Follow Me: Proxemics and Responsiveness Preferences of Elderly Users in a Person-Following Robot

Shanee Honig*, Tal Oron-Gilad & Yael Edan
Human Factors Laboratory
Dept. of Industrial Engineering and Management
Ben-Gurion University of the Negev, Israel
*Corresponding Author: shaneeh@post.bgu.ac.il

agricultural biological & cognitive robotics

Introduction

Aging populations in many countries have significantly enhanced interest in developing service robots that help older adults maintain their independence [1]. However, beyond the considerable technical challenges of service robots, lie significant socio-psychological barriers. To ensure the acceptance of such robotic assistants, it is first necessary to understand the unique perspectives, preferences and limitations of older adult users and incorporate them into the interaction design. Person-following is an important aspect in assistive robotic applications since it can facilitate many daily tasks (e.g., carrying groceries, physical monitoring), yet, preferences of older users toward robot proxemics and responsiveness in such situations remain unknown.

Preliminary research [2] has shown that a robot's following distance affects walking efficiency (e.g., unwanted stops), user comfort and robot likeability. Moreover, it was found that perceptions and preferences regarding the relations between personal space and responsiveness vary in different situations. In the current study, we assess whether similar findings hold true for older adult users.

Objective

To examine older adult users' sensitivity to robot following distance (in terms of intrusiveness, quality of walk, and engagement) in a person-following scenario, and assess whether these preferences change when cognitive load is added. It was hypothesized that participants will walk more naturally as the following distance grew (i.e., social space as termed by Hall) and will feel most comfortable when performing a task while interacting with the robot.

Method

Participants: 24 participants (11 Female, 13 Male), ages 65-85.

Environment: Open space hall of a high tech - research facility.

Design: Each participant completed four trials in which they walked on a predetermined indoor path while a Pioneer LX robot followed them using the algorithm described in [3]. Three of the trials differed in the combination of robot's following distance and acceleration values (0.8m, 0.5m/s; 1.2m, 0.8m/s; 1.7m, 0.9m/s). During the fourth trial, participants were asked to perform a secondary visual search task to evaluate whether cognitive workload has an effect on their human-robot engagement level and overall experience.

Figure 1. Experimental robot setup based on the Pioneer LX Robot

Procedure

Participants filled informed consent forms and pre-test questionnaires. The Technology Adoption Propensity (TAP) index [4] was used to assess experience and attitudes towards technology. The robot was introduced to the participants as their live-in personal assistant. evaluate explicit distance preferences, participants were first shown the three following distances statically and asked which they think they would prefer. Then, they completed a 25-meter predetermined indoor path under each of the four experimental conditions. Questionnaires were administered after each trial and at the end of the experiment to evaluate subjective experiences. Questionnaires used 5-point Likert scale (1-"Strongly disagree", 5-"Strongly agree"). Engagement was evaluated during each trial by counting the times a participant looked back at the robot or referenced it verbally.

Figure 2: The visual search task; count the red squares posted alongside the walking path

Figure 3: An older participant being followed by the robot

Results

Preferred Distance and Acceleration: *Static*: 0.8m (11/24); *While walking:* No Preference (10/24) possibly due to larger-than-planned actual following distances (mean=2.17m, SD=0.46). These larger distances were the results of two factors: 1) participants tended to walk faster than expected (41.3 m/min); 2) robot acceleration was limited by the characteristics of the environment (in higher acceleration rates the robot tended to slip) causing the robot not to be able to obtain the necessary speeds required to maintain its targeted following distances.

Secondary Task: Older participants (above median age of 70) and participants with higher technological aptitude had more difficulty completing the visual search task (task failure rates: Younger: 15%, Older: 55%, Low Aptitude: 18%, High aptitude: 46%). Moreover, users with more engagement encounters (looked back more) had higher task failure rates (45% vs. 23%).

Robot Likeability: Younger participants and those with lower technological aptitude rated the robot as friendlier (Younger: mean=3.85, SD=1.18, Older: mean=3.45, SD=1.17, p=0.05; Low aptitude: mean=3.82, SD=1.04, High Aptitude: mean=3.54, SD=1.29, p=0.04). Participants with lower technological aptitude also rated the robot as less disruptive (p=0.04) and scary (p=0.04). Younger participants perceived the robot as safer (p=0.00).

Engagement with Robot: Women engaged with the robot 2.2 times more frequently than men, younger participants engaged 5 times more than older participants, technologically oriented participants engaged 2 times more than those with lower aptitude.

Question	Technology Group		Age Group	
Robot was considerate of my personal space	**T1**: 4.1 (1.2);	**T2**: 4.1 (1.3)	**A1**: 4.6 (0.8)	**A2** 3.5 (1.4)
Robot's behavior was a result of my behavior	**T1**: 3.8 (1.3);	**T2**: 4.2 (1.1)	**A1**: 4.5 (0.8)	**A2** 3.5 (1.4)
I was satisfied with the robot's following	**T1**: 4.0 (1.3);	**T2**: 4.1 (1.2)	**A1**: 4.4 (0.9)	**A2** 3.6 (1.3)
Task required my concentration	**T1**: 2.1 (1.5);	**T2**: 2.9 (1.5)	**A1**: 2.6 (1.6)	**A2** 2.4 (1.4)
Task prevented me from walking naturally	**T1**: 1.4 (0.7);	**T2**: 2.5 (1.4)	**A1**: 1.9 (1.3)	**A2** 2.0 (1.2)
Robot was Friendly	**T1**: 3.8 (1.0);	**T2**: 3.5 (1.3)	**A1**: 3.9 (1.2)	**A2** 3.5 (1.2)
Robot was Disruptive	**T1**: 1.6 (0.9);	**T2**: 1.9 (1.2)	**A1**: 1.7 (1.0)	**A2** 1.9 (1.1)
Robot was Considerate	**T1**: 3.8 (1.0);	**T2**: 3.9 (1.2)	**A1**: 4.3 (0.6)	**A2** 3.3 (1.3)
Robot was Noisy	**T1**: 1.9 (0.7);	**T2**: 2.5 (1.2)	**A1**: 2.6 (0.9)	**A2** 1.7 (0.9)

Figure 4: The influence of technological group and age group on participant perceptions. Values indicate mean and SD. Yellow indicates p-value < 0.05, orange indicates p-value < 0.1. Age groups were defined using the median (70 years): the first group (A1) included 10 participants ages 65-70, the second group (A2) included 14 participants 71-85. Technology groups were identified using the TAP index: the first group (T1) included 11 participants who consistently showed low technological propensity, the second group (T2) included 13 participants who consistently showed high technological propensity.

Discussion and Conclusions

- The explicit preference of the closest following distance (0.8m) while standing, the implicit indifference to the following distances and acceleration values while walking and general positive attitudes indicate upon high levels of trust and acceptance among older adult users towards the robot.
- There is high variance in proxemic preferences and robot perceptions of older adult users from different age groups and with different technological propensities. Robotic behavior may need to be adjusted to target the preferences of these specialized demographics.
- Participants who succeeded in the secondary task engaged less with the robot and perceived the robot's behavior differently than the rest. This indicates that user tasks and needs must be taken into account in the design of robotic spatial behavior.
- **Limitations**: environmental conditions restricted the robot's ability to maintain the targeted following distances; the visual search task was not personally relevant to participants, likely affecting perceived engagement; robot acceptance may have been high due to sampling bias.

Acknowledgements

This research was supported by the Israeli Ministry of Science, Technology & Space, Grant # 47897, "Follow me", the Helmsley Charitable Trust through the Agricultural, Biological and Cognitive Robotics Center and by the Rabbi W. Gunther Plaut Chair in Manufacturing Engineering, both at Ben-Gurion University of the Negev.

References

[1] J. M. Beer & L. Takayama, "Mobile remote presence systems for older adults," in Proc. of the 6th Int. Conference on Human-robot interaction - HRI '11, 2011, p. 19.
[2] T. Oron-Gilad, Edan, Y. & V. Fleishman. "Follow me": proxemics and robot movement considerations in a person following setup (in preparation).
[3] G. Doisy, A. Jevtić, E. Lucet, & Y. Edan, "Adaptive person-following algorithm based on depth images and mapping," IROS 2012 Work. Robot Motion Plan., pp. 43–48, 2012.
[4] M. Ratchford & M. Barnhart, "Development & validation of the technology adoption propensity (TAP) index," J. Bus. Res., vol. 65, no. 8, pp. 1209–1215, 2012.