ASSETS: U: Using Telepresence Robot to Improve Self-Efficacy of People with Developmental Disabilities

Natalie Friedman
Cornell Tech
2 W Loop Rd,
New York, NY 10044
nvf4@cornell.edu

ABSTRACT

People with Developmental Disabilities (DD) often rely on other people to perform basic activities such as leaving the house and accessing public spaces. This problem, exaggerated by a decrease in community engagement, has been documented to decrease their sense of self-efficacy. Telepresence robots provide a unique opportunity for people with DD to access public spaces, particularly for those who are homebound or dependent on others for using transportation or buying exhibit tickets. This research evaluates the use of telepresence robots operated by people with DD in exploring a public exhibit. This study was in partnership with Hope Services, an organization that provides skill-improving activities for people with DD. Our analysis consisted of quantitative and qualitative methods using data from semi-structured pre- and post-interviews focusing on participants' sense of physical and social self-efficacy, and well-being. Our study revealed positive trends toward showing that using telepresence can contribute to wellbeing and physical and social self-efficacy. Therefore, we believe that there is some promise for using telepresence robots to tour an exploratory space for people with DD and that it can be a viable option for those who face accessibility limitations.

Keywords

Developmental disability, accessibility, mobility, physical self-efficacy, social self-efficacy, telepresence, social-connectedness

MOTIVATION

People with Developmental Disabilities (DD) often rely on other people to perform basic activities such as buying bus and admission tickets to access public spaces. This problem, exaggerated by a decrease in community engagement, has been documented to decrease their sense of self-efficacy.

Low-Mobility Populations

Assistive technology has improved the physical rehabilitation of those with mobility impairments [1]. There has also been work with fully immersive 3D environments for people to improve their finger flexibility using a Glove, Kinect and Oculus Rift [13]. However, there has been little work to improve self-efficacy, wellbeing and accessibility together through telepresence robots. Those who have low mobility often lose access to social interactions and a sense of physical self-efficacy. Specifically, it can be difficult to manage social interactions in the context of pain and fatigue [18]. The current study focuses on those with limited accessibility because we want to give the participants a higher sense of physical self-efficacy, which we will promote through assistive technology.

Researchers have used telepresence in a conference setting and have collected feedback from those with accessibility challenges. Some participants felt "empowered" and explained that telepresence alleviated mobility issues that they faced while attending the conference in person [14]. For us, this implies that using telepresence could alleviate some mobility difficulties the participants would face in a public space without a telepresence robot.

Accessibility and Well-being

Motor-impaired users have been empowered by using assistive mobile manipulators in order to perform tasks [6]. Loss of mobility has a negative impact on many aspects of life (e.g., physical activity, healthcare, social activities), which can lead to impacts on health and well-being [5]. Mobility loss can cause difficulty in leaving the home to go on outings and socializing with friends. When individuals with mobility impairments realize these challenges, they can experience a loss of both self-efficacy and social-connectedness [8], which can lead to lower life satisfaction [17]. Studies have also shown that social participation contributes to happiness [11] and self-efficacy can provide the foundation for well-being [3][22]. Overall, an increase in social-connectedness and a sense of physical self-efficacy will likely improve the wellness of someone with accessibility limitations. The current study aims at a similar goal through different means: empowering users through performing movements.

Telepresence

Telepresence robots (Figure 1) provide a unique opportunity for people with DD to access public spaces, particularly for those who are homebound or dependent on others for example, using transportation, or buying exhibit tickets.

When we speak about telepresence, we use terminology to describe the operators and the people surrounding the robot. The remote operator (Figure 2) can be defined as a user who is not physically at the location of the robot but instead, controlling the robot. The local operator is at the physical location of the robot and can interact with the robot. Robotic telepresence systems offer the unique chance to participate in and to directly contribute to physically situated tasks [18]. Takayama & Go (2012) observe a telepresence robot becoming "invisible-in-use," as if the remote and local participants feel as though they are "face-to-face." [21] In this current study, we hope that participants will socially and physically participate in the physically situated task.

Figure 1. The Beam+ interface for the remote operators

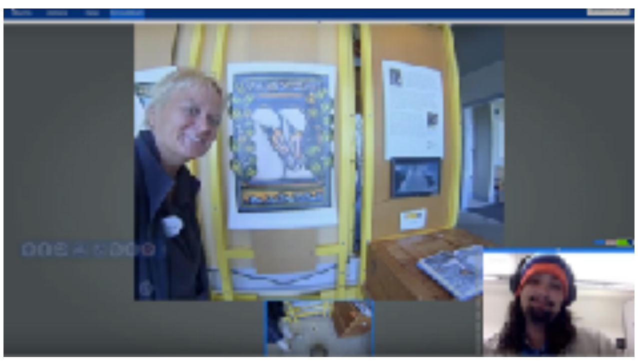

Figure 2. The back of Beam+ at the Meet the Scientists exhibit

RELATED WORK

Self-efficacy

A higher well being and self-efficacy is especially important for people with populations with low mobility because of their limited access to public spaces and struggle with independence. Bandura [3] defines self-efficacy as "a belief in one's competence to produce desirable outcomes through one's own efforts." A healthy overall well-being can be developed and maintained through self-efficacy according to the World Health Organization (1998) [22]. There are several ways to achieve self-efficacy. One source of self-efficacy include mastery experiences [2]. Mastery experiences or "enactive attainment" can be defined as learning through experiencing and mastering it. The current study can be an example of a mastery experience. One of the aims of this study is to achieve well-being through increasing social and physical self-efficacy.

Social Self - Efficacy

Social self-efficacy refers to an individual's belief in their capability to initiate and develop of social contact [9]. According to the disengagement theory, mentioned above, older adults tend to withdraw from society. Because of this, there is a potentially lowered social self efficacy among older adults. Initiation is a primary component of achieving self-efficacy, and telepresence has proven to enable initiation. One participant using telepresence in a conference space explained, "I'm able to meet new people" [14] which demonstrates one application of initiation through telepresence.

We hope that with telepresence, we can provide access to participation in society as well as social relationships. Grounding is defined as "the process of creating common ground to achieve mutual understanding." Grounding has been accomplished through a mediated presence (Baker et al., 1999). If we can achieve grounding between a tour guide and a visitor through telepresence, then this could raise social self-efficacy.

Physical Self - Efficacy

Physical self-efficacy refers to feelings about one's own physical capabilities [10]. Gill demonstrated that a higher physical performance leads to higher physical self-efficacy. In our current study, we hope that ease of use increases after practice, contributing to physical self-efficacy.

Scherer interviews people with mobility impairments and finds that mobile independence is an important value. She quotes a person with a mobility impairment: "I can't tell you how much my van has helped me see the light in so many ways. Before, I had the motorcycle - and I drove that every day. I had that independence, and all of a sudden it got struck down. Here I was stuck. I'm fortunate I had the power wheelchair to get me out when I needed to get out. Now that's just expanded with the van." [19] It is possible to draw from this that those with mobility impairments could benefit from telepresence as another means to navigate and move around.

Mobility and Telepresence

Researchers Stuck et al. (2017) have found opportunity in telepresence technologies for the purposes of lessening accessibility barriers for aging adults with mobility limitations [20]. These researchers conducted a study on attitudes of the mobility impaired towards telepresence that found that perceived benefits included visualization, more immersive interaction and improved ease of use. As for concerns, the participants expressed worry about damage or harm to either themselves or to the environment, physical obstacles and effort in using the technology [20].

In Rae, Mutlu, and Takayama's research, mobility in telepresence provides a sense of "being there" in high mobility tasks [18]. In a study done using Beam+ in a conference setting, a participant explained, "I have the feeling I'm there" [14]. In the current study, we hope that giving a sense of mobility to the remote operators will give them a sense of 'being there' as well.

We also hope that remote operators gain a sense of social-connectedness with the locals. Researchers have found that local users expressed a higher similarity with remote users when interacting with each other via a moving telepresence robot than via a stationary robot. Their results also supported the idea that movement has more meaning when it uses the body partner's orientation [7]. Body orientation is one of the very subtle cues that can be difficult for a robot to learn and is an example of something that is intuitive for humans, which is why telepresence has the potential to achieve an appropriate body orientation.

STUDY DESIGN

To investigate these effects, we examined both the difference in social and physical self-efficacy as well as wellbeing before and after people with DD used a Beam+ telepresence robot. Participants remotely operated a Beam+ to interact with the locals and view exhibits at the Seymour Marine Discovery Center, a local community-supported marine science education center

Participants

Six participants were recruited from Hope Services, a local organization that provides skill-improving activities for people with DD. Participants had the following disabilities: Autism, Klinefelter Syndrome, Mild Cognitive Disability, Unspecified Organic Brain Syndrome, Mild to Moderate Intellectual Disability, Inverted X Syndrome, Obsessive Compulsive Disorder, and Dandy Walker with Epilepsy.

Demographics

Participants were age 23-43, primarily male (83%), and primarily white (50%; 17% Hispanic/Latino; 33% Undisclosed). Participants had lower mobility (50%; medium 17%; high 33%) and mixed prior technology use (50% prior FPS video game use).

Measures

Measures used included: NASA TLX (flow) [12], WHO Disability Assessment Schedule 2.0 (mobility) [22], Nowak & Biocca's scale (presence) [15], and Peto et al.'s scale (self- efficacy)[16].

Some questions were modified slightly to facilitate participant understanding, and underwent face validation from expert consultation with psychologists and disability specialists.

• "Did you feel rushed?" Measuring flow, adapted from NASA TLX scale [12]

• "Is it stressful for you to move around a crowded space?" Measuring physical self-efficacy, adapted from Peto et. al. [16]

Procedure

First, the researcher explained the consent process and provided a tutorial on how to operate the Beam+ followed by practice with an in-house Beam+. Participants were verbally given a pre- interview that measured demographics, wellbeing, and physical & social self-efficacy. The tour consisted of two exhibits led by a docent: an Albatross art exhibit exhibit and Meet the Scientists exhibit. After the tour, participants were given a semi-structured post- interview that measured their current physical and social self-efficacy, wellbeing, flow and presence.

RESULTS

We have produced a central hypothesis that operating a telepresence robot in an exploratory space will achieve a heightened well-being. We found positive trends for wellbeing and physical and social self- efficacy. Wellbeing was measured using the question, "Tell me 3 words that tell me how you feel right now" before and after interacting with the Beam+. All individual words used are in the word clouds in Figure 3, scaled by frequency.

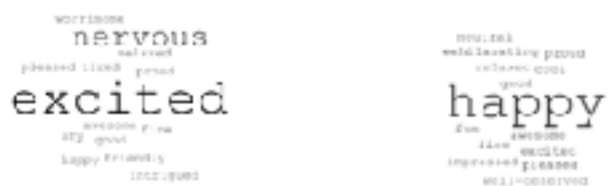

Figure 3. Pre- and post-interview wellbeing responses.

Participants were high in anticipation (i.e., "excited" and "nervous") before using the telepresence robot, but shifted

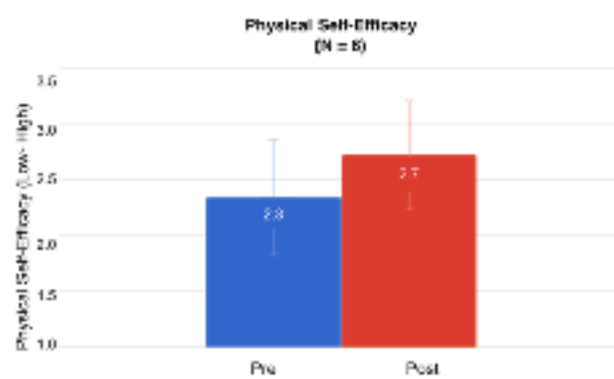

Figure 4. Physical Self-Efficacy measured pre and post intervention

to be more uniformly "happy" afterwards. A sentiment analysis of the aggregated valence scores indicate a positive trend in wellbeing between the pre- ($M=.7$, $SD=.09$) and post-tour ($M= .76$, $SD=.05$) for this particular question; $t(5) = 2.45$, $p <.10$.

We conducted paired-sample t-tests (two-tailed) comparing the pre- and post-measures of self-efficacy (Figures 4 and 5). We found a positive trend in physical self-efficacy between the pre- ($M=2.3$, $SD=.5$) and post-tour ($M=2.7$, $SD=.4$) interviews; $t(6) = 2.23$, $p <.10$ and a positive trend

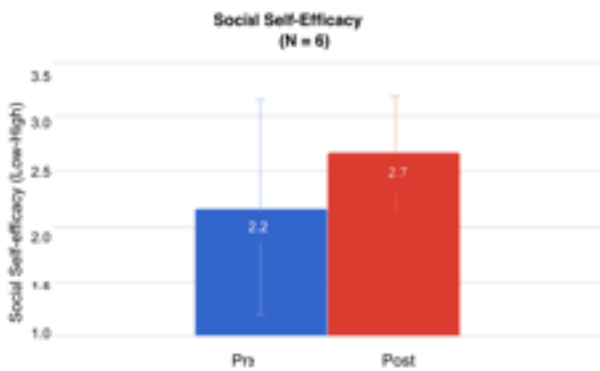

Figure 5. Social Self-Efficacy measured pre and post intervention

in social self- efficacy between the pre-tour (M=2.2, SD=.98) and post-tour (M=2.67, SD=.52) interviews; t(6) = -2.24, p < . 10.

However, because we only have six participants, we should view these results as trends rather than statistically significant. Qualitative findings support these trends. During the study, one participant mentioned, “I could do it every day. I liked moving around the whole room,” which could indicate physical self-efficacy.

UNIQUENESS OF THE APPROACH

Telepresence Robots as the Perfect Tool

Telepresence is a surprisingly effective tool for people with developmental disabilities because of its physical (wheels) and social (camera and display) capacities. For people with developmental disabilities, telepresence can operate as a special encouragement for them to be social and to move, thereby giving the opportunity to increase physical and social self-efficacy. This is valuable for people with developmental disabilities because their cognitive ability often limits their ability to go into public, and consequently, to be social.

Site Selection

We chose the Seymour Marine Discovery Center as a site because it affords a type of communal and social activity that otherwise is normally difficult for low-mobility populations to engage in. Additionally, this is a challenging site for this population to exercise mobile independence. Moreover, because this population’s low mobility is caused by developmental disabilities, the difficulty of driving or taking public transit to the site, and buying admission tickets would make independently accessing the site too challenging. Contributions

This study set out to understand how use of a telepresence robot in an exploratory space would affect wellbeing and self-efficacy for individuals with DD. By studying people without independent transport, we aim to benefit and provide a basis of research for a wider population who can’t drive independently. We found evidence for a positive affect on wellbeing as well as social and physical self-efficacy, showing telepresence could be an effective accessibility tool.

Longer interactions could be beneficial to establish closeness between the remote and local operator. We have also showed that public spaces may be a viable option to put telepresence robots into. This not only presents an opportunity for spontaneous interaction with new people, but also it provides an opportunity to safely get to a public space. The community support facilitator at Hope Services found that the complex nature of some of the material at the Seymour Center made the interaction more confusing. Thus, something to consider when placing the telepresence robots in public spaces, is to be certain that the surroundings are visually compelling through the eyes of the remote operator population. The facilitator explained that seeing the (in house) physical robot move around made the whole idea of operating a robot easier to conceptualize. This may have decreased anxiety about operating a robot. When an operator with developmental disabilities uses telepresence, he or she should see the robot move around in the remote space, physically next to the operator.

ACKNOWLEDGMENTS

I would like to thank Dr. Leila Takayama for her consistent encouragement and support of my work for this project and in the past 2 years. I would also like to thank Dr. Sri Kurniawan for her helpful advice and mentorship though my college career. Thank you to Kat Hsaio, Alison Scott, Rosa Lutz, Bali Southam, and Chad Tubbs for helping me plan this project and run the studies. Thank you to the Seymour Marine Discovery Center for collaborating with the Re-Embodied Cognition Lab. Thank you to Hope Services for participating in the tours.

REFERENCES

1. Sonia Arteaga, Jessica Chevalier, Andrew Coile, Andrew William Hill, Serdar Sali, Sangheeta Sudhakhrisnan, and Sri H. Kurniawan. 2008. Low-cost accelerometry-based posture monitoring system for stroke survivors. In Proceedings of the 10th international ACM SIGACCESS conference on Computers and accessibility (Assets '08). ACM, New York, NY, USA, 243-244. DOI: https://doi.org/10.1145/1414471.1414519

2. Albert Bandura. 1994. Self-Efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of Human Behavior*, (pp. 71-81). New York: Academic Press.

3. Albert Bandura. 1977. Self-e cacy: toward a unifying theory of behavioral change. *Psychological review,* 84, 2 (1977), 191.

4. Michael Baker, Tia Hansen, Richard Joiner, and David Traum. 1999. The role of grounding in collaborative learning tasks. *Collaborative*

learning: Cognitive and computational approaches 31 (1999), 63.

5. Jenay M. Beer and Leila Takayama. 2011. Mobile remote presence systems for older adults: acceptance, benefits, and concerns. In Proceedings of the 6th international conference on Human-robot interaction (HRI '11). ACM, New York, NY, USA, 19-26. DOI: https://doi.org/10.1145/1957656.1957665

6. Tiffany L. Chen,. , Matei Ciocarlie, Steve Cousins, Phillip Grice, Kaijen Hsiao, Kelsey Hawkins, Charles C. Kemp, King, Chih-Hung, Daniel A Lazewatsky, Adam E Leeper, Hai Nguyen, Andreas Paepcke, Caroline Pantofaru, William D. Smart & Takayama, L. 2013. Robots for humanity: A case study in assistive mobile manipulation. In IEEE Robotics and Automation Magazine, 20 (1), 30-39.

7. Mina Choi, Rachel Kornfield, Leila Takayama, and Bilge Mutlu. 2017. Movement Matters: Effects of Motion and Mimicry on Perception of Similarity and Closeness in Robot-Mediated Communication. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17). ACM, New York, NY, USA, 325-335. DOI: https://doi.org/10.1145/3025453.3025734

8. Fiona M. Collen, Derick T. Wade, Carole M. Bradshaw. 1990. Mobility after stroke: Reliability of measures of impairment and disability. International Disability Studies, 12(1), 6-9.

9. Viktor Gecas. 1989. The social psychology of self-efficacy. Annual Review of Sociology, 15, 291-316.

10. Gill, 2007. The influence of controllability on college women's efficacy and attributions in physical activity. Baton Rouge, LA: ProQuest Information & Learning.

11. Hsu & Chang, 2015. Social connections and happiness among the elder population of Taiwan. Aging and Mental Health, 19(12).

12. Sandra Hart. 2006. Nasa-task load index (NASA-TLX); 20 years later. PsycEXTRA Dataset (2006). DOI:http://dx.doi.org/10.1037/e577632012-009

13. Conor Kaminer, Kevin LeBras, Jordan McCall, Tan Phan, Paul Naud, Mircea Teodorescu, and Sri Kurniawan. 2014. An immersive physical therapy game for stroke survivors. In *Proceedings of the 16th international ACM SIGACCESS conference on Computers & accessibility*. ACM, 299–300.

14. Carman Neustaedter, Gina Venolia, Jason Procyk, and Daniel Hawkins. 2016. To Beam or not to Beam: A study of remote telepresence attendance at an academic conference. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*. ACM, 418–431.

15. Nowak, & Biocca. 2003. The effect of the agency and anthropomorphism on users' sense of telepresence, copresence, and social presence in virtual environments. Presence, 12(5), 481 - 494.

16. V Peto, C Jenkinson, R Fitzpatrick, and R Greenhall. 1995. The development and validation of a short measure of functioning and well being for individuals with Parkinson's disease. Quality of life research 4, 3 (1995), 241–248.

17. Monuir G. Ragheb & Charles A. Griffith. 1982. The contribution of leisure participation and leisure satisfaction to life satisfaction of older persons. Journal of Leisure Research, 14(4), 295-306.

18. Irene Rae, Bilge Mutlu, and Leila Takayama. 2014. Bodies in motion: mobility, presence, and task awareness in telepresence. In Proceedings of the 32nd annual ACM conference on Human factors in computing systems. ACM, 2153–2162.

19. Marcia Scherer. 2016. Living in the state of stuck. Brookline Books. Schroeder, R. (2002).

20. Rachel E Stuck, Jordan Q Hartley, Tracy L Mitzner, Jenay M Beer, and Wendy A Rogers. 2017. Understanding attitudes of adults aging with mobility impairments toward telepresence robots. In Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction. ACM, 293–294.

21. Leila Takayama, & Janet Go, 2012. Mixing metaphors in mobile remote presence. In Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work (CSCW '12). ACM, New York, NY, USA, 495-504. DOI: https://doi.org/10.1145/2145204.2145281

22. World Health Organization. 2017. World Health Organization Disability Assessment Schedule 2.0. The SAGE Encyclopedia of Abnormal and Clinical Psychology. DOI:http://dx.doi.org/10.4135/9781483365817.n1493