Improving Teleoperation Interfaces to Support Therapists in Robot-Assisted Therapy

Saad Elbeleidy
selbeleidy@mines.edu
MIRRORLab, Colorado School of Mines
Golden, Colorado, USA

ABSTRACT

Socially assistive robots (SARs) receive significant research attention due to their positive impact across many contexts. For example, studies have shown that autistic children are receptive to SARs in therapy, and achieve similar learning outcomes compared to human-delivered therapy. Given the sensitive nature of therapy and the current state of autonomous robots, however, SARs are in practice teleoperated by a therapist who controls their motion and dialogue. This presents an opportunity to produce more effective SAR teleoperation interfaces in the context of therapy for autistic children. In this paper, I outline research for improving teleoperation interfaces of SARs through (1) analyzing current teleoperation usage, (2) interviewing teleoperators about their needs, and (3) implementing and evaluating varied designs for teleoperation interfaces.

ACM Reference Format:
Saad Elbeleidy. 2022. Improving Teleoperation Interfaces to Support Therapists in Robot-Assisted Therapy. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts (CHI '22 Extended Abstracts), April 29-May 5, 2022, New Orleans, LA, USA.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3491101.3503804

1 INTRODUCTION

Research on Socially Assistive Robots (SARs) for use with autistic children[1] is on the rise. Research has shown that using robots to deliver interventions to autistic children produces measurable improvements in children's engagement[9, 18], spontaneous verbalization [5, 6, 12, 14, 20], and prosocial behaviors [4, 8, 23, 24] across both short and long-term studies [19]. Importantly, SARs result in similar learning outcomes when compared to therapy delivered by humans [22] but children are more receptive to SARs [9, 18]. Children's receptiveness is especially valuable given the importance of child engagement in therapy [1].

Most studies examining the effectiveness of SARs in therapy with autistic children take place in a laboratory context since robots have yet to be widely deployed in clinics. There is an opportunity for wide deployment of robots to support a larger audience of autistic children but cost is generally a barrier since these robots are fairly costly. However, low-cost alternative robotic hardware solutions have been developed (e.g. Romibo [21]), which use a touchscreen device such as a smartphone for the robot's face while the robot's body is similar to a fuzzy doll. While these solutions facilitate hardware accessibility, they do not address the software barriers that would need to be addressed for these robots to be effectively automated or teleoperated.

While SAR autonomy is a heavily researched topic [7, 11, 20], with various approaches taken to create effective autonomous robots, in practice, therapists are teleoperating robots [2, 15]. In our recent unpublished work, we have identified that SAR researchers have mostly focused on autonomous robots despite recommendations from Level of Autonomy guidelines that would suggest erring on the side of *less* autonomy in most SAR domains. Additionally, while autonomous robots are still a developing technology, robot teleoperation is a more immediate solution that allows the therapy industry to adopt robots as tools for therapeutic intervention delivery. Teleoperation could also provide valuable data to inform the development of autonomous robots, if that path is chosen in the future. However, robot teleoperation is also an effective long-term mechanism of delivering therapy. Given the sensitive nature of therapy, it would be valuable to continue having a human in-the-loop. Additionally, as autistic children develop and improve their skills, the presence of a therapist can be valuable in verifying that these skills transfer to human-human interactions.

2 RESEARCH QUESTIONS

To address the opportunity to widely deploy teleoperated SARs in therapy for autistic children, I present the following research question as the high-level scope I aim to explore:

RQ How can we design effective teleoperation interfaces for robot-assisted therapy for children with autism?

To answer this high level research question, I plan to specifically focus on the following relevant components:

Q1 How are current teleoperation systems being used in robot-assisted therapy for autistic children?
Q2 What are therapists' needs in conducting therapy for autistic children, specifically in teleoperating robots?
Q3 What interface capabilities can meet therapists' needs in operating a robot in therapy for autistic children?

These questions aim to help us understand the current state of robot usage and deployment, the needs of therapists in conducting therapy, and the way in which different interface designs meet these needs. Answering these questions will move us towards designing effective teleoperation interfaces for robot-assisted therapy for autistic children.

[1]Throughout this paper I will use identity first language as preferred by autistic self-advocates [3, 16].

CHI '22 Extended Abstracts, April 29-May 5, 2022, New Orleans, LA, USA

ACM ISBN 978-1-4503-9156-6/22/04.
https://doi.org/10.1145/3491101.3503804

Figure 1: The Peerbots interface used for teleoperating robots during sessions. The interface allows therapists to author content, organize content in collections called "palettes", connect to a robot, and control the robot's verbalization and motion. ©Peerbots

3 RESEARCH METHODOLOGY

In the remainder of this paper, I present my progress so far in answering each of these questions and my plan for ongoing work. This research includes archival data analysis, qualitative analysis of semi-structured interviews, and experimental evaluation of interface design improvements.

3.1 Therapist Usage

In order to find a population that works with robots in therapy in practice (i.e. outside of a research context) we have partnered with Fine Art Miracles (FAM) [13]. FAM is a service nonprofit that uses experiential therapeutic modalities to assist children and the elderly who are experiencing challenges. FAM runs 8-week programs for children with special needs at their schools to assist them with a variety of different skills. Therapists at FAM use the Peerbots[17] open source software to teleoperate robots in these weekly sessions. An example of the interface is shown in Figure 1. We acquired usage logs from two 8-week sessions run by a therapist including the content authored by therapists and verbalized by the robots. From there, we identified key content themes and usage patterns that led to design recommendations for improving robot teleoperation in the context of therapy [10].

We found that the utterances verbalized by FAM's robots typically reflected one of five key intents: (1) rapport-building, (2) lesson content, (3) feedback, (4) attention management, or (5) ignorance. From these themes we identified key patterns about the therapist's usage that informed our design recommendations. While authoring, therapists author content in a sequential pattern where content is expected to be verbalized in the authoring order. Therapists also place dialogue options (buttons) with the same intent throughout a given collection, presumably for when that intent is reasonable in relation to surrounding options. For example, a feedback option verbalizing "good job" and another verbalizing "great" may appear several times within a collection, usually after questions. Another example is when the robot is greeting a child; multiple dialogue options are authored in order for the robot to say each child's name. Therapists also author collections specifically for a given session which we mostly determined from the collection names. During a session, therapists follow a sequential structure in relation to these themes; they may start with lesson content, then provide feedback when applicable and end a session with rapport-building. The bulk of any given session is lesson content.

From these usage patterns we provided some preliminary design recommendations to improve teleoperation interfaces for therapy with autistic children. Given the identified themes and their sequencing, we recommend that authoring and teleoperation interfaces provide custom capabilities focused on the needs identified for each content theme. Due to the prevalence of duplicate intents of dialogue options and the inclusion of ignorance responses, we recommend the ability for interfaces to handle dynamic content that incorporates information discovered during a session. Finally, by looking at the sheer number of options within each collection

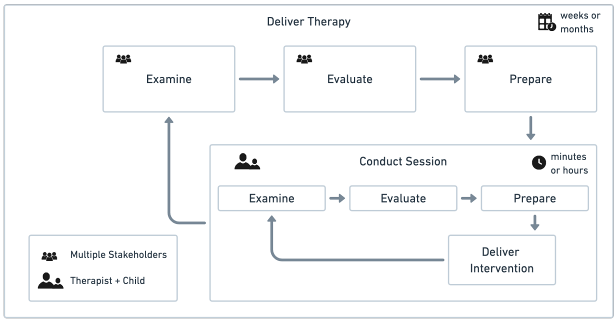

Figure 2: An illustration of the dual cyclic process that occurs in the delivery of therapy to a client.

for a therapist, as can be seen in Figure 1, we recommend the inclusion of suggested options that can lower the time for a therapist to make their desired dialogue selection. Through our analysis of this archival data and our recommendations, we've begun to uncover some usage patterns of teleoperation in practice. Upon implementing design improvements, we plan to monitor therapists' usage and survey them to determine the effectiveness of these interfaces and ways to improve them as discussed in Section 3.3

3.2 Therapists' Needs

We asked therapists about therapy in general and when teleoperating a robot to better understand their needs and how they differ with the presence of a robot. We conducted semi-structured interviews with therapists asking about (1) how they prepare for and conduct therapy in general, and if applicable, (2) why they've used robots in therapy, (3) how they prepare and conduct therapy when using a robot, and (4) how they would use a specific interface (Peerbots) in teleoperating a robot in therapy. From their answers we uncovered six themes of therapists' needs that are consistent regardless of robot usage, determine how robots change therapy, and identify unmet needs in robot teleoperation. The six themes of needs and difficulties that therapists discussed were on preparation, variety, awareness, adaptability, documentation, and evaluation.

From therapists' stories we identified that therapy follows a dual-cycle process with an inner cycle and outer cycle. Each cycle follows a similar patterns of examining the client, evaluating their needs, preparing to meet them, then delivering an intervention. The cycle continues with therapists determining the success of that intervention and adapting accordingly. The outer cycle occurs on a time scale of weeks, months, or years, where each intervention delivered is a therapy session for the client. The inner cycle, on the other hand, is what occurs within each session. While clients may have long term needs, therapy is about meeting their in-the-moment needs as well and will differ depending on the day the therapy session occurs and what else happened that day for the client. A visual illustration of this dual-cycle is available in Figure 2.

By interpreting therapists' stories through the lens of this dual-cycle model, we uncovered several important patterns across themes of therapists' needs. Therapists have to manage the uncertainty that exists within therapy to maintain an emotionally safe space for their client. They do so by adapting cleverly in the moment to customize therapeutic interventions to meet their client's needs. Therapists described robots specifically as being supportive in that space but that they present a variety/attention tradeoff; robots provide a lot of content variety but may require more attention to manage. This variety is helpful because therapy constantly changes as children accomplish their goals and move on to more complex tasks. Collaboration is also an essential part of therapists' ability to keep track of everything going on in a child's life at school and at home.

We recommend the following guidelines to developers building tools to support therapists:

- Meet therapists' needs in the moment.
- Account for the differences in and relationships between the inner and outer cycle of therapy.
- Move tasks from the inner cycle to the outer cycle whenever possible.

We have also developed guidelines targeting each theme of needs we uncovered for therapists.

3.3 Interface Capabilities

Therapists needs in this space are immense. In my research, I plan to focus on ways that technology can support therapists in documentation and evaluation. Specifically, I plan to look at two ways that tools can support therapists:

(1) Priming therapists' content delivery by presenting the client's goals and documentation in the inner cycle.
(2) Summarizing previous sessions to support therapists in their evaluation of past sessions.

Research plan: I plan on running co-design workshops with therapists to evaluate preliminary designs shown in Figure 3 & 4 of a documentation sidebar and session summary report. After co-designing updated interfaces with therapists, I plan on running in-lab experiments to evaluate the effectiveness of these designs in supporting therapists and determine therapists' perception of their usability. Finally, after the in-lab experiments, I'll run cognitive walkthrough sessions with therapists to evaluate how well these features work together. As therapists introduce additional documentation information, this information should likely also be included in the summary reports that they use to review sessions. In the cognitive walkthroughs, we'll be able to evaluate how well the whole system fits together. From the co-design, in-lab evaluations, and cognitive walkthroughs, I should be able to provide recommendations and guidelines for developers building tools to support therapists in robot-assisted therapy.

Evaluation: To evaluate these interface capabilities, I will use a combination of quantitative and qualitative metrics. I will evaluate how often therapists use and edit documentation, and how often they view summary reports. I will also consider therapists' perceptions of the utility of these features. When evaluating these tools, my focus will be on effectiveness as defined by therapists' preferences and ease of use as opposed to effectiveness in therapeutic delivery. I will be assuming that therapists' preferences are a proxy for effective therapy.

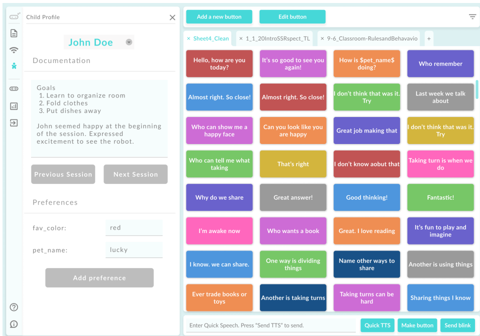

Figure 3: A sidebar showing a child's documentation in the session for therapists to reference.

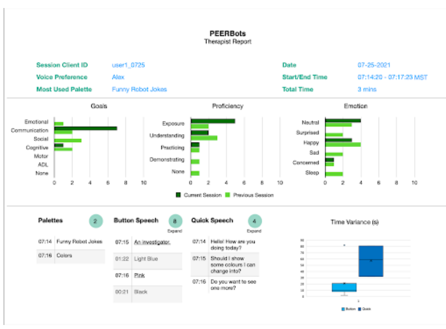

Figure 4: A report showing an example summary of a therapist's usage of a robot in a therapy session with a child.

4 CONCLUSION

Socially assistive robots have shown much success in the context of therapy for children with autism. When used in practice, therapists currently teleoperate these robots. There is an opportunity to improve the effectiveness of robot teleoperation interfaces used in therapy to aid in their large scale deployment. To make progress towards improving these teleoperation interfaces, I believe it is important to (1) understand how therapists currently teleoperate robots in therapy with autistic children, (2) understand what therapists' needs are in therapy in general, and (3) evaluate different interface designs in terms of therapists' perception of their utility. I described some progress in each of these areas and a path forward that I hope will provide the sufficient research to help in deploying SARs at a larger scale. Most importantly, therapists need to become the central focus of these interfaces as they are the users who operate these robots in practice.

ACKNOWLEDGMENTS

I would like to thank Dr. Tom Williams, Aubrey Shick, and Dr. Elizabeth Reddy for their guidance on this research.

REFERENCES

[1] Kenneth Barish. 2004. What Is Therapeutic in Child Therapy? I. Therapeutic Engagement. *Psychoanalytic psychology* 21, 3 (2004), 385.

[2] Laura Boccanfuso, Sarah Scarborough, Ruth K Abramson, Alicia V Hall, Harry H Wright, and Jason M O'Kane. 2017. A low-cost socially assistive robot and robot-assisted intervention for children with autism spectrum disorder: field trials and lessons learned. *Autonomous Robots* 41, 3 (2017), 637–655.

[3] Kristen Bottema-Beutel, Steven K Kapp, Jessica Nina Lester, Noah J Sasson, and Brittany N Hand. 2021. Avoiding ableist language: Suggestions for autism researchers. *Autism in Adulthood* 3, 1 (2021), 18–29.

[4] Thierry Chaminade, David Da Fonseca, Delphine Rosset, Ewald Lutcher, Gordon Cheng, and Christine Deruelle. 2012. FMRI study of young adults with autism interacting with a humanoid robot. In *2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication*. IEEE, 380–385.

[5] Eva Yin-han Chung. 2019. Robotic intervention program for enhancement of social engagement among children with autism spectrum disorder. *Journal of Developmental and Physical Disabilities* 31, 4 (2019), 419–434.

[6] Eva Yin-han Chung. 2020. Robot-Mediated Social Skill Intervention Programme for Children with Autism Spectrum Disorder: An ABA Time-Series Study. *International Journal of Social Robotics* (2020), 1–13.

[7] Caitlyn Elise Clabaugh, Kartik Mahajan, Shomik Jain, Roxanna Pakkar, David Becerra, Zhonghao Shi, Eric Deng, Rhianna Lee, Gisele Ragusa, and Maja Mataric. 2019. Long-term personalization of an in-home socially assistive robot for children with autism spectrum disorders. *Frontiers in Robotics and AI* 6 (2019), 110.

[8] Oliver Damm, Karoline Malchus, Petra Jaecks, Soeren Krach, Frieder Paulus, Marnix Naber, Andreas Jansen, Inge Kamp-Becker, Wolfgang Einhaeuser-Treyer, Prisca Stenneken, et al. 2013. Different gaze behavior in human-robot interaction in Asperger's syndrome: An eye-tracking study. In *2013 IEEE RO-MAN*. IEEE, 368–369.

[9] Julia Dawe, Craig Sutherland, Alex Barco, and Elizabeth Broadbent. 2019. Can social robots help children in healthcare contexts? A scoping review. *BMJ paediatrics open* 3, 1 (2019).

[10] Elbeleidy, Saad, Rosen, Daniel, Liu, Dan, Shick, Aubrey, and Williams, Tom. 2021. Analyzing Teleoperation Interface Usage of Robots in Therapy for Children with Autism. *ACM Interaction Design and Children Conference.*

[11] David Feil-Seifer and Maja J Matarić. 2009. Towards the integration of socially assistive robots into the lives of children with ASD. In *International Conference on Human-Robot Interaction Workshop on Societal Impact: How Socially Accepted Robots Can be Integrated in our Society*, Vol. 21.

[12] Irini Giannopulu. 2013. Multimodal cognitive nonverbal and verbal interactions: the neurorehabilitation of autistic children via mobile toy robots. *IARIA International Journal of Advances in Life Sciences* 5 (2013).

[13] Fine Art Miracles Inc. 2021. *Fine Art Miracles*. https://fineartmiracles.com/

[14] Elizabeth S Kim, Lauren D Berkovits, Emily P Bernier, Dan Leyzberg, Frederick Shic, Rhea Paul, and Brian Scassellati. 2013. Social robots as embedded reinforcers of social behavior in children with autism. *Journal of autism and developmental disorders* 43, 5 (2013), 1038–1049.

[15] Maja J Matarić and Brian Scassellati. 2016. Socially assistive robotics. In *Springer handbook of robotics*. Springer, 1973–1994.

[16] Autistic Self Advocacy Network and L. Berry. 2020. *Welcome to the Autistic Community*. Autistic Press. https://books.google.com/books?id=bzRszQEACAAJ

[17] PEERbots. 2021. *PEERbots*. https://peerbots.org

[18] Ben Robins, Kerstin Dautenhahn, Rene Te Boekhorst, and Aude Billard. 2004. Effects of repeated exposure to a humanoid robot on children with autism. In *Designing a more inclusive world*. Springer, 225–236.

[19] Brian Scassellati, Henny Admoni, and Maja Matarić. 2012. Robots for use in autism research. *Annual review of biomedical engineering* 14 (2012).

[20] Brian Scassellati, Laura Boccanfuso, Chien-Ming Huang, Marilena Mademtzi, Meiying Qin, Nicole Salomons, Pamela Ventola, and Frederick Shic. 2018. Improving social skills in children with ASD using a long-term, in-home social robot. *Science Robotics* 3, 21 (2018).

[21] Aubrey Shick. 2013. Romibo Robot Project: An Open-Source Effort to Develop a Low-Cost Sensory Adaptable Robot for Special Needs Therapy and Education. In *ACM SIGGRAPH 2013 Studio Talks* (Anaheim, California) *(SIGGRAPH '13)*. Association for Computing Machinery, New York, NY, USA, Article 16, 1 pages. https://doi.org/10.1145/2503673.2503689

[22] Wing-Chee So, Miranda Kit-Yi Wong, Wan-Yi Lam, Chun-Ho Cheng, Sin-Ying Ku, Ka-Yee Lam, Ying Huang, and Wai-Leung Wong. 2019. Who is a better teacher for children with autism? Comparison of learning outcomes between robot-based and human-based interventions in gestural production and recognition. *Research in developmental disabilities* 86 (2019), 62–75.

[23] Joshua Wainer, Ester Ferrari, Kerstin Dautenhahn, and Ben Robins. 2010. The effectiveness of using a robotics class to foster collaboration among groups of children with autism in an exploratory study. *Personal and Ubiquitous Computing* 14, 5 (2010), 445–455.

[24] Joshua Wainer, Ben Robins, Farshid Amirabdollahian, and Kerstin Dautenhahn. 2014. Using the humanoid robot KASPAR to autonomously play triadic games and facilitate collaborative play among children with autism. *IEEE Transactions on Autonomous Mental Development* 6, 3 (2014), 183–199.