Therapists' Perspectives After Implementing a Robot into Autism Therapy

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Abstract— **Socially assistive robots (SARs) are currently being developed to assist in the delivery of Applied Behavior Analysis (ABA) therapies to individuals diagnosed with Autism Spectrum Disorder (ASD). Although SARs have demonstrated positive outcomes, minimal research has focused on investigating needs of the therapists that deliver treatments. Therapist perspectives are important as they will likely be the primary end-users of SARs. In this study, we investigated the perceptions and design requirements of ABA therapists towards SARs and the interfaces used to operate them. Therapists were interviewed after they independently designed, developed, and implemented their own robot-mediated interventions. Overall, therapists' general perceptions towards integrating a SAR within their existing workflow was positive and they expected that children would benefit from ABA therapies delivered by a SAR. The therapists also provided insights on design requirements for utilizing SARs and their interfaces as well as potential clinical and future use cases for this technology.**

I. Introduction

Applied Behavior Analysis (ABA) is an evidenced-based practice commonly utilized for teaching children with Autism Spectrum Disorder (ASD) language, communication, social, emotional, and daily living skills, as well as reducing challenging behaviors. ABA is the most widely accepted practice for early childhood intervention both in school and clinical settings [1]. Over the last 10 years, the demand for ABA professionals has grown 4209% with a continued growth of 17% from 2019 to 2020 [2]. Since there is such a large demand for these services, researchers are investigating technological solutions to improve therapy delivery [3].

Socially assistive robots (SARs) are one such technology being developed and investigated to aid in the delivery of ABA-based treatments [4]–[8]. These robot-mediated treatments have been used to teach children with ASD a range of important social and communication skills such as wh-question answering [4], question asking [5], emotion recognition [6], appropriate eye gaze [6], greetings [7], and imitation [8]. In general, these robot-mediated interventions (RMIs) were designed by researchers with extensive experience in developing applications with robots and only a handful of these treatments were designed in consultation with board certified behavior analysts (BCBA). BCBAs are professionals responsible for defining goals and treatment plans for individuals with ASD [9]. Frontline therapists are then responsible for implementing the day-to-day treatment [10] which also includes preparing materials and documenting progress. However, it remains unclear the clinical utility of these technologies due to lack of collaboration with all ABA professionals involved in an individual's treatment [11].

It is vital to investigate ABA professionals' perceptions and acceptance towards the clinical utility of SARs in delivering treatments because they are the stakeholders responsible for planning and administering treatments to individuals with ASD. If SARs are to be integrated into clinical settings, ABA therapists are the staff that will independently design, develop, and implement robot-based ABA interventions according to the BCBA's defined goals and treatment plan without the assistance of an expert roboticist. Hence, it is important to investigate ABA therapists' acceptance of SAR technology and their perceptions of fitting SARs into their workflows. Technology development which does not consider how SARs may disrupt end-users existing workflows will lead to technology rejection [12].

In this work, we conducted a study to investigate ABA professionals' trust, perceptions, acceptance, and recommendations towards the use of SARs in clinical practice based on their experience with independently designing and implementing RMIs for children with ASD. The ABA professionals were trained on utilizing both a commercial and custom application for operating the robot. They then independently designed, developed, and implemented an emotion recognition RMI to children with ASD in their clinic. After experiencing the entire workflow of implementing an RMI, interviews were then conducted to investigate participants' perceptions and acceptance of the technology.

II. Related Works

To date, several studies have investigated therapist perceptions towards the use of SARs in the delivery of treatment and teaching individuals with ASD [13]–[17].

In [13], interviews were conducted with four individuals that had experience interacting with individuals diagnosed with ASD to evaluate the feasibility and usability of an emotion recognition RMI that was demonstrated to them in-person. Overall, participants found the intervention engaging and provided recommendations for improving the delivery.

In [14], interviews and focus groups were conducted with rehabilitation and speech & language therapists to identify design requirements for SARs to assist therapies. During the focus group sessions, participants were given a live demonstration of the Pepper robot guiding the moderator through rehabilitation exercises to familiarize them with the robot's capabilities. Therapists were positive towards SARs delivering therapies and suggested areas robots could provide support. Participants also provided key design considerations for personalized and adaptive interaction strategies.

In [15], semi-structured interviews and focus groups were conducted with special education teachers to investigate their perceptions towards potential uses, benefits, and concerns of

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using robots for teaching children with ASD. Participants were presented six images of example humanoid robots. Results of the study revealed that the participants expected children with ASD to find the robots engaging and predictable which could support their learning. Furthermore, they highlighted potential roles for robots within education and emphasized that if robots are to be used, the skills learned need to generalize to humans.

In [16], current and future education and rehabilitation practitioners working with children with intellectual disabilities were surveyed to determine their intention to utilize SARs. Participants were given a presentation on robot capabilities and potential use cases for children with ASD. Participants also had the opportunity to play an image recognition game and verbally control the movement of the robot before they were administered a questionnaire. Results found participants had positive attitudes towards the use of robots, but current practitioners had lower intentions to use the robot than the students.

In [17], current and future therapists' perceptions towards the ethical acceptability, trust, sociability, and usability of a SAR in therapy for children with ASD was investigated. Participants were administered a survey after viewing video clips with six different character, animal, and human-like robots, which were not interacting with children. Results of the questionnaire suggested therapists were positive towards using SARs for therapy and found it ethically acceptable but it should not replace a human therapist.

Current studies investigating practitioners' perceptions towards SARs have found they are positive towards the technology and identified potential benefits in using it for delivering therapy to children with ASD. Despite these positive perceptions, studies found that practitioners are concerned with the usability and ease of use for integrating this technology within their workflows [15], [16]. Some of these studies also did not have therapists comment or focus on including robots within their workflows [13], [14], [17]. As suggested by these studies [14]–[17], the participants had minimal exposure to SARs and did not have opportunities to design or implement therapies utilizing SARs. These therapist perceptions may be based on prior experiences with other technologies and not SARs [18]. There is currently limited research on investigating the needs of ABA professionals for integrating SARs into therapy and instead current research focuses on the needs of the individual with ASD [15].

III. Methodology

We aimed to address the aforementioned limitation by investigating therapist perceptions towards SARs after they designed, developed, and implemented an ABA-based RMI for children with ASD. Therapists were trained on commercial and customized interfaces for controlling a SAR, as well as designed and delivered their own RMI. We conducted individual follow-up interviews with participants to investigate perceptions towards SARs, the RMI workflow, and integrating this technology into existing practices.

A. Participants

A total of eight participants were recruited for this study. The inclusion criteria were: 1) working as a therapist in an ABA clinic, 2) at least one year of experience delivering ABA therapy, and 3) no prior history of seizures with virtual reality (VR). Participants included one male BCBA and seven female behavior therapists. The age range of participants was 22-33 (μ=25.13, σ=4.05) years old with a range of 1-8 (μ=3.38, σ=1.93) years of experience delivering ABA therapies.

B. Study Procedure

The study was divided into four days for each participant. The days with each participant focused on the following objectives: 1) ABA intervention familiarization, 2) robot training and RMI design, 3) RMI delivery to a child, and 4) interviews for gathering user experiences.

The first day focused on familiarizing participants with an ABA-based emotion recognition intervention to provide them a baseline to compare their existing workflow with an RMI workflow. The participants did not have prior experience with the specific intervention and this familiarization day followed a standard workflow within clinics. The BCBA-D (Dr. Korneder) provided the therapist written and verbal instructions on the intervention goals and procedures. The participant then implemented the intervention with a child.

The second day focused on training participants to operate the Pepper humanoid SAR using two interfaces and allowing them to independently design an emotion recognition RMI. A researcher trained the participants on the basic principles for creating and delivering speech and motions on Pepper using a custom VR teleoperation system developed by our research group [19] and the commercially available software Choregraphe [20], shown in Fig. 1 (a) and (b), respectively. Participants then independently designed, without the assistance of a researcher, an emotion recognition RMI with both interfaces and practiced delivering the intervention in a mock scenario with a researcher as a simulated child.

The third day focused on participants experiencing the workflow for an RMI in an ABA clinical setting with a child diagnosed with ASD, represented in Fig. 1 (c). Participants used each system to deliver one session of nine trials of the emotion recognition RMI. Each trial consisted of the robot, controlled by the therapist, demonstrating an emotion and asking the child what emotion the robot is feeling. Two sessions of eighteen trials were conducted by each participant utilizing both control systems.

On the last day participants were interviewed to investigate their perceptions after using the SAR to deliver an RMI. Interviews were semi-structured with an interview protocol and opportunities for further discussion on topics if needed. Interview questions were designed based on the definitions of constructs in the Almere model, which is a questionnaire for investigating acceptance towards SARs [21]. Interviews were via online meetings and recorded for post-analysis.

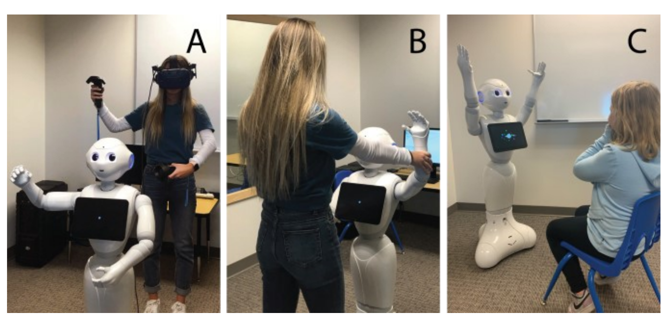

Figure 1. a) VR Interface, b) Choregraphe Interface, c) Intervention Delivery

D. *Thematic Analysis*

Each participant's interview was transcribed and edited for errors. The transcriptions were imported into a qualitative research analysis software and coded inductively and deductively by one researcher and reviewed by another for accuracy. Namely, excerpts of discrete topics from each interview were extracted for further analysis with each having 33 to 61 (μ=50.9, σ=8.22) excerpts. Codes were developed based on recurring themes found in excerpts across participants. These codes were assigned to excerpts and transcripts were reviewed using the identified codes.

IV. Results and Discussion

Thematic analysis of participants' experiences using SARs for ABA therapies resulted in four themes. These themes focused on: A) design requirements for SARs and their interfaces; B) clinical and future use cases for SARs; C) perceptions of SARs interacting with children with ASD; and D) general perceptions therapists had towards the robot.

A. *Design Requirements*

During the interviews, participants provided numerous design requirements for SARs and the interfaces used for programming and controlling the SAR during intervention delivery. Therapists' design requirements focused on SARs' timing and responsiveness; physical prompting; adaptability; situational awareness & reliability and their effects on trust; usability of the control interfaces; and therapist workload.

1) Timing & Responsiveness— A common ABA intervention approach is discrete trial training which includes the presentation of an instruction, followed by a prompt (if needed), the child's response, and consequential reinforcement or error correction. All therapists agreed a design requirement of robots delivering ABA therapy was it must be responsive and timing for the delivery of prompts, error corrections, and reinforcements must be accurate. Timing is crucial to delivering interventions in ABA because the progression of a child's learning determines the delay between presenting an instruction and a prompt [22]. The timing of the prompt is dictated by a standard ABA protocol for lesson progression which transitions from immediate prompting, to delayed prompting, to removal of prompting. Errors in learning can occur if prompting is not provided at a predetermined level. Error corrections and reinforcement in response to the child must occur within 5 seconds to guarantee learning [23]. Namely, delays in prompting and reinforcement can lead to errors in learning as a delayed prompt may be delivered after an incorrect response from the child or a delayed reinforcement may follow a behavior other than the targeted behavior [22] , [23].

Timing and responsiveness were salient topics because participants found the time in executing behaviors on the SAR varied when using the interfaces. Participants considered the main advantage of VR control to be the ability to control the speech and joints in real-time. Namely, there was no significant time delay between the participant's actions and when it was presented to the child. However, participants expressed concern with using Choregraphe to deliver prompts and reinforcement because they found a significant time delay between the child's response and when they were able to provide feedback. These delays were due to a combination of the time for participants to choose a behavior on the Graphical User Interface (GUI) and delays in the application executing the behavior on the SAR. Overall, it was suggested delivering interventions with pre-scripted animations with the addition of a microphone to control the timing of the robot's speech.

2) Physical Prompting— Prompts are vocal statements, a demonstration of behavior, or manual guidance to evoke a response or help an individual with ASD complete a targeted behavior correctly and accurately. Manual guidance, herein referred to as physical prompting, is implemented by a therapist gently placing his/her hands over the child's to help them complete a behavior. For example, during play interactions therapists would place their hands over the child's to help them roll a ball. If during physical prompting the child shows resistance the ABA therapist removes the prompt and reassess prompting strategies.

The need for a robot to deliver physical prompts was emphasized by participants in multiple contexts. Some example contexts included: task analysis where daily living skills (e.g., eating) are broken down into sequential steps; visual motor imitation where the child copies the physical action of an agent; and lastly, following vocal directions. Participants expressed concern the robot would not be able to physically prompt in these situations, therefore significantly limiting programs it could perform. It is common for many learners that a skill is first introduced with physical prompts and gradually shifts to vocal or demonstration prompts, which are initially not sufficient for evoking behavior [24].

3) Adaptability— Another topic frequently raised by participants was the robot's ability to adapt to a child's needs. Children's actions cannot always be predicted and participants indicated SARs must be able to adapt to changing child behavior for successful delivery of interventions [25]. The scenarios, indicated by therapists, requiring adaptation included problem behavior, personalization, and motivation.

Therapists suggested a SAR needs to adapt to a child when they exhibit problem behavior. They commented children with ASD do not always sit still, and "If a child were to get up out of their seat and I was able to move the robot to block them from escaping from the work area, that would be more helpful". Hence, it needs to navigate around its environment to address this challenge. Another common problem behavior scenario was suggested: "Sometimes you present [instruction] and next thing you know your kids in the middle of a tantrum, and if Pepper's in the middle of a trial she can't stop that trial and go into what we would do to stop these behaviors . . . and so in that instance, it would be hard for a robot to do that." This aligns with research, where educators and practitioners in [15] and [16] shared the concern a robot is not equipped to interpret and respond to children's variable behavior.

Personalization to a child was considered a requirement for the SAR because children often have preferences in how a therapy is delivered. Therapists specifically focused on children's preferences in reinforcers which can be in the forms of physical (tickles, hugs), tangible (toys), non-verbal (clapping), or verbal (praises). The reinforcer used depends on the preference of the child. There was also concern the robot could not deliver physical reinforcers. Participants expressed the robot could not recognize a child's preferences and adapt. This aligns with [14] where participants believed a

SAR's ability to personalize to a child's needs is necessary because they have unique preferences in their learning.

Lastly, therapists often switch interventions or programs if they notice a child has lost motivation. It has been shown that increased engagement or motivation comes from following a child's lead, interspersing known mastered targets with acquisition targets, and reinforcing attempts [25]. A participant mentioned "when we're working with [the] client, if [the child] loses attention, if he's lost his motivation . . . there's ways for me to interact with that and remedy those situations." Hence, therapists said the robot must be able to adapt to a child's level of attending to effectively deliver therapy. Therapists in [14] were also concerned a robot could not be adaptive and 'read' the patient because therapists often adapt to situations based on contextual clues. Similarly, [13] and [14] reported that personalization affects children's motivation and engagement during learning.

4) Situational Awareness & Reliability Affect Trust— Therapists often reflected on their trust towards the robot delivering ABA therapy. Their trust was primarily influenced by the interfaces utilized to control the SAR with respect to situational awareness and reliability.

Although the VR system was at an advantage for responsiveness and adaptability to children, participants felt they lacked situational awareness. Participants had no visual feedback on whether the robot was moving the way they intended during teleoperation, leading to distrust in the SAR. Most participants agreed a 3rd person perspective displayed in the VR headset would help them visualize the robot and child interaction. In contrast, participants found they could trust the Choregraphe interface because it displayed a virtual model of the robot's pose in real-time. Therapists also expressed an overall view of the environment surrounding the robot would be beneficial: "It's great that you can see the kid because that's your main focus but knowing what's going on around you is important too, especially because we did it in a classroom, there's always something happening."

Therapists indicated consistency in the implementation of their pre-programmed behaviors designed in Choregraphe strengthened their trust in utilizing a SAR. Participants elaborated the consistency would benefit the child's learning because there would not be treatment drift between therapists: "There's no room for human error . . . sometimes we diverge from the way things are supposed to be ran . . . and then everyone's running them a different way and the kid's not learning . . . in that sense, it would be really helpful." This is important because high treatment integrity in the delivery of interventions is necessary for effective and efficient teaching of targeted skills [26]. Similarly, educators in [15] believed the consistency and predictability of a robot to be a potential benefit for use in therapy for children with ASD.

5) Usability of Interface— Participants' experience with the VR and Choregraphe interfaces focused on three design requirements: precision and accuracy for the generation of movements, real-time flexibility, and organization.

Participants emphasized fine motor controllability of the robot's motions is important for the delivery of ABA interventions to communicate and model behaviors for a child. Even in using the same robot, the interfaces in this study differed in the ability to control the robot's poses. Participants found generating motions with Choregraphe easier and preferred it for interventions requiring the use of robot joint motions. Choregraphe allowed participants to use kinesthetic teaching to create poses for robot behaviors using the SAR's full range of motion. Participants felt this approach provided them more precise control over the robot's movements since they directly manipulated the robot's joints. On the other hand, the VR interface was programmed with limitations in how the robot's joints could be moved and lacked one-to-one mapping between human and robot poses. This was due to limitations in the human pose capture of the VR sensors and differences in degrees of freedom between the robot and human. Consequently, participants had difficultly learning the robot's limitations in range of motion while utilizing VR.

Participants reflected on the real-time flexibility of using the two interfaces to control the robot's behaviors but had contrasting opinions on the necessity of this feature. Namely, participants' preferences differed when comparing pre-programing robot behaviors prior to an intervention in Choregraphe compared to real-time control of the robot's joints and speech using VR. Some participants preferred pre-programming behaviors because during the delivery of an intervention they did not need to consider how to exhibit the correct motions for delivering an instruction. They could simply select the appropriate behavior to execute on a screen. Others suggested the lack of adaptability in robot behaviors reduced usefulness of the robot and preferred the VR method.

One of the major drawbacks of Choregraphe is the organization of the GUI. Participants suggested the GUI layout could be improved with similar behaviors grouped together on the screen so it is easier to find and implement the intended behavior during an intervention. Since Choregraphe has been designed to be a general visual programing interface, the current layout does not provide a clear method to label or reorganize behaviors according to the needs of each operator.

6) Workload— Participants had the opportunity to experience the robot within their existing workflow as well as its potential influence on their workload. Therapists suggested the robot could decrease workload by automating repetitive interventions and engaging the child while therapists focused on additional responsibilities. They also expressed concern it could increase workload due to training new staff and the setup time required for an intervention.

Participants were interested in the robot performing autonomous actions, whether interacting with the child independently or in cooperation with the therapist. One participant suggested the robot could reduce workload by autonomously running interventions therapists deliver daily. Another participant emphasized the robot would allow them the opportunity to complete tasks they typically would not have the time for: "Giving us some hands-off time to watch the kid and have more time to do the background things. If we were able to just click a button and something did an intervention for you, that'd be awesome." They also noted a desire to cooperate with the robot to deliver interventions. A scenario of co-presenting interventions was suggested where the therapist would implement more complex interventions and the robot would deliver routine or enjoyable interventions interspersed throughout the session. Namely, therapists often mix interventions of differing difficulty when running programs to maintain a child's motivation. Overall, the robot was viewed as helpful and "an extra hand" that could cooperate with therapists. Several of the educators in [15] also felt the use of a SAR could help decrease workload by supporting staff in prompting and praising the children.

However, there were concerns introducing SARs could potentially increase workload due to the time required to train new staff with a complex technology, as well as the setup and preparation required for an intervention. A participant shared how daunting training could be for staff: "[Using the robot] requires so much understanding of the system that it would cause so much animosity and stress upon the [therapists] that are already stressed about so much with the kids, that I think simplifying the system would be necessary." Participants were also concerned with the amount of preparation time as the current Choregraphe application requires therapists to pre-program the robot for their planned interventions. This programming step could take a significant amount of time for therapists new to the system or to individualize interventions for different children. This was considered a barrier especially in situations where a child masters programs quickly. Similarly, educators and practitioners in [15] and [16] had similar concerns because of the missing knowledge, skills, and training required to program the robot and its behavior. A concern was also raised regarding adding an aspect to keep track of while caring for a child: "If you're using the robot for therapy and you have to take it to somewhere else and you have your kid, you got your kid's materials, and then have to move the robot, and if your kid is somebody who needs you to hold [their] hand, you have to do that and maybe nobody else is around. So, I think that part would be hard."

B. Clinical and Future Use

Therapists also provided perspectives on current and future uses of SARs within an ABA clinic based on their perceptions of current and envisioned future capabilities of robots.

1) Supporting Child Independence— A common challenge within ABA therapy is that individuals with ASD can become dependent on a therapists' prompts or assistance to demonstrate a skill [24]. Participants indicated the robot could especially be valuable for addressing this issue and fading therapists out of a skill acquisition program. Independent activity schedules is one such program which would benefit from using a robot to support a child's transition to independence. Namely, independent activity schedules focus on teaching a child to independently engage in activities and promote on-task behaviors. This is typically accomplished by having a child independently complete a sequence of their preferred activities or activity books based on a picture schedule. Participants suggested after the child could complete the program with the therapist, the robot could be the next step towards independence by being the one delivering the prompts: "If the therapist started out with the kid working on a worksheet . . . then if we're working on the kid doing it totally independent . . . we'd be able to remove ourselves out of the picture, but then put the robot in the room with them and deliver those prompts through the robot."

2) Robot as Substitute— Participants suggested the robot would be useful when individuals besides the child's primary therapist are needed, such as assisting in mastering targets or in place of a peer. Namely, to demonstrate generalization of a skill a child needs to exhibit the skill with at minimum two adults [23]. In such a case, participants suggested the robot could be used in place of another adult when a child needs to demonstrate generalization of a skill. This is especially useful during the COVID-19 pandemic for reducing the risk of exposure or when limited staff are available. The robot was also considered advantageous for social programs between two children since it could substitute for a peer when there are no available children or no other children at the same level of learning. Namely, the robot can be adapted according to the skill level of a child and simulate a peer in social programs. Current research in robotics has utilized SARs in peer programs [27], [28]. However, educators, parents, and therapists in [15] and [17] were concerned a robot does not support generalization and did not want the child to interact with the robot in the absence of an adult. Our participants believed the SAR would aid in generalization by simulating a therapist to master skills or a peer in play programs, as they observed the interactions between a child and a robot are similar to a therapist and a child.

3) ABA Programs— During the interviews, participants suggested a range of ABA programs SARs could support based on Pepper's vocal, screen, and joint motion capabilities. Therapists considered Pepper's ability to speak to be beneficial for delivering language and communication programs such as teaching a child to label their environment ask/answer wh-questions, respond to instructions, listen to a story, and apply general conversational skills. Participants suggested the screen on Pepper would enable the effective delivery of programs including identifying or labeling pictures; comprehension programs where the child reads along with a story; academic programs for identifying words or numbers; and pretend play or building structures which require video modeling. Participants also thought the SAR would be successful with assisting in academic and leisure programs that included comprehension of stories, letter identification, and completing activities while referencing a picture schedule. Therapists in our study considered the robot for use in several ABA programs aligning with [13] and [14] stating the robot's ability to communicate would benefit these interventions as well.

4) Program Limitations— Participants considered programs the robot may not be able to perform including programs requiring physical prompting, fine motor skills, or those with unpredictable conversation.

Participants suggested the robot would be disadvantageous for programs requiring physical prompting such as task analysis or peer programs. Task analysis programs, like toileting or tying shoes, require physical prompting to help the child through fine motor steps of daily living skills. Peer programs also require physical prompts to teach children to play with a peer or take their turn.

It was suggested the robot may have difficulty in programs requiring fine motor skills or may not have the physical capabilities to easily grasp or manipulate objects for interventions. These limitations affect the robot in programs such as fine motor imitation (e.g., teaching a child how to represent a 'thumbs up' with their hands) or where therapists give or receive objects from a child.

When considering their experience with Choregraphe, participants mentioned a limitation in not being able to program every response possibly needed in interacting with a child. During communication interventions, there are unlimited responses a child can give requiring different reactions. The therapists suggested speaking through a microphone would address this issue.

5) Additional Functionalities & Use Cases— Beyond their existing experiences with robots, participants discussed how they envisioned a robot could be used in future situations. Therapists communicated additional robot functionalities that would be beneficial in integrating robots within their existing therapy delivery workflow. These additional robot functions included collecting data on children's behaviors during a therapy, recognizing and reconciling problem behaviors, assisting with training new staff, and having access to a database of frequently delivered and previously programmed interventions for the SAR to perform.

Multiple participants mentioned the robot could be extremely helpful with collecting data on a child's behaviors during an intervention. It is standard protocol during ABA therapies to collect data on the performance of all skill acquisition interventions and problem behavior to evaluate the child's progress [23]. Therapists said such functionality would significantly reduce their stress and workload, as well as allow them to focus on their assigned child.

A few participants mentioned a robot must be capable of recognizing, predicting, and resolving problem behavior like a therapist. One participant commented that after working with a child over time they can anticipate, recognize, and address problem behavior by adapting to a child's needs. Therapists further elaborated the robot should identify those situations when they occur and "remedy it the way we would." This robot function could be useful in alerting other staff of a problem when the robot or therapist needs help.

Participants also commented the robot would be useful in training new staff. Namely, the robot could assist in developing the competencies required to become a registered behavior technician (i.e., therapist). Specifically, when staff are not conveniently available to answer questions of new therapists, the SAR could demonstrate tools used in therapies such as error corrections, time delays, and discrete trial training steps. Training new behavior therapists requires multiple training sessions to master competencies and generally up to three months of practice [10], [23].

A recommendation by several therapists was to create a database with a variety of functions or sets of interventions they could utilize as needed. Therapists indicated in their current practice there is a database to copy interventions into their program plans and suggested this be implemented for using SARs: "That would be helpful if we could go in and be like okay, I need a [labeling] program and we can just pull that and run it versus setting up all those trials; it would just take so long [to set up] for so many kids."

C. Interaction with Children

Therapists interact one-on-one for multiple sessions per week with the child who is receiving ABA therapy. Thus, they become familiar with the child's preferences, habits, and form a strong bond with them. During the interviews, participants frequently provided their opinions and expectations on SARs interacting with children during ABA therapy. These insights were based on their actual experience observing the children interacting with the SAR. The primary topics they focused on were the child's enjoyment, benefits to learning, human characteristics for ASD, and the robot's appearance.

1) Child Enjoyment— Participants agreed the robot brought joy to the children and commented they have since expressed excitement to interact with the robot. Participants stated seeing the child engage and have fun with the robot was a highlight of their experience. Therapists agreed delivering therapies through the robot benefited the children because "It gives them something fun to do and they're still working and they don't even know it. Which is very cool." It was noted the robot could also be a reinforcer for children's positive behaviors. Using a robot as a reinforcer may be supported by social motivation theory which suggests that individuals with ASD prefer nonhuman and mechanical stimuli over maintaining relations with human partners [29]. In [13]–[15], therapists and educators agreed children would find a SAR more engaging to work with during therapies and stressed the benefit of SARs contributing to motivation towards learning.

2) Benefits to Learning— Therapists expressed the robot would benefit a child's learning by introducing technology into their interactions and assisting in the process of teaching. It was mentioned children being exposed to new things was an advantage of interacting with the robot: "To give the kids more exposure and see them interact with other things rather than just people and see how they interact with technology . . . [the robot] gives them another chance to learn how to use something new and get creative with it." Positive exposure to new or novel items helps decrease problem behavior and broadens reinforcers, and is shown to increase interests for individuals with ASD [30]. However, there were some concerns from participants regarding overuse of technology which aligns with existing literature [15]. Beyond the delivery of ABA-based interventions, participants suggested several additional roles for a SAR to support children's learning, such as the role of a secondary adult for skill generalization or a peer for social skills training. Participants believed interacting with unfamiliar agents ultimately assists children with ASD in learning and adapting to other situations in the future.

3) Human Characteristics for ASD— Participants suggested situations a SAR may not contribute to as it lacks some human characteristics required for ABA. These included pairing with a child, adapting to naturalistic teaching methods, and working with children that are non-verbal or lacking attending skills.

An important part of ABA is for the therapist to form a positive bond or "pair" with the child before beginning to work with them [31]. One therapist suggested the robot could not form a personable connection with the child or fully understand and respond to a child's emotions. This concern has been brought up in prior literature on healthcare robots lacking the "warm" care humans can provide to a patient [32].

Some participants viewed delivering interventions through a SAR less natural than current practices. One participant expressed "We get down and we play with the kids and I don't know that the robot can do that . . . During work, when we're doing our programs, the robot is pretty similar to the way we would act . . . but just not the playing and the naturalistic type of thing." Natural approaches to teaching include following the child's lead, implementing played-based reinforcers, and teaching during play [25].

Participants expressed worry the robot would not be suitable to all children. One therapist brought up experiences with nonverbal or younger children: "There's certain criteria for the child, right? They have to have a certain level of attending, have a certain level of ability…" This was of concern for handling situations where a child often exhibits problem behavior or may not respond well to the robot. Further research is to be conducted to determine the criteria for engaging an individual with ASD in RMIs. Considerations include a child's ability to attend and follow safety instructions, as well as the necessity of physical prompting.

4) Appearance— Therapists had differing opinions regarding a SAR's appropriate appearance. Some participants thought the robot should embody an animal or character. Others thought it would be best for the robot to look more humanoid to effectively deliver ABA therapies. Therapists' varying opinions on the appropriate appearance of the robot is supported by current literature which suggests preferences on robot appearance can vary tremendously across individuals with ASD [33]. One participant suggested the robot should wear the clinic uniform to appear like a therapist and make the child more comfortable in its presence.

D. General Perceptions

At the end of the interview, therapists were given the opportunity to share their experiences and perceptions after designing and implementing an RMI. These perceptions primarily focused on the effects of societal pressures, as well as how their prior expectations were altered and initial anxieties relieved after using the SAR for ABA therapies.

1) Social Factors— Although the therapists in this study were able to form their own opinions on the use of SARs in ABA therapies from their experience, societal pressures still had a significant impact on their overall acceptance of robots. Multiple participants mentioned a common negative stereotype or misconception the general population has against ABA: "I would sort of go back to . . . those bad stereotypes [of] ABA turns kids into robots, and ABA makes kids speak like robots or kids with autism talk like robots." The negativity placed on ABA by society affected how the therapists perceived the SAR. One participant argued "They already think what we do is kind of crazy and robotic in a sense. But it really isn't. And I really don't think Pepper is super robotic either, 'cause you control her, like it was my voice." Another participant also expressed they would not feel comfortable using the SAR in their daily interventions until it was more universally accepted. It has been widely acknowledged that technology acceptance is impacted by social influence [34]. It is important to investigate the rationale for these perceptions and how to address them.

2) Prior Expectations— Therapists' perceptions changed after they had the opportunity to utilize and control a SAR for ABA therapies. Participants noted the robot exceeded their expectations. It was frequently mentioned the mobility of the robot was shocking, with a participant expressing "It was really cool how high tech [the robot] actually was. I didn't think that the robot was going to move or anything . . . but being able to move the arms and stuff was really cool" and another, "Seeing how much it could actually do . . . I thought it would be a lot more limited than what it really was. So, I thought it was cool that we were able to program ourselves into the robot." Therapists mentioned their skepticisms about the use of SARs in ABA therapies disappeared once they saw the capabilities and benefits of it. Most participants expressed the experience of utilizing a SAR widened their perspective on the use of technology in ABA and how much the field will benefit and grow from it. One therapist stated the experience "Made me a better [therapist] for sure." Although some were skeptical before their interaction with a SAR, therapists agreed their perceptions were altered in a positive way from the experience. Before the demonstration in [14], therapists had difficulty understanding how SARs could be useful in therapy, however viewing a robot demonstration had a significant impact on the acceptance by participants.

3) Relief of Technology Induced Anxiety— A common topic brought up by participants was utilizing the SAR was much easier than expected. Before interacting with the robot, participants reflected they had hesitation and worries. Originally, some therapists expressed animosity towards the robot due to lack of experience with technology or feelings of inadequacy. In [35], therapists and parents of children with ASD were also discouraged and did not believe they had the knowledge to use a robot. Therapists' worries were quickly put at ease once interacting with the robot itself. Participants expressed sentiments of the experience being "easier than I thought" and noted they left feeling satisfied, accomplished, and at ease. While previously expecting programming a robot to be an impossible task, therapists enjoyed the process and its simplicity. One participant positively spoke about working with and programming the robot: "It was not hard whatsoever. Anyone can do it." Overall, participants' initial hesitations about learning to utilize a SAR for ABA therapies were dissolved once the ease of use of the system was realized. The interviews in our study were conducted after the participants were able to directly use the technology to design an RMI and resulted in their perceived ease of use of the technology being higher than they expected. This is in contrast to results shown in [16] where the practitioners had a simple interaction with the robot that reflected unwillingness to use the SAR in practice due to concerns with its ease of use.

V. Recommendations

ABA therapists in this study were positive towards implementing SARs into their existing workflows and provided their perspectives, as well as recommendations, based on their experience designing and delivering an RMI. The following design considerations and recommendations for future implementations of SARs within ABA therapies were derived from interviews with the therapists.

Protocols for the delivery of ABA therapies are rigorous and therapists expect SARs to follow or address challenges in implementing existing procedures for these therapies. Namely, the future development of RMIs should ensure accurate timing and responsiveness of robot behaviors according to children's responses in therapy. ABA therapies are dynamic, and SARs must address the rapidly changing learning needs, behaviors, and engagement of children with ASD during a session. Furthermore, if SARs are to be broadly applied to therapies it is necessary they provide physical prompting or identify alternative means to address this need.

In addition to SARs and their interfaces following ABA protocols, they should be sufficiently easy to use and learn, and reduce workload for therapists to consider them practically usable. This technology is expected to have a database of available intervention content that is flexible and easy to modify according to the needs of each child. Children's levels of learning are highly variable in ABA, making it imperative the robot can accommodate these differences. Therapists also require the behaviors of a robot and their interactions with children are predictable and transparent, as well as real-time control of the robot's voice during teleoperation. Moreover, advancing the autonomy of SARs to deliver interventions and support therapists could significantly reduce workload and increase acceptance. It is vital SAR technologies are evaluated by having therapists directly apply it to their workflow, as their perceptions prior to use may not accurately reflect their perceptions after use.

Within an ABA setting, a SAR can play the roles of a therapist or peer to support teaching and generalizing skills. SARs could contribute to social, language, communication, academic, and independence skills. A well-rounded session of therapy should include direct teaching, as well as play-based and group instruction, with smooth transitions between these activities. Additionally, functions that would benefit both the child and therapist are collecting therapeutic data, cooperatively delivering interventions, and training staff.

Overall, ABA therapists found SARs can benefit children's learning, enjoyment, engagement, and motivation during therapies. However, there were concerns pertaining to societal pressures which would prevent therapists from adopting the technology. In the future, it would be valuable to investigate the perceptions of all stakeholders towards using SARs in the treatment of children with ASD. Furthermore, more studies are necessary to support RMIs as an evidence-based practice within ABA therapy.

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