**

Advantage	Examples Quotes	Method
Easy / simple method	"I hadn't thought about that, but it's simple and it's effective and to point to something"	Laser Pointer
Minimal memory demands	"You don't have to remember anything"	Laser Pointer
Preprogrammed method	"Well, the advantages is that if the robot is - has the capabilities or is - is programmed to understand your movement of its arms on a particular thing to know exactly what to do."	Physical Manipulation
Person-specific preference	"So that's why I'm thinking - that's my experience with the touch tone screen and it's amazing to me how many things you can touch on there."	Device
Quick or fast method	"But, if you could just manipulate the arm and just set it right down on it that this is what you want it to do, you know, whatever it is, I think it might be quicker."	Physical Manipulation
Robot high performance level	"It's unlikely the robot would make a mistake with something that obvious."	Laser Pointer
Specificity in command	"Yes, if for example I wanted a cup of coffee, and I could program it to get the cup and how much I like in it and so forth."	Physical Manipulation

Table 2

Disadvantages of Control Methods

Disadvantage	Examples Quotes	Method
Communication challenge with robot	"Robots are supposed to be kinda human like so if you point to something, if you haven't told the person what you want them to do, pointing to it is not gonna help."	Laser Pointer
Human performance limitations	"Suppose I have not the strength to do it [physically move the robot]"	Physical Manipulation
Input control device malfunctions or fails	"Well, things could go around - go wrong, computers go down, you lose your pad, iPad."	Device
Person-specific preferences	"Some people like to work with computers, some people don't." "But, there may be people who don't want to touch a robot."	Device Physical Manipulation
Proximity limitation	"You'd have to be within a line of sight of the object you're going to pick up."	Laser Pointer
Other users	"You wouldn't want your grand children getting a hold of the laser."	Laser Pointer
Time consuming	"But it would be demanding on the person to go through all the different things during that learning process. I would think it would be quite a lengthy time period to do that."	Physical Manipulation

Table 3

Willingness to Use Methods of Robot Control

Method of Control	<i>M</i>	<i>SD</i>	Examples/Description
One handed remote control	4.67	0.65	Television or DVD remote
Handheld device with touch screen	4.58	0.67	Smart phones, touch screen tablets
Laser pointer	4.42	0.79	Handheld device with a laser emitting beam of visible light
Voice control	4.25	0.87	Spoken language
Home computer	4.00	1.28	Desktop or laptop
Body or hand gestures	3.83	0.84	Pointing or waving
Two-handed remote control	3.67	0.89	Remote similar to toy car or video game controllers
Physical manipulation	3.58	1.08	Physical touch to move the robot
Computer keyboard	3.50	1.17	Keyboard that contains letters, numbers, directional arrow keys
Joystick	3.25	1.42	Device consisting of a stick that pivots on a base
Joystick	3.25	1.42	Device consisting of a stick that pivots on a base

Note: 1=not at all willing, 2=slightly willing, 3=somewhat willing, 4=mostly willing, 5=completely willing.